JABATAN PERIKANAN MALAYSIA
Kementerian Pertanian dan Keterjaminan Makanan Malaysia,
Aras 1-6, Blok Menara 4G2, Wisma Tani, Presint 4,
Pusat Pentadbiran Kerajaan Persekutuan,
62628 PUTRAJAYA,
MALAYSIA,
Tel: 603-88704000, Fax: 603-88895490
Email: hqhelp@dof.gov.my | www.dof.gov.my

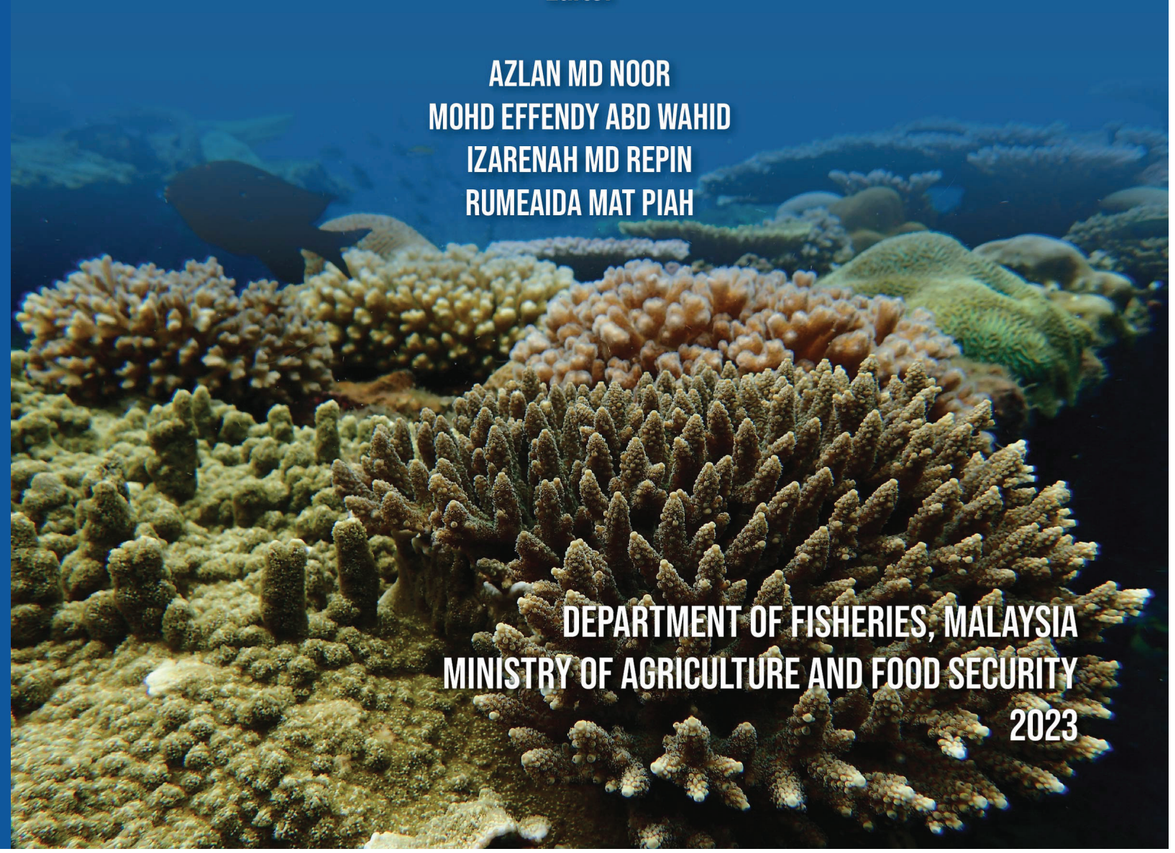
ISBN 978-967-2840-44-2

MALAYSIA MARINE ECOLOGICAL GAP ASSESSMENT REPORT

MALAYSIA MARINE ECOLOGICAL GAP ASSESSMENT REPORT

Editor

AZLAN MD NOOR
MOHD EFFENDY ABD WAHID
IZARENAH MD REPIN
RUMEAIDA MAT PIAH



DEPARTMENT OF FISHERIES, MALAYSIA
MINISTRY OF AGRICULTURE AND FOOD SECURITY
2023

MALAYSIA MARINE ECOLOGICAL GAP ASSESSMENT REPORT

Editor

AZLAN MD NOOR
MOHD EFFENDY ABD WAHID
IZARENAH MD REPIN
RUMEAIDA MAT PIAH

Jabatan Perikanan Malaysia
Kementerian Pertanian dan Keterjaminan Makanan
2023

Copyright : 2023 Department of Fisheries Malaysia
Reproduction of this publication for educational or other non-commercial purposes is authorised without prior written permission from the copyright holder provided the source is fully acknowledge

Reproduction of this publication for resale and other commercial purposes is prohibited without prior written permission of the copyright holder.

First printing : 2023

ISBN : ISBN 978-967-2840-44-2

Citation : Azlan Md Nor, Mohd Effendy Abd Wahid, Izarenah Md Repin, Rumeaida Mat Piah, 2023. Malaysia Marine Ecological Gap Assessment Project Report. Department of Fisheries Malaysia, Ministry of Agriculture and Food Security

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

Book cover courtesy to: Dr James Tan Chun Hong

Available from : Division of Marine Park and Resource Management
Department of Fisheries Malaysia
Ministry of Agriculture and Food security
Wisma Tani, Aras 3
Blok Menara 4G2, Presint 4
62628 Putrajaya
Tel: 03-8870 4005 Fax: 03-8881 1086
www.dof.gov.my

Cataloguing-in-Publication Data

Perpustakaan Negara Malaysia

A catalogue record for this book is available from the National Library of Malaysia

ISBN 978-967-2840-44-2

Printed by : FNZ Print
No. 1, Jalan P10/18, Taman Perindustrian Selaman,
43650 Bandar Baru Bangi,
Selangor
www.fnzprint.com.my

TABLE OF CONTENT

	Preface	v
	Executive summary	vi
	INTRODUCTION	1
CHAPTER 1	CORAL REEF AND FISHES	6
CHAPTER 2	MARINE INVERTEBRATES	91
CHAPTER 3	MARINE ENDANGERED SPECIES	192
CHAPTER 4	MARINE HABITAT AND ECOLOGICAL PROCESSES	241
CHAPTER 5	MARINE PLANTS	324
CHAPTER 6	LAWS AND POLICIES	492
CHAPTER 7	GEOGRAPHIC INFORMATION SYSTEM (GIS)	572
CHAPTER 8	SOCIAL AND ECONOMICS	633

PREFACE

It is with great pleasure that I present the Malaysia Marine Ecological Gap Assessment Project, a collaborative effort between the Department of Fisheries Malaysia, specifically through the Fisheries Conservation and Protection Division, and the Universiti Malaysia Terengganu. This initiative, enhanced by the valuable contributions of committed researchers from diverse local universities, underscores a shared dedication to deepening our comprehension of Malaysia's marine ecosystems and biodiversity.

The primary objective of this project is to meticulously compile and analyze scientific information and data on marine ecosystems and biodiversity in Malaysian waters. We have endeavored to assimilate findings from diverse sources, including researchers from Higher Education Institutions, Research Institutes, NGOs, government agencies, and other stakeholders.

Acknowledging the growing interest and exploration of marine studies and research at both global and national levels, the Department recognizes the crucial role of scientific information in improving the effectiveness of managing ocean resources. This endeavor aligns seamlessly with the global initiatives set forth by the United Nations through The United Nations Decade of Ocean Science for Sustainable Development (2021-2030). The shared commitment to generating global ocean science knowledge underscores the significance of collaboration among nations, presenting a golden opportunity for collective efforts toward sustainable ocean development.

The comprehensive nature of this project is reflected in its successful compilation of marine field information spanning eight crucial categories: coral reefs, marine invertebrates, endangered marine species, marine ecological habitats and processes, marine plants, marine policy and legislation, GIS, and socio-economics. Beyond this invaluable compilation, our focus extends to the critical analysis of information gaps. This examination serves a dual purpose—providing essential insights into the marine landscape while guiding future research endeavors for the Department, academia, and other stakeholders.

The ultimate aim of the Malaysia Marine Ecological Gap Assessment Project is to produce a comprehensive document that stands as a reference for various stakeholders involved in biodiversity resources and marine ecosystems in Malaysia. This document holds the potential to become a national reference, guiding efforts in biodiversity conservation and sustainable marine resource utilization. As we strive toward the shared goal of sustainable development, it is our hope that this document will serve as a cornerstone for informed decision-making, shaping the future of our nation's marine ecosystems.

Dato' Adnan bin Hussain
Director General
Department of Fisheries Malaysia
2023

EXECUTIVE SUMMARY

CORAL REEF AND FISHES

The ocean, comprising over 90% of Earth's habitable space, is vital for global biodiversity, generating half of the world's oxygen and absorbing 26% of annual anthropogenic carbon dioxide emissions. Despite covering 70% of Earth's surface, coral reefs, known as the "rainforests of the sea," occupy less than 0.1% of the world's ocean but support 25% of its fish species. Coral reefs serve as essential habitats, providing shelter, breeding grounds, and protection for marine life while playing a crucial role in maintaining the health and functionality of the planet. The 2021 report from the Global Coral Reef Monitoring Network, compiled by Souter et al. (2021), based on nearly 2 million observations from 73 countries spanning 40 years (1978–2019), reveals a significant decline in global average coral cover from 32.5% to 28.8% between 2009 and 2018, representing a loss of 13.5% of the world's hard coral, equivalent to approximately 11,700 km2. Similarly, global fish stocks have declined to 64.6% in 2019 from 90% in 1974, primarily due to overfishing, leading to adverse effects on marine environments and jeopardizing the livelihoods of billions of people who rely on fish as a crucial protein source. Malaysia's coral reefs, spanning approximately 3,600 km2 in coastal waters, particularly in Sabah and Sarawak, as well as the eastern coast of Peninsular Malaysia, exhibit the highest diversity of coral species in Eastern Malaysia (>550 species) compared to Peninsular Malaysia (>360 species), with a 47.83% live coral cover reported in 2022, suggesting a potential positive impact from reduced tourism activities during the COVID-19 pandemic. From 1984 to 2022, studies on Malaysian coral reefs were initially low before 2000, gradually increasing with fluctuations, peaking at 17 publications in 2016 covering various regions, and experiencing a temporary decline in the following two years before resuming an upward trend. Sabah recorded the highest number of studies carried out throughout the years (n=56; 25.81%), followed by Terengganu (n=42; 19.35%) and Pahang (n=31; 14.29%). Out of 227 publications, only 68 of them have reported lists of coral species at each study site. A total of 572 species of hard corals belonging to 25 families were documented across Malaysian coastal waters, with Acroporidae being the most abundant family (27.48%), followed by Merulinidae (21.16%) and Fungiidae (9.71%). Flabellidae and Tubiporidae were recorded with the lowest abundance (0.06%). The family Acroporidae, comprising seven genera, with Acropora being the most abundant (57.16%) followed by Montipora (31.10%), was consistently present and prevalent across all study sites. While there has been extensive documentation on the composition of hard corals in Malaysia, reported occurrences of soft corals and octocorals have been very limited. To date, we have found only two publications providing a species list of soft corals in Malaysia, with Penang recording 3 species and Johor recording 6 species. From this study, 586 coral species were assessed for the IUCN Red List, with only 76 species categorized as Not Evaluated. Among them, 25 species were listed as Data Deficient (DD), 193 as Least Concern (LC), and 138 as Near Threatened (NT). It is alarming that 154 species are threatened, including 142 species classified as Vulnerable, 10 as Endangered, and 2 as Critically Endangered. Of the 52 reviewed publications on Malaysian fishes, the earliest study by Ambak et al. (1986) focused on Lizard Fish growth characteristics, with publications initially scarce until a

slight increase in 1994, peaking in 2005, followed by a steady decline from 2009 to 2014. In terms of state, Terengganu recorded the most studies published (n=20; 28.57%), followed by Kedah (n=15; 21.43%) and Johor (n=8; 11.43%). The least studies were recorded in Selangor, Melaka and Kelantan (n=1; 1.43%). A total of 1065 fish species were documented in Malaysian waters across all 52 reviewed publications, comprising two classes: Actinopteri (1042 species; 97.84%) and Elasmobranchii (23 species; 2.16%). The most prevalent group, Actinopteri, included 111 families, with the largest family being Pomacentridae with 110 species (10.56%), followed by Labridae with 87 species (8.35%). Seven of the fishes are listed as IUCN Endangered species and one listed as Critically Endangered. There are several knowledge gaps identified in this study. First, there is an insufficient inventory of coral reefs at the species level, with many studies reporting family names instead of specific species, complicating the evaluation process for endemic, endangered, and ecologically resilient species. Second, there is a lack of continuous or long-term monitoring of benthic covers and changes in coral reef structures, emphasizing the importance of referencing videos and photos, particularly using quadrat and transect methods at tourist attraction sites, for effective long-term monitoring. Third, there is a scarcity of long-term data collection on crucial physical parameters of the waters, such as seawater temperature, turbidity, chlorophyll concentration, and nutrient levels, which are essential for a comprehensive understanding and management of these delicate ecosystems. Then, there is a scarcity of data or studies on the connectivity between coral reefs, both within Marine Protected Areas (MPAs) and among MPAs. Also, there is a significant gap in coral reef studies regarding the effects of the monsoon season on biological responses and survivability, as well as a lack of data on areas not designated as MPAs, including coastlines and fisheries intended areas. Lastly, there were fewer research and publications in well-known areas such as Pulau Pangkor, Melaka, and Pulau Perak, which may be attributed to a shortage of taxonomists for fish and coral reefs. This investigation delineates several knowledge gaps within the field: an inadequacy in the species-level inventory of coral reefs, constrained long-term monitoring of benthic covers and coral structures, a paucity of sustained data concerning pivotal water parameters, an absence of insights into coral reef connectivity both intra- and inter-Marine Protected Areas, and a notable deficit in comprehending the repercussions of the monsoon season on coral ecosystems. Furthermore, there exists a shortage of scientific research and publications in renowned regions, potentially attributable to a scarcity of taxonomists specializing in the study of fish and coral reefs.

MARINE INVERTEBRATES

Marine invertebrate communities are highly diverse and mainly found in the soft-bottom substrates. They are vital as ecological indicators and are important elements in marine food web. Previous studies on marine invertebrates in Malaysia were mostly fragmented and scattered across agencies and research institutes. The present study will therefore bridge the gap of knowledge and will provide the scientific evidence of number and diversity of marine invertebrate fauna available in Malaysian waters. The outcomes of this research will also lead to the precise decision making by the policymakers including proposing new areas to gazetted as MPAs. This study is based on secondary data collected from published and unpublished of previous works, from various sources. All

sources related to marine invertebrates (with the main focus on macrobenthos) were gathered and later screened according to the suitability of the present study. There was a total of 148 documents collected. The highest number of studies were recorded in 2014 with a total of 14 publications, but in later years it was recorded a steady decrease until 2022. Terengganu contributed to the highest percentage of marine invertebrate studies (n=37; 21.64%), followed by Johor (n=26; 15.20%). The dominance of Terengganu in terms of the most studied state is mainly contributed by a public university with a niche area focusing on fisheries and marine resources; both of which are related to marine invertebrates. The coastal water recorded the highest percentage of marine invertebrate studies (n= 38, 23.75%), followed by mangrove (n= 33, 20.63%). Taxonomically, Arthropoda recorded the highest percentage of abundance (n=25338; 43.22%), followed by Mollusca (n=17416; 29.70%) and Echinodermata (n= 8423; 14.37%). Findings from the present study showed that discrepancies of taxonomic levels across studies impaired the opportunity to directly compare data between habitats and areas. In relation to the potential Marine Protected Areas, the present study proposes Setiu Wetlands, Merchang, Punang-Sari, Merambong Shoal, Tanjung Adang Shoal and Pulau Gazumbo as the suitable candidates considering several factors including high diversity and the increase rate of human intervention. Finally, in order to precisely evaluate the status of marine invertebrates in Malaysia, it is recommended a holistic study to be carried out collaboratively to record the data at different areas, different types of habitats and on consistent taxonomic levels. This will provide a thorough information for a better management of the marine ecosystems.

MARINE ENDANGERED SPECIES

The focal marine endangered species (MES) in this report is the Dugong (Sirenians), marine mammals such as dolphin and whales (Cetaceans), sea turtles (Chelonians), sharks and rays (Chondrichthyans), and as well as giant clams (Tridacnidae). All these five genera are registered as either endangered or vulnerable under the IUCN Red List and listed as protected species under the Malaysian Department of Fisheries. Twenty-nine marine mammal species, including Dugong, were confirmed to be straddling Malaysian. They face threats such as fish bycatch, diminishing fish stocks and habitats caused by pollution or illegal trawling, and behavioral disturbance by heavy tourism vessels, which may unsustainably reduce their numbers. Meanwhile, out of seven species of turtles identified globally, four have been found to nest and present in Malaysian waters. They are the green turtles (*Chelonia mydas*), leatherback turtles (*Dermochelys coriacea*), hawksbill turtles (*Eretmochelys imbricate*), and the olive ridleys (*Lepidochelys olivacea*). The threats to the sea turtle nationwide include traditional consumption and trading of eggs, accidental catch, irresponsible tourism, light pollution, and loss of nesting sites due to coastal development. Only the green turtles show a stable population throughout Malaysia, while other species, such as leatherbacks, hawksbills, and olive ridleys, have drastically declined in the last few decades. Sharks, as apex predators, are essential for maintaining marine ecosystem health. They contribute significantly to both fishing and tourism industries globally. Robust monitoring and research efforts, including advanced technologies like satellite tagging and genetic analysis, provide critical data for shark conservation. International collaboration is imperative because sharks are highly migratory, and addressing the

illegal shark fin trade requires coordinated global efforts. Reducing the demand for shark products, raising awareness about sustainable practices, and advocating for comprehensive conservation policies are paramount steps in the conservation of sharks. This report aims to record, document, and analyze marine mammal and sea turtle information/data from previous studies in Malaysian waters to be translated into a comprehensive inventory report, including the production of geospatial maps of the distribution of marine endangered species. Information gaps and the need for further research will be analyzed on marine mammals and sea turtles to obtain additional information to ensure that they represent areas of interest to be protected more comprehensively. It is hoped that by the end of this study, the areas that have the potential to be protected as Marine Protected Areas (MPA) for marine mammals and sea turtles with the creation of maritime ecological corridors will be identified.

MARINE HABITAT AND ECOLOGICAL PROCESSES

Ecology, the science of understanding organism-environment relations, plays a pivotal role in marine ecosystem management. Essential ecological principles—such as species diversity, ecological processes, and habitat connectivity—are critical for effective marine spatial planning (MSP). This report delves into the ecological dynamics of Malaysian waters, aiming to identify knowledge gaps, prioritize critical habitats, and recommend future research directions. The oceans, vast and complex, harbor poorly understood ecosystems. Biological events, like spawning, are sensitive to environmental changes, and anthropogenic threats can disrupt ecosystems, making them susceptible to perturbations. This study focuses on ecological processes specific to marine ecosystems, anticipating ongoing changes in the coming decades. The objectives of this study are: 1) to identify data and information gaps in describing marine habitats and ecological processes in Malaysian waters; and 2) to highlight critical marine habitats and associated ecological processes for future research directions. A comprehensive review of 434 papers from 1981 to 2022 was conducted, encompassing habitat location, oceanography, threats, and more. The study covers all Malaysian states, including Labuan, with coordinates recorded based on available latitude and longitude or nearest spatial references. In general, marine ecological studies in Malaysia are divided into six indicators: biological community structure, population dynamics, threats and pollution, attributes of ecological processes, trophic dynamics, and seascape/connectivity studies. The majority of research falls under community structure, population dynamics, threats, and ecological attributes. Detailed ecological processes at different marine habitats have been listed in Table 1 of the report. In general, several recommendations have been suggested for future research, namely: 1) strategically plan future research to address diverse areas lacking in current understanding, preparing for increasing climate change threats; 2) prioritize studies on coastal and marine habitat profiles to comprehend essential ecological processes and optimize ecosystem functioning; 3) adopt an integrated ecological approach, utilizing scientific criteria to identify ecologically significant marine areas for protection; and 4) emphasize trophic dynamics studies to better understand food web dynamics, incorporating advanced techniques like fatty acid profiles and stable isotope analysis. This report provides a comprehensive overview of the state of marine habitat and ecological processes in Malaysian waters. The identified research gaps and recommendations guide proactive species and habitat

management, emphasizing the need for strategic research planning and integrated ecological approaches to safeguard Malaysia's marine ecosystems in the face of evolving threats. The accompanying GIS maps offer a visual representation of the study's primary findings.

MARINE PLANTS

Marine plants, including microalgae, seaweed, seagrasses, and mangroves are a diverse and widespread group of photosynthetic organisms. They can be found in almost all aquatic environments, from marine to brackish and freshwater areas. Microalgae, seaweeds, seagrass and mangroves are essential components of coastal marine ecosystems and play a significant role as primary producers, providing food, habitat structure, breeding grounds, and shelter for many coastal organisms. The effects of human activities, such as beach grooming, coastal erosion, and sea-level rise on coastal, estuarine and open ocean habitats will influence the diversity, abundance and distribution of these marine plants. Biodiversity studies of tropical microalgae, seaweeds, seagrass and mangroves are currently gaining attention. However, more efforts are needed to understand its status. The previous data on the biodiversity of seaweeds in the Straits of Malacca was reported by Phang et al. (2008; 2005) on the marine algae of Pulau Jarak, Sembilan Group of Islands and Pulau Perak. As reported in 2006, by Phang et al. (2006), the recorded marine algae in Malaysia comprise 381 taxa with 105 taxa from Chlorophyta, 186 taxa from Rhodophyta, 73 taxa from Phaeophyta and 17 taxa from Cyanophyta. However, based on a preliminary literature search, there are duration gaps and a lack of overall data and related information on the actual status of diversity and distribution of marine plants in Peninsular Malaysia, Sabah and Sarawak to date. Therefore, data collected from this desktop study, gather the latest data and related information on the diversity and distribution of marine plants in Malaysia. Microalgae, seaweeds, seagrass and mangroves are critical components of marine biodiversity and play vital roles in ecosystem function, yet many species are vulnerable to global environmental change and anthropogenic impacts. Understanding how such impacts have affected the diversity and distribution patterns of marine plants will facilitate predictions of how marine plants will respond to ongoing global environmental change, and thus inform management and conservation strategies.

LAWS AND POLICIES

Marine biodiversity comprises of enormous interlinked marine ecosystems, which establish an interconnecting web of marine living resources and their habitats. Marine and coastal ecosystems are sensitive to human activities, and conservation of marine and coastal biodiversity requires the protection of a wide range of environmental components. It has been widely recognized that links between science and coastal management could be strengthened by improving the capacity for decision-making by considering scientific data. There have been several issues raised in past studies on marine biodiversity, resources and health in Malaysian waters. Coral reefs and fisheries habitat have been under stress due to excessive human pressure through tourism activities despite strict enforcement of fishing rules in the marine protected areas, where

the human activities are regulated. The matter might worsen in unprotected marine areas where there are sensitive ecosystems or areas that haven identified as ecologically or biodiversity sensitive areas (EBSAs) but have yet to be designated as protected areas. Other than that, IUU Fishing undermines national and regional efforts to manage fisheries sustainably and to conserve marine biodiversity. IUU fishing activities have negative impacts on the sustainability of marine resources and caused fish stocks to decline. With very limited regional enforcement bodies and the absence of a regional multilateral agreement, IUU fishing is difficult to overcome and eventually will affect the global fish stocks and national economy. This study was carried out with two objectives namely: (i) to record, document, and analyze data on the policies and legislation related to marine biodiversity and other related data from previous studies in Malaysian waters, which are to be translated into a comprehensive inventory report; and (ii) to analyze the information gap and further research requirements to obtain additional information to ensure it represents the area of interest to be protected more thoroughly. The research approach adopted were content analysis on data collected on marine biodiversity-related legislations, policies, action plans, regulations, and literatures collected from local, regional, and international database. The results from the research are divided into three main parts: (i) Protection of the marine environment and biodiversity; (ii) Addressing IUU Fishing; and (iii) Ecosystem-based management approach to protect our marine biodiversity. The gaps in the Malaysian marine environmental governance framework are subsequently identified where six gaps are highlighted i.e.: (i) The division of power in marine environmental protection; (ii) Sectorial and outdated domestic legal framework on marine environmental protection; (iii) Lack of spatial management consideration in marine protection efforts; (iv) Lack of local participation in MPAs management; (v) Failure to adopt and comply Ecotourism Guidelines; and (vi) Gaps in marine conservation in unprotected areas. This is followed by four recommendations namely: (i) Shifting to co-management in MPA designation and management; (ii) Adoption and implementation of Marine Spatial Planning; (iii) Strengthening MPAs and other islands management in line with Ecotourism Guidelines; and (iv) Mainstreaming food security in marine biodiversity conservation. This report concludes by reiterating the importance of abiding by the recommendations afore-mentioned in order to safeguard our marine biodiversity from further loss.

GEOGRAPHIC INFORMATION SYSTEM (GIS)

The utilization of Geographic Information System (GIS) within the framework of the "Projek Pengumpulan Data/Maklumat Ekosistem Dan Biodiversiti Marin Di Perairan Malaysia" project has yielded significant advancements in data acquisition, synthesis, and representation. This comprehensive endeavor, designed to enhance our comprehension of marine ecosystems and biodiversity, has successfully integrated a multitude of GIS layers spanning various categories. The project's foundational Basemap layers consist of essential cartographic elements including Bathymetry, Shoreline demarcations, Malaysia's Exclusive Economic Zone (EEZ), Peninsular Malaysia and Labuan Landuse data, and delineations of Coastal zone limits both on land and sea. These Basemap layers provide the spatial context necessary for more intricate analyses. Furthermore, the project's Marine Ecosystem and Biodiversity layers, totaling 28 in

number, encompass an array of vital components. These layers encapsulate comprehensive insights into Coral Reefs, Fish populations, Marine Invertebrates, Marine Habitats, Total Abundance and Species count of Marine Invertebrates, Dominant Species, Red List species, methodological approaches, as well as Abundance and Percentage distribution of Marine Invertebrates. Additionally, the GIS layers expound upon the frequency and locations of Marine Organism sightings, with differentiating categories for sightings at Universiti Malaysia Terengganu (UMT) and beyond. Quantitative data on the number of individuals within both UMT and Non-UMT locations are detailed. The layers also delve into aspects of Marine Habitat and Ecological Processes, Ecological Field of Study, Species of Concern, Mangrove Habitats including coverage area, threats, and height parameters. Marine Seaweed, Microalgae, and Seagrass also find representation among these layers. The GIS layers collaboratively constitute an invaluable resource for researchers, policymakers, and stakeholders, furnishing a profound understanding of Malaysia's maritime domains. The GIS-driven approach aids in the synthesis of diverse data streams, fostering a holistic comprehension of marine environments and the biodiversity they harbor.

SOCIAL AND ECONOMICS

Coastal areas worldwide are dynamic ecosystems situated at the crossroads of terrestrial, marine, and freshwater systems. Roughly 2.4 billion people, constituting 40% of the global population, inhabit these coastal regions. Malaysia is no exception to this trend, as a Southeast Asian country where approximately 70 percent of its population resides in coastal zones. The majority of communities within Malaysia's coastal areas comprise fishermen and farmers who have called this region their permanent home for over 15 years. Throughout its history, Malaysia has harnessed its seas and oceans as sources of wealth, opportunity, and abundance. The nation boasts some of Southeast Asia's most significant marine resources and coral reefs. These marine and coastal ecosystems provide an array of services that benefit human populations, and the richness of marine resources has solidified Malaysia's reputation as a favoured tourist destination among international visitors and elevated the quality of life for local coastal communities. Therefore, this report assumes the role of a comprehensive Malaysian marine ecological gap assessment within the socio-economic scope. The survey data from 2010 uncovers significant demographic attributes: citizenship, ethnicity, gender, age, and education. The majority (89.8%) of the population are Malaysian citizens, while non-citizens account for 10.2%. Predominant ethnic groups are Malays and Bumiputera (70.6%), followed by Chinese (24.6%), Indians (4%), and others (0.8%). Gender distribution is nearly equal, with 51% male and 49% female. In 2010, 91% of Malaysian coastal and island residents held formal education backgrounds: 28% at primary level, 48% at secondary level, and 15% at tertiary level. The remaining 9% had no formal education. Moreover, the 2010 survey on socio-economic activities reveals that Service Workers and Sales comprised the highest employment category (22%), followed by Craft and Related Trades Workers (12%), Elementary Occupation (11%), and Plant and Machine-operators and Assemblers (11%). 7% were classified under Unknown jobs. In terms of industries, Manufacturing led with 17.98%, followed by Wholesale and Retail Trade (Motor Vehicle and Motorcycles Repair) at 15.74%, and Agriculture, Forestry, and Fishing at 13.34%. Additionally, coastal and island communities engage in agro-tourism

activities, including restaurants (Medan Ikan Bakar), accommodation (chalets), and Sportfishing. Moreover, derived from desktop literature surveys, demographic data from 61 selected papers predominantly highlight communities aged 15 to 70 as respondents for surveys, discussions, and interviews. Additionally, a significant portion of papers included children as respondents. Most of these articles concentrate on health, coastal hazards, and social and economic aspects. Besides, the desktop literature surveys yielded a total of 108 articles on the social and economic activities of coastal and island communities in Malaysia. An analysis of these articles reveals that the socioeconomic activities of most coastal communities center around marine sectors, such as tourism, fishing, agriculture, and manufacturing, which constitute their primary sources of monthly income. Nonetheless, the desktop literature survey yielded 26 articles dedicated to the economic evaluation of marine biodiversity resources. It is worth noting that the majority of these papers predominantly concentrate on assessing the economic value of mainland socio-economic resources in comparison to the evaluation of marine resources. Section 5 addresses the gaps identified in existing literature by compiling the viewpoints of various authors. These gaps have been categorized into three main areas: humankind, the economy, and the environment. Within the humankind category, three distinct subtopics have been identified: lifestyle, skills and knowledge, and health or disease, each of which is frequently discussed by authors. Under the economy category, arguments revolve around subtopics such as socioeconomics, tourism, fisheries, and telecommunications. Within the environmental realm, literature commonly focuses on ecosystem, climate change, coastal hazards, waste management, water, and sewage issues. The analysis has yielded three overarching themes and six corresponding sub-themes for this comprehensive discourse. The first theme is "Impacts," under which we delve into the effects on economic, community, environmental, and health aspects within coastal and island areas. This comprehensive examination provides a holistic understanding of the repercussions of various factors on these vital dimensions. The second theme "Awareness/Knowledge/Experience/Conservation/Enforcement/Programs/Approach," encompasses a multifaceted approach. It involves a comprehensive exploration of the actions taken by stakeholders, government agencies, and non-governmental organizations to safeguard the well-being of coastal communities. This includes preventative measures to address health, economic, community, and environmental concerns, thereby ensuring the safety and resilience of coastal areas. Lastly, the theme "Social Problems among Coastal Communities" focuses on the common social issues frequently encountered by coastal communities. By addressing these challenges, we gain insights into the various dynamics that shape the lives of these communities.

INTRODUCTION

Azlan Mohd Noor, Mohd Effendy Abd Wahid, Izarenah Md Repin, Rumeaida Mat Piah

Marine ecosystems, defined as major units of ecological function in the marine environment, comprises of the communities of organisms and their physical, chemical, and geological environment (Grassle, 2013), is an important ecosystem, provide various services to the communities in the world. Seas surrounding Malaysia is one of the largest continental shelf areas in the world contain very productive and diverse habitat (Mazlan et al., 2005).

Threat to biodiversity are varies but most significant are habitat modification and destruction and overharvest of the resources. Mazlan et al., (2005) emphasize that Malaysia's seas should be the center for marine biological research and data collection. Currently, the complete information on the biological diversity, marine ecology, socio-economics and management and policies are still lacking and decentralized. The Department of Fisheries, Malaysia took a significant effort in providing and presenting the information on biological diversity, marine ecology, socio-economics and marine related management and policies. Hence, this project was conducted. This project aims to provide vast information on marine ecosystem and biodiversity of Malaysian waters. Specifically, the objectives of the projects are:

i. To record, documented and analysis of the information and relevant data on biological diversity, marine ecology, socio-economic and management in terms of laws and policy based on previous studies that have been conducted.
ii. This project also aims to carry out gap analysis and identify more information needed in order to further identify the possible area that can be potentially protected as Marine Protected Area.

FOCUS GROUP MEMBERS

To achieve the objectives of the project, eight Focus Group (FG) were created which covers all important aspects of marine ecosystem as in Figure 1. Each Focus Group comprised of the representative from the Department of Fisheries, Malaysia and Universiti Malaysia Terengganu. Members of each Focus Group as in Table 1.

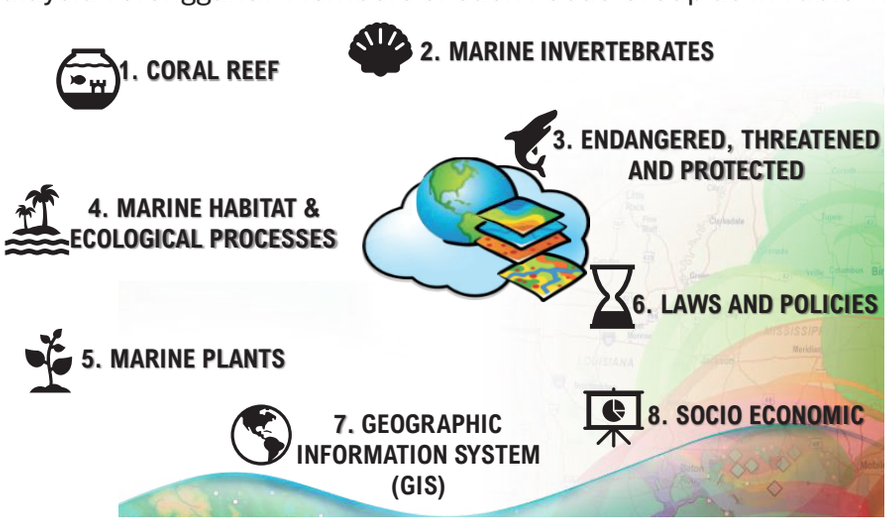


Figure 1. Eight Focus Group

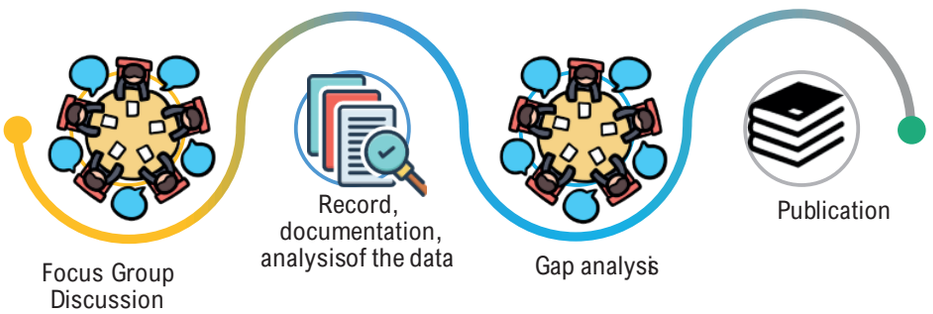
Table 1. Members of each focus group

Focus Group 1: Coral Reef
1. Assoc. Prof. Dr. Tan Chun Hong (UMT)
2. Mr. Yusri Yusuf (UMT)
3. Mr. Zaidnuddin Ilias (FRI)
4. Mr. Md Nizam Ismail (FRI)
5. Mr. Muhammad Faisal Abdul Rahman (UMT)
6. Ms. Puteri Nur Adila Megat Yusop (UMT)
Focus Group 2: Marine Invertebrates
1. Dr. Wan Mohd Rauhan Wan Hussin (UMT)
2. Assoc. Prof. Dr Mohd Hanafi Idris (UMT)
3. Dr. Che Zulkifli Che Ismail (DOF)
4. Ms. Nur Fazne Ibrahim (UMT)
5. Ms. Fatin Sharmimi Muhammad (UMT)
Focus Group 3: Endangered, Threatened and Protected Marine Species
1. Assoc. Prof. Dr. Mohd Uzair Rusli (UMT)
2. Assoc. Prof. Dr. Saifullah Arifin Jaaman @ Sharman (UMT)
3. Dr. Ahmad Ali
4. Mr. Daud Awang (DOF)
5. Mrs. Faizah Ismail (DOF)
6. Mr. Mohd Fathullah Ruslan (DOF)
7. Mr. Muhammad Amirul Siddiq Abd Rashid (DOF)
Focus Group 4: Marine Habitat and Ecological Processes
1. Assoc. Prof. Dr. Maizah Mohd Abdullah (UMT)
2. Prof. Dr. Zainudin Bachok (UMT)
3. Mr. Ryon Siow (DOF)
4. Mr. Abd. Haris Hilmi Ahmad Arshad (DOF)
5. Dr. Nurulafifah Yahya (UMT)
6. Ms. Nur Sanim Azlan (UMT)
Focus Group 5: Marine Plants
1. Dr. Emienour Muzalina Mustafa (UMT)
2. Dr. Siti Mariam Muhammad Nor (UMT)
3. Mrs. Nuridan Abd Han (DOF)
4. Mr. Daud Awang (DOF)
5. Prof. Emeritus Dr Phang Siew Moi (UM)
6. Dr Jillian Ooi Lean Sim (UM)
7. Mr. Tariq Mubarak Husin (FRIM)
8. Dr Siti Aisyah Abdullah
Focus Group 6: Law and Policy
1. Prof. Dr. Wan Izatul Asma Wan Talaat (UMT)
2. Dr. Mohd Safuan Che Din (UMT)
3. Mrs. Izarenah Md Repin (DOF)
4. Mrs. Hemalatha A/P Raja Sekaran (DOF)
5. Mrs. Nurashikin Salihudin (DOF)
Focus Group 7: Geographic Information System (GIS)
1. Mr. Idham bin Khalil (UMT)
2. Prof. Dr. Aidy @ Mohamed Shawal Bin M Muslim (UMT)
3. Mr. Mohd Nasir Mohamad (UMT)
4. Mrs. Eleanor Daniella binti Lokman (DOF)
5. Dr. Hadzley bin Harith (DOF)

Focus Group 8: Socio-economics
1. Prof. Dr. Nur Azura Sanusi (UMT) 2. Dr. Nazli Aziz (UMT) 3. Mrs. Norhanida Daud (DOF) 4. Ms Yogeswary Segar (UMT) 5. Mr. Mohd Fikri Mohamad (UMT)

*FRI represent Fisheries Research Institute, DoF

SCOPE OF THE PROJECT



1. **DESKTOP STUDY**
   This project was conducted based on the collection and derivation of the data from all available resources. Collection of the data and inventory of marine organisms and habitat based on the studies and publications available. Each Focus Group conducted a few Focus Group Discussions where the information obtained from various resources were analysed.

2. **DATA ANALYSIS AND MAPPING**
   The information obtain from the secondary data was analysed. Gap analysis was conducted to identify biodiversity (i.e., species, ecosystem and ecological processes) that are not adequately conserved within a protected area network or through other effective and long-term conservation measures

3. **WORKSHOP AND PUBLICATION**
   Throughout this project, a few meetings and workshops have been conducted. An online progress presentation was conducted on the 12 April 2022 through Cisco Webex, which attended by personnels from the Department of Fisheries. During this workshop preliminary findings were presented and the challenges faced by all members were discussed. Second Progress Presentation was conducted physically to the Department of Fisheries, Malaysia on the 22rd April 2022.

   Workshop for Progress Presentation with the Department of Fisheries, stakeholders and researchers from other universities in Malaysia was conducted through Cisco Webex online meeting on the 23rd June 2022. Among participants attended this online workshop were from Universiti Malaysia Sabah, WWF and Ministry of Energy and Natural Resources (KETSA). Some findings were presented and the team members received some suggestions and comments for improvement.

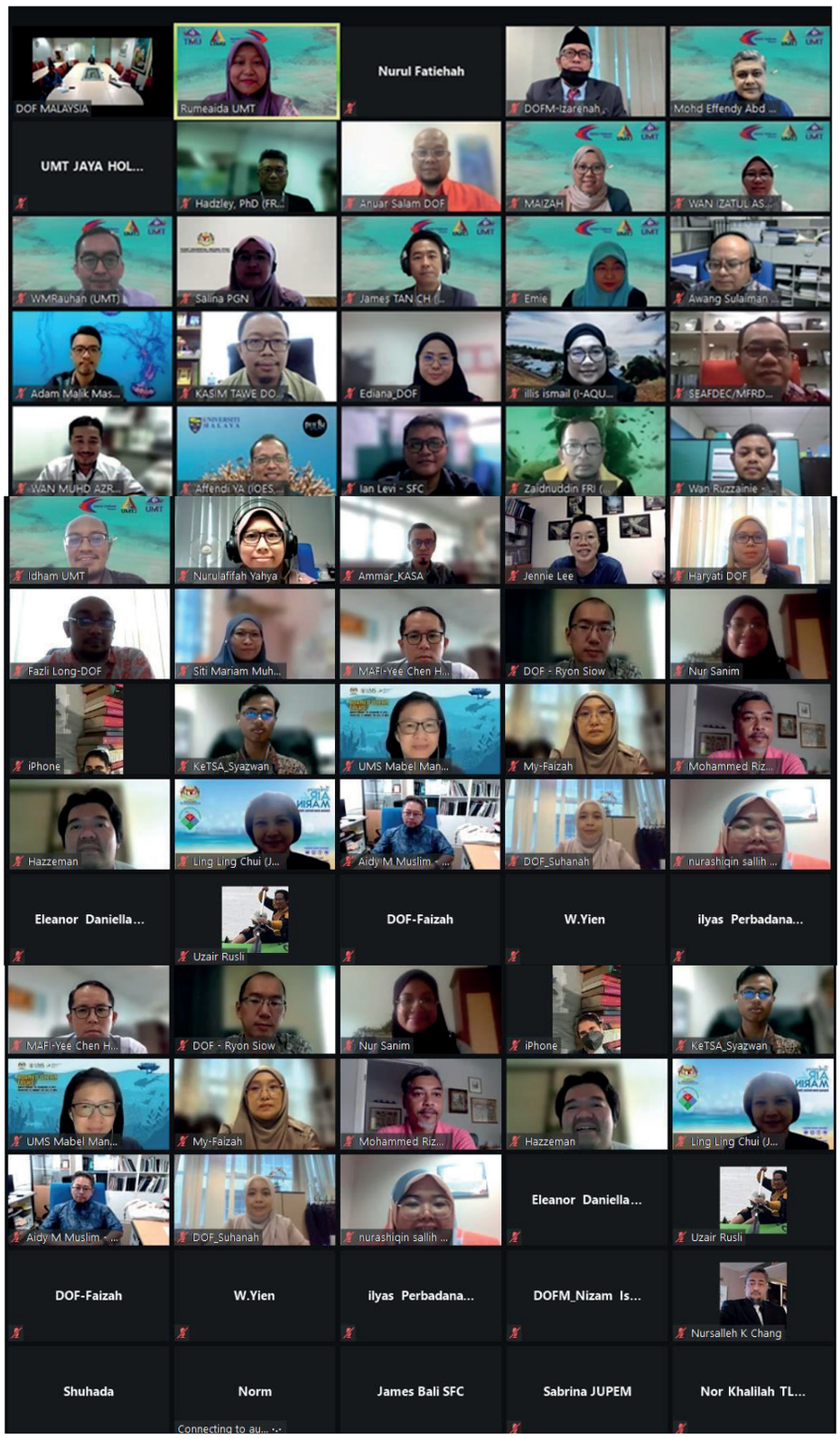


Figure 2. Some of the participants for online progress presentation conducted on the 23rd June 2022 through Cisco Webex.

Workshop for Presentation of Final Report was conducted on the 1st September 2022, in Putrajaya. During this workshop, the findings were presented and discussed.

From all the information obtain, an extensive and comprehensive report was meticulously presented including a geospatial map of marine resources. Chapter 1-8 of this report covers the abundance and diversity of hard corals and coral reef fish population; the abundance, richness and distribution of marine invertebrates; status review on habitats, threats and conservation initiatives in Malaysia for endangered, threatened and protected marine species; list of critical marine habitats and the associated ecological processes, and suggestion of future research direction for marine ecological studies in Malaysian waters; diversity and distribution of marine plants including microalgae, seaweed, seagrass and mangroves including the production of geospatial maps of marine plant resources; inputs for proposal on a special committee to plan, manage and control all aspects of marine biodiversity in Malaysian water and inputs for proposal for a Management Plan and information on demographics of coastal and island and socioeconomics of population in Malaysia.

This comprehensive document prepared by committed researchers from Universiti Malaysia Terengganu and the Department of Fisheries will serve as an important reference for various information to achieve the management and conservation goals of marine ecosystems in Malaysia.

CHAPTER 1

CORAL REEFS AND FISHES

Tan Chun Hong
Zaidnuddin Ilias
Md Nizam bin Ismail
Muhammad Faisal Abd. Rahman
Puteri Nur Adila Megat Yusop

1.0 INTRODUCTION

Over 90% of the habitable space on the planet were established by the ocean, where it acts as one of the main repositories for the world's biodiversity. Both the ocean and the life within are important to ensuring the planet's healthy functionality, supplying about half of the oxygen we breathe[1] and absorbing about 26% of the anthropogenic carbon dioxide released into the atmosphere annually[2]. Although the oceans covered about 70% of the earth's surface, yet less than 0.1% of the world's ocean is covered by coral reefs.

Coral reefs are often called the "rainforests of the sea" because of the diversity of life found. About 25% of the ocean's fish depended on the healthy coral reefs. Coral reefs also acts as shelter, nursery and breeding grounds for fishes and many other marine organisms. The abundance of marine life that depends on the coral reefs also makes it a feeding ground for this marine life. It also protects the coastlines from erosion and storms.

A detailed report on global status of coral reef was published in 2021 by Global Coral Reef Monitoring Network (GCRMN). These monitoring reports were compiled comprehensively by Souter et al. (2021)[294] from almost 2 million observations from 73 countries during the last 40 years (1978 – 2019). Up until the year 1997, global average of coral cover was high and stable (32.1% – 32.5%) before the first global-scale of mass coral bleaching event in 1998. Consequently, the global average coral cover declined (32.5% - 30%) within 5 years. It is not until the year 2002 - 2009 that the global average coral cover returned to pre-1998 level (33.3%). Unfortunately, the global average coral cover went downward since 2009 until 2018, declining to 28.8%. This represents a loss of 13.5% of the world's hard coral, equating to about 11, 700 km^2 of coral.

Malaysia's coral reefs were estimated to cover around 3,600 km^2 of the coastal waters, mainly in Sabah and Sarawak, as well as the eastern coast of Peninsular Malaysia. Eastern Malaysia (Sabah, Sarawak) estimated the highest diversity of coral species (>550 species) compared to the Peninsular Malaysia (>360 species)[295]. According to the report published by Reef Check Malaysia in 2022[296], the coral in the waters of Malaysia are in 'Fair' condition with a total of 47.83% of coverage. This indicates the further increase of live coral cover from previous years of 2020 (41.32%) and 2021 (44.26%) may have resulted from the reduction of impacts and disturbances through tourism activities due to movement restrictions during the global pandemic of COVID-19[296].

On the other hand, fish are a key component of marine biotic communities. They are completely related to other organisms through the food web and other mechanisms. As the principal link between the primary and secondary producers and apex species, they often constitute important dietary or ecological components for terrestrial-oriented species. Over the years, global fish stocks continued to decline due to over-exploitation. Based on assessment from Food and Agriculture Organization (FAO), the fraction of fishery stocks has decreased to 64.6% (2019), compared to the year 1974 (90%)[297].

One of the factors for the declining of fish stocks are overfishing. Overfishing is defined as when the fishes were caught faster than the stocks were able to replenish. The damages caused through overfishing goes beyond the marine environment, where billions of people around the world rely on fish as a source of protein and also as the

principal livelihood. As a result, it changes the size of fish remaining, as well as how they reproduce and their maturity rate. An imbalance in the marine food web were bound to occur when to many fish were harvested out of the ocean, leading to loss of other important marine life, including vulnerable species such as sea turtles and corals[298].

Unfortunately, these ecosystems were continuously threatened severely by human activities. Pollutions, unsustainable fishing activities and climate change have driven the percentage of coral cover downhill over the years. Rising ocean temperatures and ocean acidification stresses the corals, leading to coral bleaching and causing physical damage to these delicate ecosystems. Hence, it is of the utmost importance for us to restore the coral reef ecosystems through sustainable management by identifying and documenting the status of our coral reefs.

2.0 OBJECTIVES

1. To record, document and analyse information on biodiversity, marine ecology, socio-economy and management from previous researches in Malaysia to be translated into a comprehensive inventory report, including geospatial mapping.
2. Analysing the information gap and the needs for further research to obtain additional information that encompasses important areas to be protected.
3. Identifying potential areas to be protected as Marine Protected Area (MPA) by establishing corridor of marine ecology.

3.0 METHODOLOGY

Data was extracted from existing publication of journals, books, proceedings and reports. Data such as live coral covers and species reported were documented and compiled from a total of 227 publications reviewed. The data were recorded from 1984 – 2022, located across all state in Malaysia. Details such as coordinates, sampling site species list, reef type and status were properly documented.

While not all references were presented with coordinate data, only those with complete set of coordinates were taken into account for the production of geospatial mapping. For studies with ranges of coordinates, only two points (end to end) were taken into consideration. All coordinates were standardised into decimal degrees (DD) format and were plotted into geospatial mapping using ArcGIS software.

Species list extracted from the existing publications were properly documented and was cross checked with the latest taxonomy classifications according to World Register of Marine Species (WoRMS). Synonymised or unaccepted species names were noted alongside the accepted names.

4.0 RESULTS/DATA ANALYSIS

4.1 Publications on coral reef

Throughout the years (1984 – 2022), we can see that the number of studies on coral reefs in Malaysia were low before the year 2000 with only 1 or 2 publications annually. Later on, the number of studies were steadily increasing with several fluctuations. The highest number of publications was recorded in the year 2016 with 17 publications. During this year, the publications covered the east coast of Peninsular Malaysia, Sabah, Sarawak and also Negeri Sembilan and Kedah (west coast of Peninsular Malaysia). Subsequently in the following two years, the number of publications dropped to 11 before increasing in the later years.

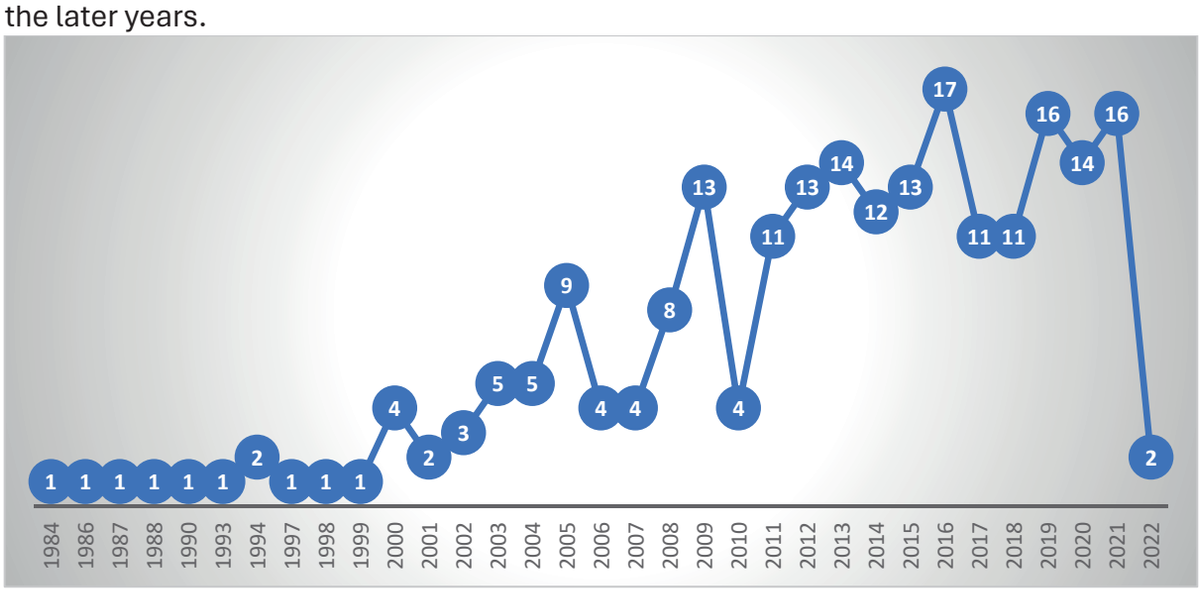


Figure 1. Number of coral reef studies in Malaysia by year.

Figure 2 shows the number of publications on coral reef in different states across Malaysia. Sabah recorded the highest number of studies carried out throughout the years (n=56; 25.81%), followed by Terengganu (n=42; 19.35%) and Pahang (n=31; 14.29%). Lowest number of studies were recorded in Kelantan and Selangor (n=1; 0.46%). To sum up, almost half of the states in Malaysia (Sabah, Terengganu, Pahang, Kedah, Sarawak and Johor) recorded more than 10 publications, and these are the states with notable dive sites with ranges of coral reefs biodiversity.

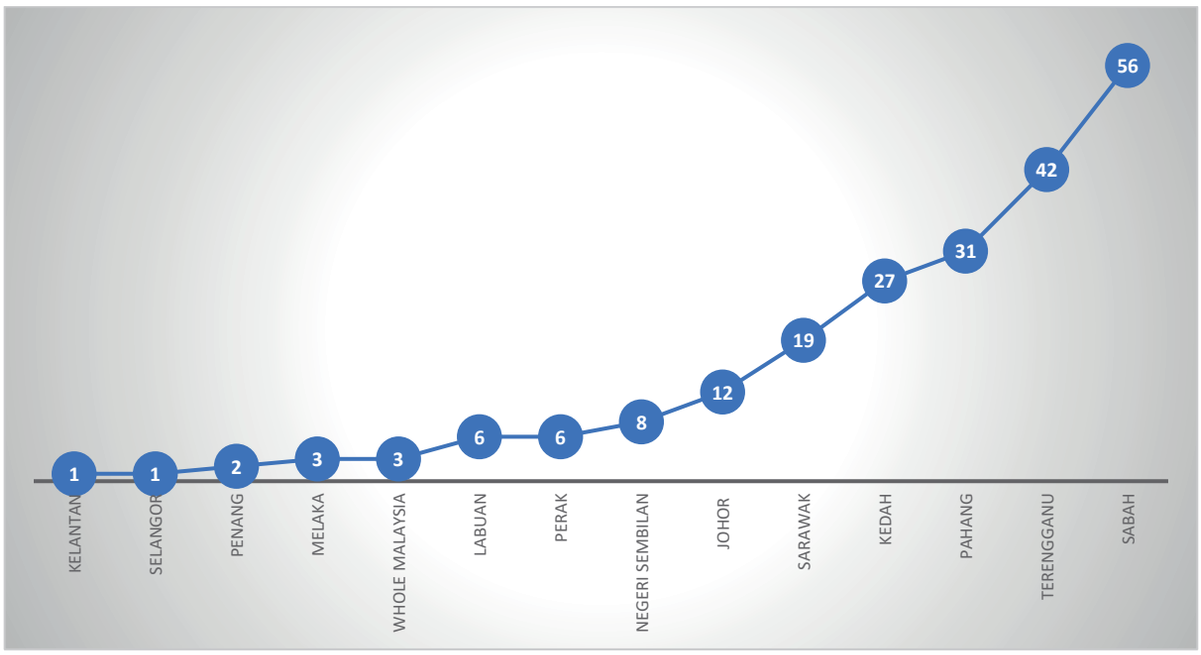


Figure 2. Number of publications on coral reef in Malaysia by state.

With an official record of 394 islands, it is not surprising that Sabah recorded the highest number of publications. Most of the studies carried out in Sabah were carried out by the Borneo Marine Research Institute (BMRI) and Reef Check Malaysia. Ever since Universiti Malaysia Sabah (UMS) upgraded their research unit in the year 2000, BMRI has made progressive strides in researches relating to marine and aquaculture fields. Aside from the publications by WWF (World Wide Fund for Nature) in 1994, there are no records of publication in Sabah that we found until BMRI collaborated with Institute of Biodiversity and Environmental Conservation of Universiti Malaysia Sarawak (UNIMAS) and published its study titled "The Status of Coral Reefs in Sabah". Since then the number of publications on coral in Sabah is steadily increasing. Reef Check Malaysia whom was registered as NGO in 2007 has also contributed to the publications on coral reefs in Sabah where they are focused on coral reef monitoring annually. Since 2007, Reef Check Malaysia alongside agencies such as Department of Marine Park, Department of Fisheries, Sabah Park, etc. have been steadily carrying out survey on the status of coral reef in Malaysia annually.

Blessed with several islands of fascinating underwater scenery and a vast biodiversity of marine life, Terengganu recorded the second highest number of publications on coral reefs. As Universiti Malaysia Terengganu (UMT) is strategically located in Terengganu and blessed with opportunities granted by the Terengganu state government to set up a research station in Bidong Island, hence 19 out of 42 (45.24%) of publications on coral reefs in Bidong Island, Terengganu were published either solely or in collaborations with UMT. Aside from Bidong Island, islands like Redang (100%) and Perhentian (69%) also recorded high number of studies conducted by several parties such as Fisheries Research Insitute (formerly known as Department of Marine Park), Reef Check Malaysia, UMT and International Islamic University of Malaysia (IIUM).

4.2 Live Coral Cover

From all the publications that were found on coral reef, more than half of the studies have reported the percentage of live coral cover (LCC) in their study area. Figure 3 showed the average percentage of LCC in each states with the trend of every 10 years. LCC in Terengganu have been documented in each of the time period. Percentage of coral cover in Terengganu was categorized as 'Good' in the earliest documented studies (65.20%) before recording a significant reduction in the 90's. Highest However, the percentage of coral cover has slightly increased within the next 20 years and were categorized as 'Fair'. Highest coral cover (88.1%) was recorded at Pulau Perhentian in 2003.

On the contrary, although Sabah have the highest number of publications on coral reefs, there were no record of LCC percentage in the state before the year 2000. In the 2000's, Sabah recorded an average of 41.6% (Fair) of LCC before having a slight reduction in the following years. Meanwhile in Pahang, the first documented LCC was reported during the 80's with 'Fair' condition (26.71%). In the next 10-years period, there was no reported LCC found within any publications. Surprisingly, LCC percentage in Pahang recorded a significant gradual growth from 'Fair' (46.32%) to 'Good' (50.42%). Highest coral cover in both Sabah and Pahang were recorded in 2008 (78.06%, Tun Sakaran Marine Parks) and 2012 (88.06%, Tioman), respectively.

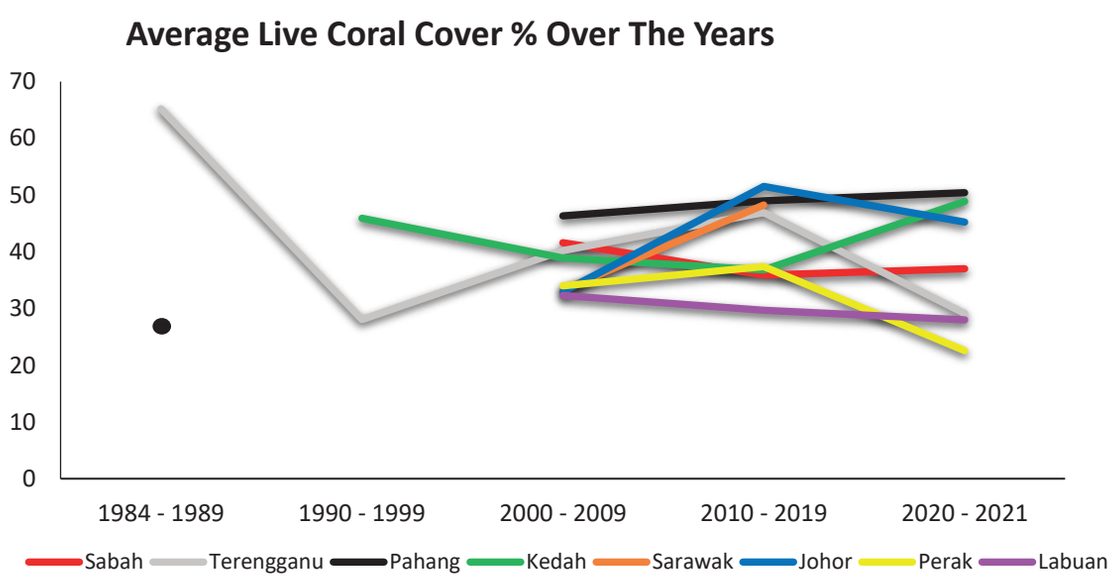


Figure 3. Average of Live Coral Cover in each state over the years.

Table 1: Live Coral Cover index status as categorized by Chou et al. (1994)[3].

Status	Excellent	Good	Fair	Poor
Percentage	>75%	75 – 50 %	50 – 25%	<25%

After reviewing the Fisheries Act 1963, Malaysia has started the gazettements of marine parks in 1994 under the Fisheries Act 1985. A total of 42 islands were gazetted as marine parks, under the jurisdiction of Pulau Tioman Marine Park, Pulau Redang Marine Park, Pulau Payar Marine Park, Mersing Marine Park and Labuan Marine Park[4]. By establishing marine parks, activities that was deemed to threaten the biodiversity of the area are prohibited through the enforcement of law/regulations, resulting in the prohibition of inclusive fishing which were the local's main source of income. Fortunately, transitioning to tourism sector through the establishment of marine parks have indeed made the livelihood of the local's better from the pristine nature attractions available. Nevertheless, these marine parks while they help to maintain the population of most marine life, the coral reefs are still prone to damages from unregulated tourism and water activities such as snorkelling and scuba diving. Intensive trampling over a long period might affect the community level (e.g. reducing cover of branching corals) because they are the most susceptible to breakage[5]. Hawkins & Robert (1993)[6] stated that repeated tissue damage from trampling will require corals to allocate energy to tissue repair which might otherwise have been used for growth and reproduction. Therefore, implementation of effective management and regulations on the tourism sector were the key to a successful marine parks establishment. Awareness programs were also crucial in order to educate both local entrepreneur and tourist on the importance of protecting our marine ecosystems.

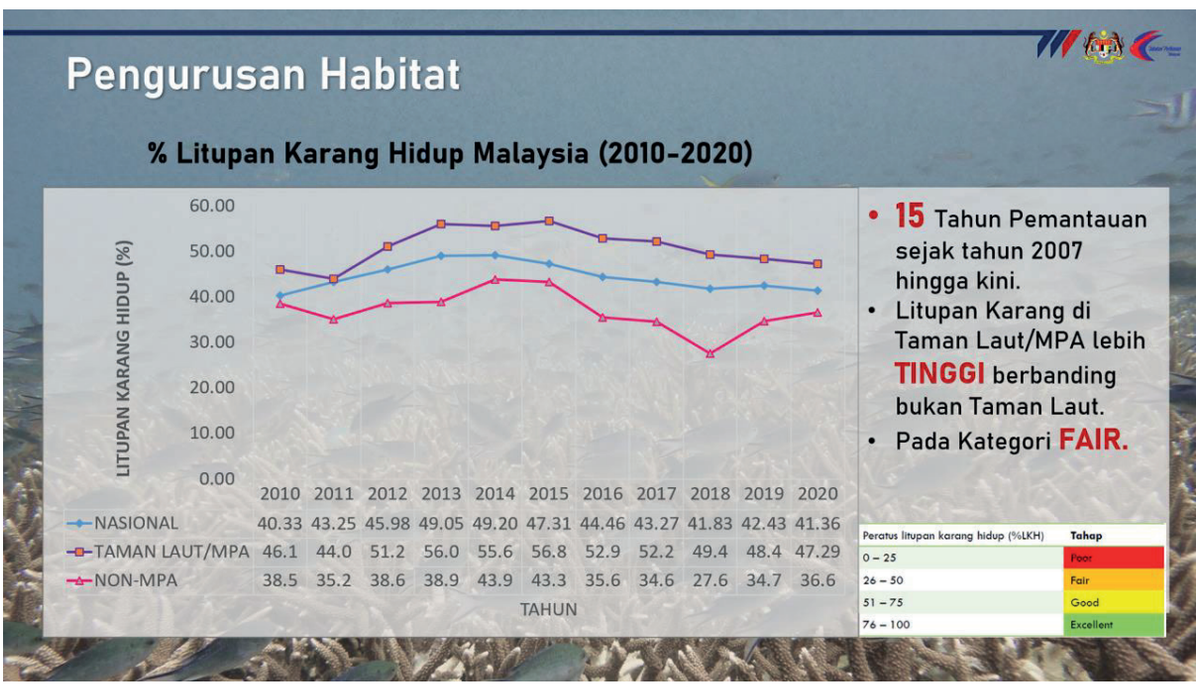


Figure 4. Charts showing trends of live coral cover in marine protected areas versus non protected areas.

4.3 Species Composition of Corals in Malaysia

Out of 227 publications, only 68 of them have reported lists of coral species in each study sites. 25 family consisted of 572 species of hard corals were documented all across Malaysian coastal waters. Acroporidae were the most abundant family (27.48%), followed by Merulinidae (21.16%) and Fungiidae (9.71%). Flabellidae and Tubiporidae were recorded having the lowest abundance (0.06%).

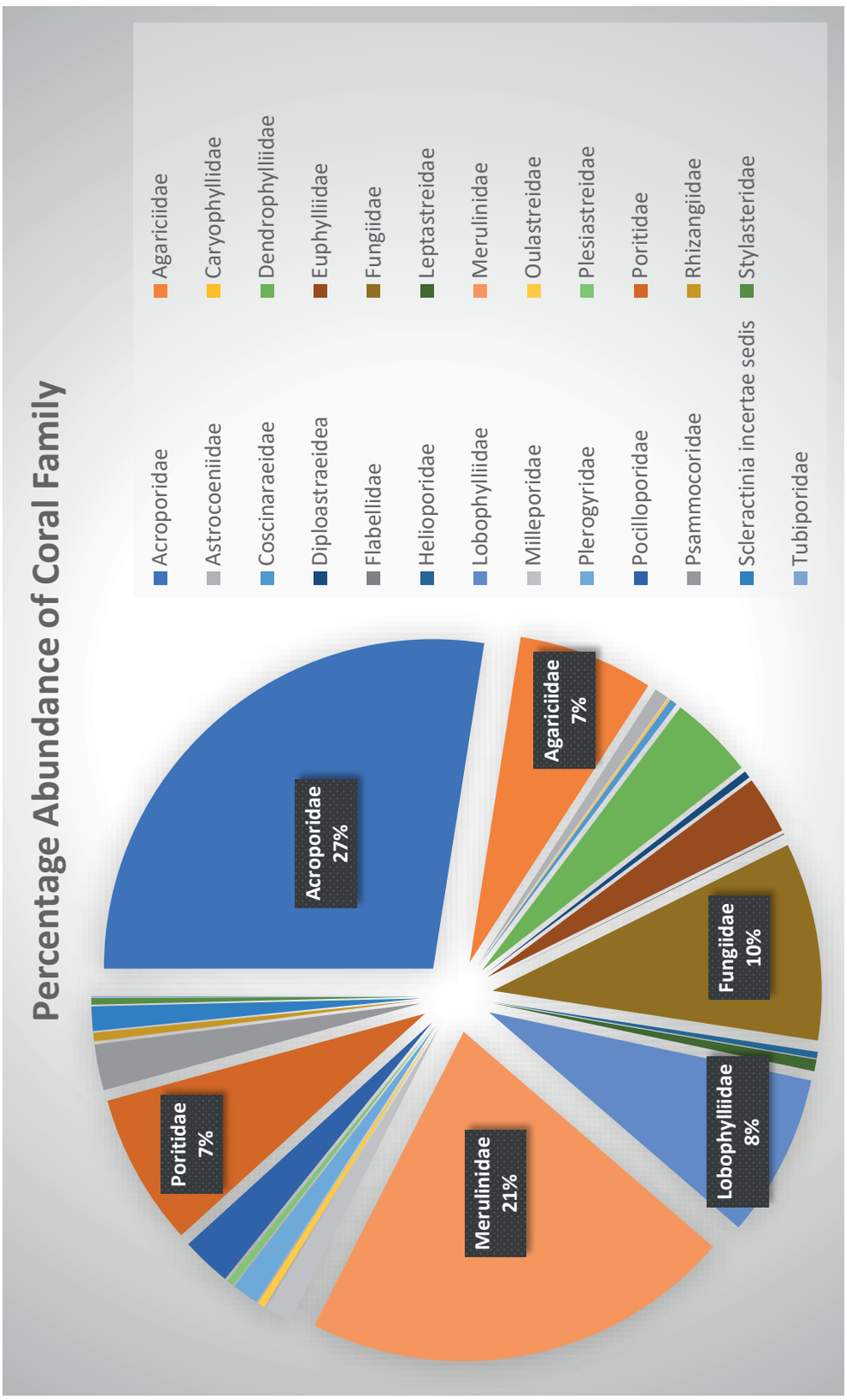


Figure 5. Pie chart illustrating the percentage composition of family classification of coral recorded in Malaysia.

The family Acroporidae consisted of 7 genus where the genus Acropora were the most abundant (57.16%), followed by Montipora (31.10%). These genus were the most common and were present at all study sites. The overall documented abundance is in accordance with Akmal et al. (2019), which stated that Acropora, Montipora and Porites were the most abundant corals in Malaysia.

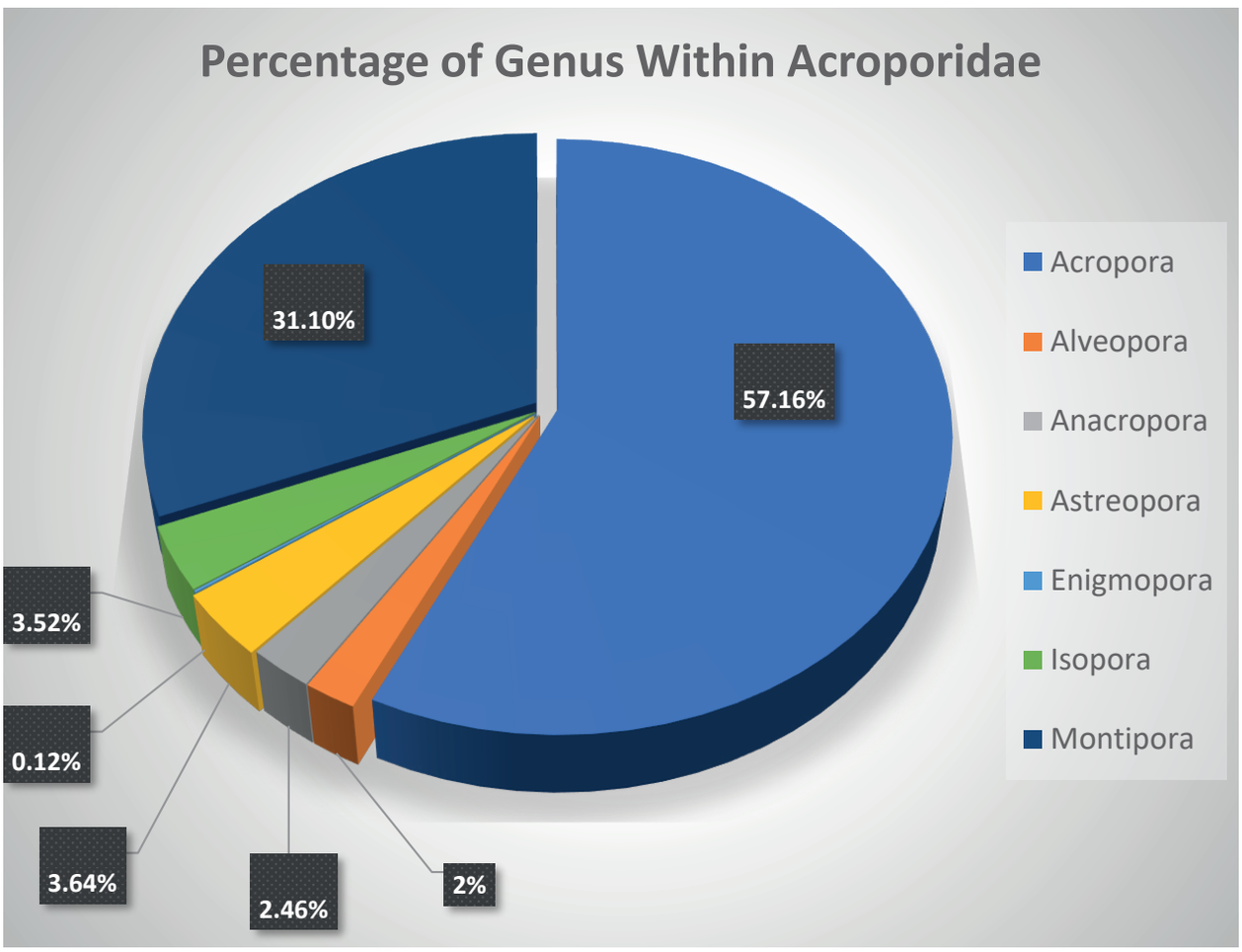


Figure 6. Percentage abundance of recorded genera within the Acroporidae family

Table 2: Species composition of hard coral species recorded in Malaysia.

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Acropora abrolhosensis	+	+	+	+							
Acropora abrotanoides	+	+		+							
Acropora aculeus	+	+	+	+							
Acropora acuminata	+										
Acropora anthocersis	+	+	+	+							
Acropora appressa		+	+	+							
Acropora aspera	+	+	+	+	+	+		+	+	+	+
Acropora austera	+	+	+	+	+	+		+	+	+	+
Acropora awi	+	+	+	+							
Acropora batunai	+										
Acropora carduus	+	+	+	+							
Acropora caroliniana	+										
Acropora cerealis	+	+	+	+	+	+		+	+	+	+
Acropora cervicornis		+									
Acropora cf polystoma	+										
Acropora clathrata	+	+	+	+							
Acropora cytherea	+	+	+	+	+	+		+	+	+	+
Acropora dendrum	+	+	+	+							
Acropora derawanensis	+										
Acropora desalwii	+										
Acropora digitifera	+	+	+	+	+	+		+	+	+	+
Acropora divaricata	+	+	+	+	+	+		+	+	+	+
Acropora donei	+	+	+	+							
Acropora echinata	+	+	+								

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Acropora elegans	+										
Acropora elseyi	+	+	+	+	+	+		+	+	+	+
Acropora exquisita	+										
Acropora fastigata	+										
Acropora florida	+	+	+	+	+	+		+	+	+	+
Acropora fragilis cf rambleri	+										
Acropora gemmifera	+	+	+	+	+	+		+	+	+	+
Acropora glauca	+										
Acropora globiceps		+		+							
Acropora grandis	+	+	+	+							
Acropora granulosa	+										
Acropora halmaherae	+										
Acropora hemprichii		+	+	+							
Acropora hoeksemai	+	+	+	+	+	+		+	+	+	+
Acropora horrida	+	+	+	+	+	+		+	+	+	+
Acropora humilis	+	+	+	+	+	+		+	+	+	+
Acropora hyacinthus	+	+	+	+	+	+		+	+	+	+
Acropora indonesia	+	+	+								
Acropora intermedia	+	+	+								
Acropora jacquelineae	+										
Acropora kirstyae		+	+	+							
Acropora latistella	+	+	+	+	+	+		+	+	+	+
Acropora listeri	+	+	+	+							
Acropora loisetteae	+										
Acropora lokani	+										
Acropora longicyathus	+										
Acropora loripes	+	+	+	+	+	+		+	+	+	+

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Acropora lutkeni	+	+	+	+							
Acropora microclados	+	+	+	+							
Acropora microphthalma	+	+	+	+	+	+		+	+	+	+
Acropora millepora	+	+	+	+	+	+		+	+	+	+
Acropora monticulosa	+	+	+	+	+	+		+	+	+	+
Acropora multiacuta	+										
Acropora muricata	+	+	+	+	+	+		+	+	+	+
Acropora nana	+	+	+	+							
Acropora nasuta	+	+	+	+	+	+		+	+	+	+
Acropora palmerae		+		+							
Acropora paniculata	+										
Acropora papillare	+	+	+	+							
Acropora pectinata		+	+	+							
Acropora pichoni	+										
Acropora robusta	+	+	+	+	+	+		+	+	+	+
Acropora plumosa	+										
Acropora polystoma	+										
Acropora proximalis		+		+							
Acropora pruinosa		+	+	+							
Acropora pulchra	+	+	+	+							
Acropora retusa		+	+	+							
Acropora ridzwani	+										
Acropora robusta	+	+	+	+	+	+		+	+	+	+
Acropora loripes	+	+	+	+	+	+		+	+	+	+
Acropora russelli	+										
Acropora samoensis	+	+	+	+	+	+		+	+	+	+
Acropora sarmentosa	+	+	+	+	+	+		+	+	+	+

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Acropora secale	+	+	+	+	+	+		+	+	+	+
Acropora selago	+	+	+	+	+	+		+	+	+	+
Acropora simplex	+										
Acropora solitaryensis	+	+	+	+	+	+		+	+	+	+
Acropora speciosa	+	+		+							
Acropora spicifera	+	+	+	+							
Acropora squamata	+										
Acropora stoddarti	+	+	+	+	+	+		+	+	+	+
Acropora subglabra	+	+	+								
Acropora subulata	+	+	+	+							
Acropora suharsonoi	+										
Acropora tenella	+										
Acropora tenuis	+	+	+	+	+	+		+	+	+	+
Acropora teres	+										
Acropora tubicinaria		+		+							
Acropora tubulosa	+										
Acropora tumida		+		+							
Acropora turaki	+										
Acropora valenciennesi	+	+	+	+	+	+		+	+	+	+
Acropora valida	+	+	+	+	+	+		+	+	+	+
Acropora vaughani	+	+	+	+							
Acropora verweyi	+										
Acropora willisae	+										
Acropora yongei	+	+	+	+	+	+		+	+	+	+
Alveopora allingi	+	+		+							
Alveopora catalai	+										

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Alveopora excelsa		+		+							
Alveopora marionensis		+		+							
Alveopora minuta		+	+	+							
Alveopora spongiosa	+	+	+	+							
Alveopora tizardi	+										
Alveopora verrilliana	+										
Anacropora forbesi	+	+	+	+							
Anacropora matthai	+	+	+	+	+	+		+	+	+	+
Anacropora pillai	+										
Anacropora puertogalerae	+										
Anacropora reticulata	+	+	+	+							
Anacropora spinosa	+										
Astreopora cucullata	+										
Astreopora gracilis	+	+	+	+	+	+		+	+	+	+
Astreopora listeri	+	+	+	+							
Astreopora myriophthalma	+	+	+	+	+	+	+	+	+	+	+
Astreopora ocellata		+	+	+							
Astreopora randalli	+										
Astreopora suggesta	+										
Enigmopora darveliensis	+										
Isopora brueggemanni	+	+	+	+	+	+		+	+	+	+
Isopora crateriformis		+		+							
Isopora cuneata	+	+	+	+							
Isopora palifera	+	+	+	+	+	+	+	+	+	+	+
Isopora togianensis		+	+	+							
Montipora aequituberculata	+	+	+	+	+	+	+	+	+	+	+

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Montipora alveopora		+		+							
Montipora altasepta	+	+	+	+	+	+		+	+	+	+
Montipora angulata	+	+		+							
Montipora australiensis	+										
Montipora cactus	+	+	+	+							
Montipora calcarea		+	+	+							
Montipora caliculata	+	+	+	+							
Montipora capitata	+										
Montipora capricornis		+	+	+							
Montipora cebuensis	+	+	+	+	+	+		+	+	+	+
Montipora cocosensis		+	+	+							
Montipora confusa	+	+	+	+	+	+		+	+	+	+
Montipora corbettensis	+	+		+							
Montipora crassituberculata	+	+	+	+							
Montipora danae	+	+	+	+			+		+		
Montipora delicatula	+	+	+	+							
Montipora digitata	+	+	+	+	+	+	+		+	+	
Montipora efflorescens	+	+	+	+							
Montipora effusa		+	+	+							
Montipora elschneri		+		+							
Montipora flabellata		+	+								
Montipora florida	+	+	+	+							
Montipora foliosa	+	+	+	+	+	+	+	+	+	+	+
Montipora foveolata	+	+	+	+							
Montipora friabilis		+	+	+							
Montipora frondens		+		+							

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Montipora gaimardi	+	+	+	+	+	+		+	+	+	+
Montipora granulosa		+		+							
Montipora grisea	+	+	+	+							
Montipora hispida	+	+	+	+	+	+		+	+	+	+
Montipora hoffmeisteri	+										
Montipora incrassata	+	+		+							
Montipora informis	+	+	+	+	+	+	+	+	+	+	+
Montipora mactanensis	+										
Montipora maeandrina	+	+	+	+							
Montipora malampaya	+	+	+	+	+	+		+	+	+	+
Montipora marshallensis		+		+							
Montipora millepora		+	+	+			+		+		
Montipora mollis	+	+	+	+	+	+		+	+	+	+
Montipora monasteriata	+	+	+	+							
Montipora nodosa		+	+	+							
Montipora palawanensis	+	+	+	+							
Montipora peltiformis	+	+	+	+							
Montipora spongodes	+										
Montipora spumosa	+	+	+	+							
Montipora stellata	+	+	+	+			+		+		
Montipora tuberculosa	+	+	+	+	+	+	+	+	+	+	+
Montipora turgescens	+	+	+								
Montipora turtlensis	+	+	+	+							
Montipora undata	+	+	+	+							
Montipora venosa	+	+	+	+							

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Montipora verruculosa	+	+	+	+							
Montipora verrucosa	+	+	+	+			+		+		
Montipora vietnamensis	+	+	+	+							
Coeloseris mayeri	+		+								
Gardineroseris planulata	+	+	+	+	+	+		+	+	+	+
Gardineroseris ponderosa		+		+							
Leptoseris amitoriensis	+										
Leptoseris explanata	+	+	+	+	+	+	+	+	+	+	+
Leptoseris foliosa	+	+	+	+							
Leptoseris fragilis	+		+								
Leptoseris gardineri	+	+	+	+			+		+		
Leptoseris glabra	+		+								
Leptoseris hawaiiensis	+	+	+	+							
Leptoseris incrustans	+	+	+	+	+	+		+	+	+	+
Leptoseris kalayaanensis	+		+								
Leptoseris mycetoseroides	+	+	+	+	+	+		+	+	+	+
Leptoseris papyracea	+	+	+	+	+	+		+	+	+	+
Leptoseris scabra	+	+	+	+	+	+	+	+	+	+	+
Leptoseris solida	+		+				+		+		
Leptoseris striata		+		+							
Leptoseris troglodyta	+		+								
Leptoseris tubulifera	+	+	+	+							
Leptoseris yabei	+	+	+	+							
Pavona bipartita	+	+	+	+	+	+		+	+	+	+
Pavona cactus	+	+	+	+	+	+	+	+	+	+	+
Pavona clavus	+	+	+	+	+	+		+	+	+	+

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Pavona danai	+	+	+	+							
Pavona decussata	+	+	+	+	+	+	+	+	+	+	+
Pavona divaricata	+	+		+							
Pavona duerdeni	+	+	+	+						+	
Pavona explanulata	+	+	+	+	+	+	+	+	+	+	+
Pavona foliata cf decussata	+										
Pavona frondifera	+	+	+	+	+	+	+	+	+	+	+
Pavona gigantea		+	+	+							
Pavona maldivensis	+	+	+	+							
Pavona minuta	+		+				+		+		
Pavona varians	+	+	+	+	+	+		+	+	+	+
Pavona venosa	+	+	+	+							
Pavona xarifae	+										
Palauastrea ramosa	+	+	+	+							
Stylocoeniella armata	+	+	+	+							
Stylocoeniella cocosensis		+	+	+							
Stylocoeniella guentheri	+	+	+	+	+	+		+	+	+	+
Stylocoeniella pistillata	+										
Paracyathus stokesii	+	+		+							
Coscinaraea hahazimaensis	+	+	+	+	+	+		+	+	+	+
Coscinaraea monile	+										
Australopsammia aurea		+		+						+	
Balanophyllia cumingii		+		+							
Balanophyllia (Eupsammia) imperialis		+		+							
Cladopsammia gracilis	+										
Dendrophyllia arbuscula		+		+						+	

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Dendrophyllia robusta	+										
Duncanopsammia peltata	+	+	+	+	+	+		+	+	+	+
Leptosammia stokesiana		+		+							
Rhizopsammia verrilli	+	+	+	+	+	+		+	+	+	+
Rhizopsammia wettsteini	+										
Tubastraea coccinea	+	+	+	+	+	+		+	+	+	+
Tubastraea diaphana	+	+	+	+	+	+		+	+	+	+
Tubastraea faulkneri		+		+							
Tubastraea micranthus	+	+	+	+	+	+		+	+	+	+
Turbinaria bifrons		+		+							
Turbinaria crater		+		+							
Turbinaria frondens	+	+	+	+	+	+	+	+	+	+	+
Turbinaria heronensis	+										
Turbinaria irregularis	+	+	+	+	+	+	+	+	+	+	+
Turbinaria mesenterina	+	+	+	+	+	+		+	+	+	+
Turbinaria mollis		+		+							
Turbinaria patula	+	+		+							
Turbinaria radicalis		+		+							
Turbinaria reniformis	+	+	+	+							
Turbinaria stellulata	+	+	+	+	+	+		+	+	+	+
Diploastrea heliopora	+	+	+	+	+	+	+	+	+	+	+
Euphyllia cristata	+	+	+							+	
Euphyllia fimbriata		+		+							
Euphyllia glabrescens	+	+	+	+	+	+	+	+	+	+	+
Euphyllia paraglabrescens		+	+	+							

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Fimbriaphyllia ancora	+	+	+	+	+	+	+	+	+	+	+
Fimbriaphyllia divisa	+	+	+	+	+	+		+	+	+	+
Fimbriaphyllia paraancora	+		+								
Fimbriaphyllia paradivisa	+	+	+	+							
Fimbriaphyllia yaeyamensis	+	+	+	+	+	+		+	+	+	+
Galaxea alta	+										
Galaxea astreata	+	+	+	+	+	+	+	+	+	+	+
Galaxea explanata		+		+							
Galaxea fascicularis	+	+	+	+	+	+	+	+	+	+	+
Galaxea horrescens	+	+	+	+							
Galaxea paucisepta		+		+							
Truncatoflabellum stokesi		+		+							
Cantharellus jebbi	+										
Ctenactis albitentaculata	+	+	+	+	+	+		+	+	+	+
Ctenactis crassa	+	+	+	+	+	+	+	+	+	+	+
Ctenactis echinata	+	+	+	+	+	+	+	+	+	+	+
Cycloseris boschmai	+		+								
Cycloseris costulata	+	+	+	+						+	
Cycloseris curvata	+	+	+	+							
Cycloseris cyclolites	+	+	+	+			+		+		
Cycloseris distorta	+	+	+	+	+	+		+	+	+	+
Cycloseris explanulata	+	+	+	+	+	+		+	+	+	+
Cycloseris fragilis	+	+	+	+	+	+		+	+	+	+
Cycloseris mokai	+	+	+								
Cycloseris sinensis	+		+								
Cycloseris sommervillei	+	+	+	+							
Cycloseris tenuis	+	+	+	+	+	+		+	+	+	+

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Cycloseris vaughani	+	+	+	+							
Cycloseris wellsi	+										
Danafungia horrida	+	+	+	+	+	+	+	+	+	+	+
Danafungia scruposa	+	+	+	+	+	+	+	+	+	+	+
Fungia fungites	+	+	+	+	+	+	+	+	+	+	+
Halomitra clavator	+										
Halomitra pileus	+	+	+	+	+		+			+	
Heliofungia actiniformis	+	+	+	+	+	+		+	+	+	+
Heliofungia fralinae	+	+	+	+							
Herpolitha limax	+	+	+	+	+	+	+	+	+	+	+
Lithophyllon cf edwardsi	+										
Lithophyllon concinna	+	+	+	+	+	+		+	+	+	+
Lithophyllon ranjithi	+		+								
Lithophyllon repanda	+	+	+	+	+	+		+	+	+	+
Lithophyllon scabra	+	+	+	+	+	+		+	+	+	+
Lithophyllon spinifer	+	+	+	+							
Lobactis scutaria	+	+	+	+	+		+			+	
Lithophyllon undulatum	+	+	+	+	+	+		+	+	+	+
Pleuractis granulosa	+	+	+	+	+	+		+	+	+	+
Pleuractis gravis	+	+	+								
Pleuractis moluccensis	+	+	+	+	+	+		+	+	+	+
Pleuractis paumotensis	+	+	+	+	+	+	+	+	+	+	+
Pleuractis taiwanensis	+		+								
Podabacia crustacea	+	+	+	+							
Podabacia motuporensis	+	+	+	+							
Podabacia sinai	+		+								
Polyphyllia talpina	+	+	+	+	+	+	+	+	+	+	+

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Sandalolitha boucheti	+		+								
Sandalolitha dentata	+	+	+	+							
Sandalolitha robusta	+	+	+	+	+	+	+	+	+	+	+
Sinuorota hexagonalis	+										
Zoopilus echinatus	+		+								
Heliopora coerulea	+	+	+	+	+	+		+	+	+	+
Leptastrea aequalis		+	+	+							
Leptastrea bottae	+										
Leptastrea purpurea	+	+	+	+	+	+	+	+	+	+	+
Leptastrea transversa		+	+	+							
Acanthastrea brevis		+	+								
Acanthastrea echinata	+	+	+	+	+	+	+	+	+	+	+
Acanthastrea hemprichii	+	+	+	+	+	+		+	+	+	+
Acanthastrea minuta	+										
Acanthastrea pachysepta	+	+	+	+							
Acanthastrea rotundoflora	+	+		+							
Acanthastrea subechinata	+	+	+								
Australogyra zelli		+	+	+							
Australophyllia wilsoni	+										
Cynarina lacrymalis	+	+	+	+	+	+		+	+	+	+
Echinomorpha nishihirai	+										
Echinophyllia aspera	+	+	+	+	+	+		+	+	+	+
Echinophyllia echinoporoides	+										
Echinophyllia glabra	+	+	+	+							
Echinophyllia orpheensis	+	+	+	+	+	+		+	+	+	+
Echinophyllia patula	+										
Homophyllia australis		+	+	+	+	+		+	+	+	+

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Homophyllia bowerbanki	+	+	+								
Lobophyllia agaricia	+	+	+	+	+	+		+	+	+	+
Lobophyllia corymbosa	+	+	+	+	+	+	+	+	+	+	+
Lobophyllia dentata		+		+							
Lobophyllia diminuta	+	+	+	+							
Lobophyllia flabelliformis	+	+	+	+			+		+		
Lobophyllia hassi	+	+	+	+							
Lobophyllia hataii	+	+	+	+	+	+		+	+	+	+
Lobophyllia hemprichii	+	+	+	+	+	+	+	+	+	+	+
Lobophyllia ishigakiensis		+		+							
Lobophyllia radians	+	+	+	+	+	+		+	+	+	+
Lobophyllia recta	+	+	+	+	+	+	+	+	+	+	+
Lobophyllia rowleyensis	+										
Lobophyllia robusta	+	+	+	+	+	+		+	+	+	+
Lobophyllia valenciennesii	+	+	+	+	+	+	+	+	+	+	+
Lobophyllia vitiensis	+	+	+	+	+	+		+	+	+	+
Micromussa lordhowensis	+	+	+	+	+	+	+	+	+	+	+
Micromussa multipunctata		+	+	+							
Micromussa regularis		+	+	+							
Oxypora echinata	+	+	+	+	+	+		+	+	+	+
Oxypora crassispinosa	+	+	+	+	+	+	+	+	+	+	+
Oxypora lacera	+	+	+	+	+	+		+	+	+	+
Astraeosmilia curvata	+										
Astraeosmilia maxima	+	+	+	+	+	+		+	+	+	+
Astraeosmilia tumida	+	+	+	+	+	+		+	+	+	+
Astrea annuligera	+	+	+	+			+		+		
Astrea curta	+	+	+	+	+	+		+	+	+	+

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Boninastrea boninensis	+										
Catalaphyllia jardinei	+	+	+	+	+	+		+	+	+	+
Caulastraea echinulata	+										
Caulastraea furcata	+						+		+		
Coelastrea aspera	+	+	+	+							
Coelastrea palauensis	+	+	+	+							
Cyphastrea agassizi		+	+	+							
Cyphastrea chalcidicum	+	+	+	+			+		+		
Cyphastrea decadia	+										
Cyphastrea japonica	+	+	+	+							
Cyphastrea microphthalma	+	+	+	+			+		+		
Cyphastrea ocellina		+	+	+							
Cyphastrea serailia	+	+	+	+			+		+		
Dipsastraea albida		+	+	+							
Dipsastraea amicorum	+	+	+	+	+	+		+	+	+	+
Dipsastraea camranensis		+	+								
Dipsastraea danae		+	+	+							
Dipsastraea faviaformis	+	+	+	+							
Dipsastraea favus	+	+	+	+			+		+		
Dipsastraea helianthoides	+	+	+	+							
Dipsastraea laxa	+	+		+							
Dipsastraea lizardensis	+	+	+	+							
Dipsastraea maritima	+	+	+	+	+	+	+	+	+	+	+
Dipsastraea marshae		+	+	+							
Dipsastraea matthaii	+	+	+	+			+		+		
Dipsastraea pallida	+	+	+	+	+	+		+	+	+	+
Dipsastraea rosaria		+	+	+							

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Dipsastraea rotumana	+	+	+	+							
Dipsastraea speciosa	+	+	+	+			+		+		
Dipsastraea stelligera	+	+	+	+	+	+		+	+	+	+
Dipsastraea truncata	+	+	+	+							
Dipsastraea veroni	+	+	+	+	+	+		+	+	+	+
Dipsastraea vietnamensis		+	+	+							
Dipsastraea wisseli	+										
Echinopora forskaliana	+										
Echinopora gemmacea	+	+	+	+	+	+	+	+	+	+	+
Echinopora hirsutissima	+										
Echinopora horrida	+	+	+	+	+	+		+	+	+	+
Echinopora lamellosa	+	+	+	+	+	+	+	+	+	+	+
Echinopora mammiformis	+	+	+	+							
Echinopora pacifica	+	+	+	+	+	+		+	+	+	+
Favites abdita	+	+	+	+	+	+	+	+	+	+	+
Favites acuticollis	+	+	+	+	+	+		+	+	+	+
Favites chinensis	+	+	+	+							
Favites colemani	+	+	+	+			+		+		
Favites complanata	+	+	+	+							
Favites flexuosa	+	+	+	+							
Favites halicora	+	+	+	+	+	+		+	+	+	+
Favites magnistellata	+	+	+	+	+	+		+	+	+	+
Favites melicerum		+	+	+							
Favites micropentagonus		+	+	+			+		+		
Favites paraflexuosus	+	+	+	+							
Favites pentagona	+	+	+	+	+	+	+	+	+	+	+
Favites rotundata	+	+	+	+			+		+		

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Favites spinosa		+	+	+							
Favites stylifera		+	+	+							
Favites valenciennesi	+	+	+	+							
Goniastrea edwardsi	+	+	+	+	+	+	+	+	+	+	+
Goniastrea favulus	+	+	+	+	+	+	+	+	+	+	+
Goniastrea minuta	+	+	+	+							
Goniastrea pectinata	+	+	+	+	+	+	+	+	+	+	+
Goniastrea retiformis	+	+	+	+	+	+	+	+	+	+	+
Goniastrea stelligera		+	+								
Hydnophora exesa	+	+	+	+	+	+	+	+	+	+	+
Hydnophora grandis	+	+	+	+	+	+		+	+	+	+
Hydnophora microconos	+	+	+	+	+	+		+	+	+	+
Hydnophora pilosa	+										
Hydnophora rigida	+	+	+	+			+		+		
Leptoria irregularis	+										
Leptoria phrygia	+	+	+	+	+	+		+	+	+	+
Merulina ampliata	+	+	+	+	+	+	+	+	+	+	+
Merulina cylindrica	+	+	+	+	+	+	+	+	+	+	+
Merulina scabricula	+	+	+	+	+	+		+	+	+	+
Merulina togianensis	+										
Mycedium elephantotus	+	+	+	+	+	+	+	+	+	+	+
Mycedium mancaoi	+										
Mycedium robokaki	+	+		+							
Mycedium spina	+										
Orbicella annularis		+		+							
Oulophyllia bennettae	+	+	+	+	+	+		+	+	+	+
Oulophyllia crispa	+	+	+	+	+	+	+	+	+	+	+

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Oulophyllia levis		+		+							
Paragoniastrea australensis	+	+	+	+			+		+		
Paragoniastrea russelli	+	+	+	+							
Paramontastraea salebrosa	+	+	+	+							
Pectinia alcicornis	+	+	+	+	+	+		+	+	+	+
Pectinia crassa	+										
Pectinia elongata	+										
Pectinia lactuca	+	+	+	+	+	+	+	+	+	+	+
Pectinia maxima	+	+	+	+	+	+		+	+	+	+
Pectinia paeonia	+	+	+	+	+	+	+	+	+	+	+
Pectinia teres	+		+								
Physophyllia ayleni	+										
Platygyra acuta	+	+	+	+							
Platygyra carnosa		+	+	+							
Platygyra contorta	+			+							
Platygyra crosslandi		+	+	+							
Platygyra daedalea	+	+	+	+	+	+	+	+	+	+	+
Platygyra lamellina	+	+	+	+	+	+		+	+	+	+
Platygyra pini	+	+	+	+			+		+		
Platygyra ryukyuensis	+	+	+	+							
Platygyra sinensis	+	+	+	+	+	+	+	+	+	+	+
Platygyra verweyi	+	+	+	+	+	+		+	+	+	+
Platygyra yaeyamaensis		+	+	+							
Trachyphyllia geoffroyi	+	+	+	+	+	+		+	+	+	+
Millepora dichotoma	+	+	+	+	+	+		+	+	+	+
Millepora exaesa	+	+	+	+	+	+		+	+	+	+
Millepora intricata	+										

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Millepora platyphylla	+	+	+	+	+	+		+	+	+	+
Millepora tenera	+	+	+	+	+	+		+	+	+	+
Oulastrea crispata	+	+	+	+	+	+	+	+	+	+	+
Blastomussa loyai		+		+							
Blastomussa merleti		+		+							
Blastomussa wellsi	+	+	+	+	+	+		+	+	+	+
Nemenzophyllia turbida	+		+								
Physogyra liechtensteini	+	+	+	+						+	
Plerogyra cauliformis	+		+								
Plerogyra diabolotus	+		+								
Plerogyra eurysepta	+										
Plerogyra multilobata	+		+								
Plerogyra simplex	+		+								
Plerogyra sinuosa	+	+	+	+	+	+	+	+	+	+	+
Plesiastrea versipora	+	+	+	+	+	+		+	+	+	+
Pocillopora acuta		+	+								
Pocillopora brevicornis										+	
Pocillopora damicornis	+	+	+	+	+	+		+	+	+	+
Pocillopora grandis	+	+	+	+	+	+		+	+	+	+
Pocillopora meandrina	+	+	+	+	+	+		+	+	+	+
Pocillopora solida		+		+						+	
Pocillopora verrucosa	+	+	+	+	+	+		+	+	+	+
Seriatopora caliendrum	+										
Seriatopora hystrix	+	+	+	+							
Seriatopora stellata	+										
Stylophora pistillata	+	+	+	+	+	+		+	+	+	+
Stylophora subseriata	+	+	+	+	+	+		+	+	+	+

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Madracis asanoi	+										
Madracis kirbyi	+	+		+							
Bernardpora stutchburyi	+	+		+							
Goniopora cellulosa	+										+
Goniopora ciliatus		+		+							
Goniopora columna	+	+	+	+			+		+		
Goniopora diminuta		+	+								
Goniopora djiboutiensis	+	+	+	+			+		+		
Goniopora eclipsensis	+	+		+							
Goniopora fruticosa	+	+	+	+							
Goniopora lobata	+	+	+	+			+		+		
Goniopora norfolkensis	+	+	+	+							
Goniopora palmensis							+		+		
Goniopora pandoraensis	+										
Goniopora pedunculata	+	+	+	+							
Goniopora pendulus		+		+							
Goniopora planulata	+	+	+	+	+	+		+	+	+	+
Goniopora savignyi		+		+							
Goniopora somaliensis	+	+	+	+			+		+		
Goniopora stokesi	+	+	+	+							
Goniopora tenella										+	
Goniopora tenuidens	+	+	+	+			+		+		
Porites annae	+	+	+	+	+	+	+	+	+	+	+
Porites aranetai		+	+	+							
Porites attenuata	+	+	+	+							
Porites australiensis	+	+	+	+							
Porites cocosensis		+	+	+							

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Porites cumulatus		+	+	+							
Porites cylindrica	+	+	+	+	+	+	+	+	+	+	+
Porites densa		+	+	+							
Porites echinulata		+	+	+							
Porites eridani		+		+						+	
Porites evermanni	+	+	+	+	+	+		+	+	+	+
Porites horizontalata	+	+	+	+	+	+		+	+	+	+
Porites latistellata	+	+	+	+							
Porites lichen	+	+	+	+							
Porites lobata	+	+	+	+			+		+		
Porites lutea	+	+	+	+			+		+	+	+
Porites mayeri	+	+	+	+							
Porites monticulosa	+	+	+	+	+	+		+	+	+	+
Porites murrayensis	+	+	+	+							
Porites negrosensis	+	+	+	+							
Porites nigrescens	+	+	+	+	+	+		+	+	+	+
Porites ornata	+										
Porites porites		+									
Porites pukoensis	+										
Porites rus	+	+	+	+	+	+	+	+	+	+	+
Porites silimaniana	+										
Porites solida	+	+	+	+	+	+		+	+	+	+
Porites stephensoni	+										
Porites superfusa		+		+							
Porites vaughani	+						+		+		
Stylaraea punctata		+	+	+							
Psammocora columna	+	+	+	+	+	+		+	+	+	+

Species	Sabah	Terengganu	Pahang	Johor	Sarawak	Labuan	Negeri Sembilan	Perak	Melaka	Kedah	Pulau Pinang
Psammocora contigua	+	+	+	+	+	+		+	+	+	+
Psammocora digitata	+	+	+	+	+	+		+	+	+	+
Psammocora exaesa	+	+	+	+	+	+		+	+	+	+
Psammocora haimiana	+	+	+	+	+	+		+	+	+	+
Psammocora nierstraszi	+	+	+	+	+	+		+	+	+	+
Psammocora profundacella	+	+	+	+	+	+		+	+	+	+
Culicia rubeola		+		+							
Pseudosiderastrea tayamai	+	+	+	+	+	+	+	+	+	+	+
Pachyseris foliosa	+	+	+	+	+	+	+	+	+	+	+
Pachyseris gemmae	+	+	+	+							
Pachyseris rugosa	+	+	+	+	+	+	+	+	+	+	+
Pachyseris speciosa	+	+	+	+	+	+	+	+	+	+	+
Distichopora violacea	+	+	+	+	+	+		+	+	+	+
Tubipora musica	+		+								

*Reference note:

Sabah[10, 11, 13, 17, 59, 62, 63, 67, 71, 92, 94, 95, 104, 105, 110, 111, 113, 115, 116, 117, 119, 122, 132, 173, 208, 231]
Terengganu[23, 25, 28, 60, 61, 62, 63, 64, 87, 107, 112, 123, 134, 140, 141, 145, 182, 190, 208, 230]
Pahang[12, 15, 16, 21, 23, 25, 28, 35, 51, 61, 62, 78, 83, 87, 90, 97, 112, 114, 123, 126, 142, 208, 230]
Johor[61, 62, 86, 123, 124, 208, 230]
Labuan[62, 208]
Perak[12, 62]
Kedah[23, 25, 62, 91, 102, 112, 115, 128, 164, 167, 197, 208]
Sarawak[62, 115, 208]
Negeri Sembilan[62, 99, 112, 115, 232]
Melaka[62, 232]
Pulau Pinang[62, 108, 164]

While there has been extensive record on the composition of hard corals in Malaysia, reported occurrence on soft corals and octocorals were very limited. Up to date, we've only found two publications that provide species list of soft corals in Malaysia. Penang recorded 3 species of soft corals[7] while Johor recorded 6 species[8]. Species occurrence of octocorals were only reported by Lau et al. (2019)[9] in Sabah with only 4 species recorded.

Table 3: Species composition of soft corals in Malaysia.

Species	Johor	Pulau Pinang
Sinularia facile		+
Sinularia flexibilis		+
Sinularia grayi		+
Dendronephthya binongkoensis	+	
Dendronephthya klunzingeri	+	
Dendronephthya minima	+	
Dendronephthya quadrata	+	
Dendronephthya roemeri	+	
Dendronephthya weberi	+	

Table 4: Species composition of octocorals in Malaysia.

Species	Sabah
Laeta waheeda	+
Phenganax marumi	+
Phenganax stokvisi	+
Phenganax subtilis	+

*Reference note:

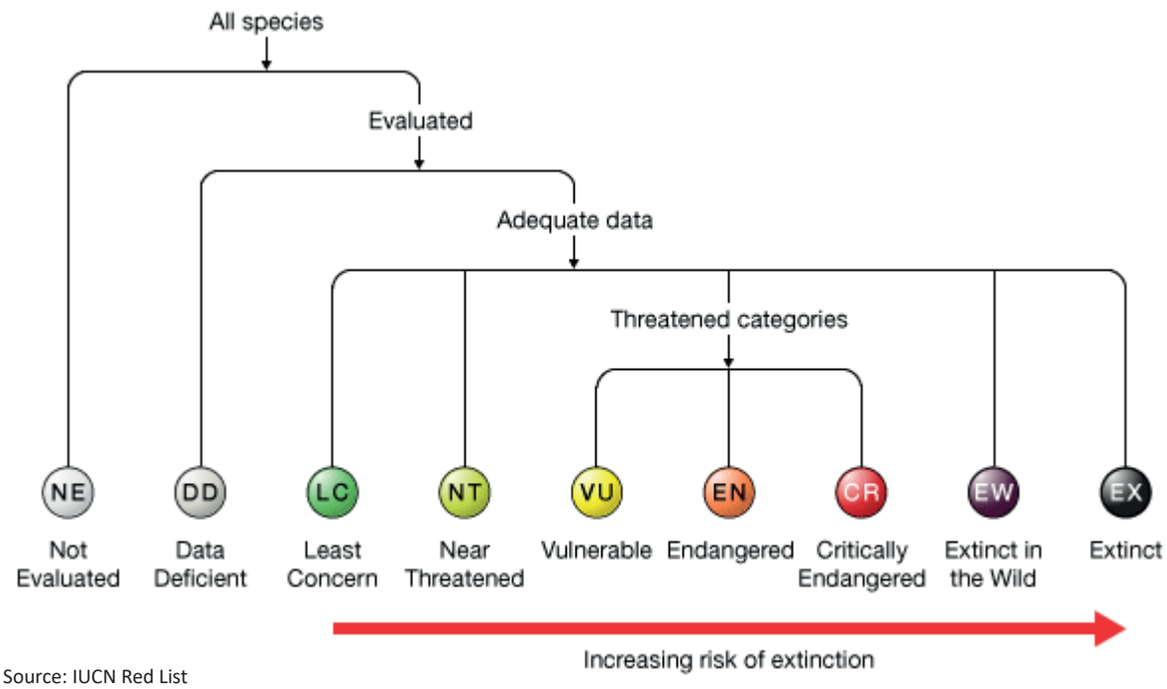
Johor[124]
Pulau Pinang[108]
Sabah[173]

4.4 IUCN Red List of coral species in Malay

Under the IUCN Red List, most of the species in the world is assessed under several categories. This list is a critical indicator of the health of the world's biodiversity. As shown in Figure 7, there are 8 categories when a species is evaluated. Each species will be evaluated using 5 criteria before being categorized into any threatened categories as shown in Figure 8. Table 5 shows the brief description of each category.

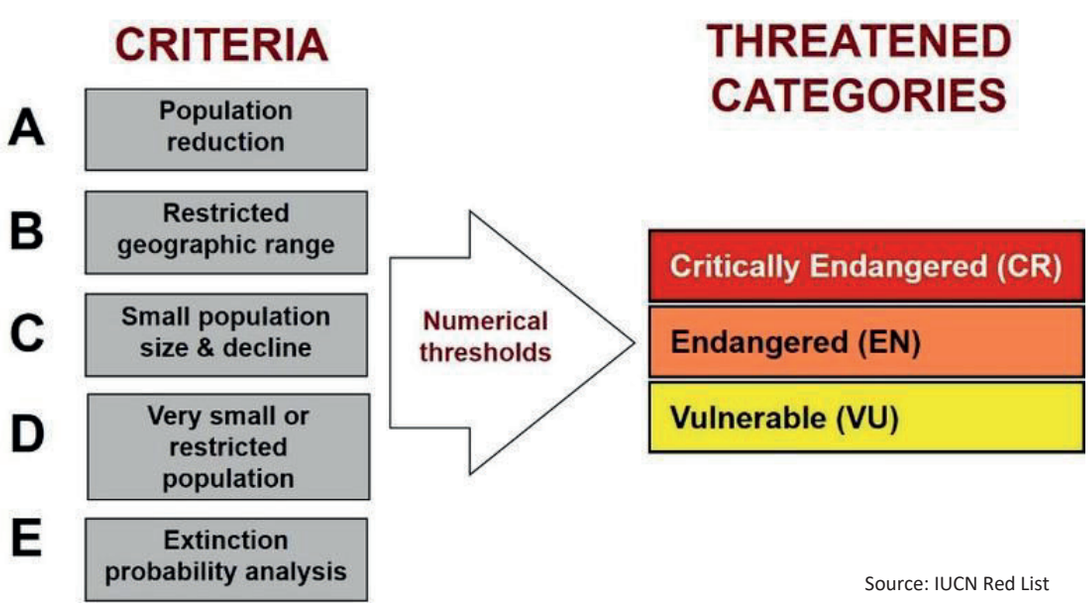
Table 5: Brief description of the category in IUCN Red List.

Category	Description
Not Evaluated (**NE**)	Not yet evaluated against the criteria
Data Deficient (**DD**)	Inadequate information to make a direct or indirect assessment of its risk of extinction using its distribution and/or population status
Least Concern (**LC**)	Evaluated against the criteria and does not qualify for CR, EN, VU or NT
Near Threatened (**NT**)	Does not qualify for Critically Endangered, Endangered or Vulnerable now but is close to qualifying for or is likely to qualify in the near future
Vulnerable (**VU**)	Best available evidence indicated that it meets any of the criteria A to E for Vulnerable
Endangered (**EN**)	Best available evidence indicated that it meets any of the criteria A to E for Endangered
Critically Endangered (**CR**)	Best available evidence indicated that it meets any of the criteria A to E for Critically Endangered
Extinct in the Wild (**EW**)	Known only to survive in cultivation, captivity or as a naturalized populations
Extinct (**EX**)	There is no reasonable doubt that the last individual has died



Source: IUCN Red List

Figure 7. Illustrations of the categories under the IUCN Red List assessment.



Source: IUCN Red List

Figure 8. Criteria used to assess the status of any species.

From this study, 586 species of corals were assessed for the IUCN Red List. Only 76 species were Not Evaluated. 25 species were listed as Data Deficient (DD), 193 species listed as Least Concern (LC) and 138 species as Near Threatened (NT). It is alarming that 154 species were threatened (Vulnerable – 142 species; Endangered – 10 species; Critically Endangered – 2).

Table 6: List of assessed species for the IUCN Red List.

Species	Status	Species	Status	Species	Status
Acropora abrolhosensis	VU	*Acropora hoeksemai*	VU	*Acropora samoensis*	LC
A. abrotanoides	LC	*A. horrida*	VU	*A. sarmentosa*	LC
A. aculeus	VU	*A. humilis*	NT	*A. secale*	NT
A. acuminata	VU	*A. hyacinthus*	NT	*A. selago*	NT
A. anthocersis	VU	*A. indonesia*	VU	*A. simplex*	VU
A. appressa	NT	*A. intermedia*	NE	*A. solitaryensis*	VU
A. aspera	VU	*A. jacquelineae*	VU	*A. speciosa*	VU
A. austera	NT	*A. kirstyae*	VU	*A. spicifera*	VU
A. awi	VU	*A. latistella*	LC	*A. squamata*	NE
A. batunai	VU	*A. listeri*	VU	*A. stoddarti*	DD
A. carduus	NT	*A. loisetteae*	VU	*A. subglabra*	LC
A. caroliniana	VU	*A. lokani*	VU	*A. subulata*	LC
A. cerealis	LC	*A. longicyathus*	LC	*A. suharsonoi*	EN
A. cervicornis	CR	*A. loripes*	NT	*A. tenella*	VU
A. cf polystoma	VU	*A. lutkeni*	NT	*A. tenuis*	NT
A. clathrata	LC	*A. microclados*	VU	*A. teres*	DD
A. cytherea	LC	*A. microphthalma*	LC	*A. tubicinaria*	NE
A. dendrum	VU	*A. millepora*	NT	*A. tubulosa*	NE
A. derawanensis	VU	*A. monticulosa*	NT	*A. tumida*	DD
A. desalwii	VU	*A. multiacuta*	VU	*A. turaki*	VU
A. digitifera	NT	*A. muricata*	NT	*A. valenciennesi*	LC
A. divaricata	NT	*A. nana*	NT	*A. valida*	LC
A. divaricata	NT	*A. nasuta*	NT	*A. vaughani*	VU
A. donei	VU	*A. palmerae*	VU	*A. verweyi*	VU
A. donei	VU	*A. paniculata*	VU	*A. willisae*	VU
A. echinata	VU	*A. papillare*	VU	*A. yongei*	LC
A. elegans	VU	*A. pectinata*	DD	*Alveopora allingi*	VU
A. elseyi	LC	*A. pichoni*	NT	*A. catalai*	NT
A. exquisita	DD	*A. robusta*	LC	*A. excelsa*	EN
A. fastigata	DD	*A. plumosa*	VU	*A. marionensis*	VU
A. florida	NT	*A. polystoma*	VU	*A. minuta*	EN
A. fragilis cf rambleri	DD	*A. proximalis*	DD	*A. spongiosa*	NT
A. gemmifera	LC	*A. pruinosa*	DD	*A. tizardi*	LC
A. glauca	NT	*A. pulchra*	LC	*A. verrilliana*	VU
A. globiceps	VU	*A. retusa*	VU	*Anacropora forbesi*	LC
A. grandis	LC	*A. ridzwani*	DD	*A. matthai*	VU
A. granulosa	NT	*A. robusta*	LC	*A. pillai*	DD
A. halmaherae	DD	*A. loripes*	NT	*A. puertogalerae*	VU
A. hemprichii	VU	*A. russelli*	VU	*A. reticulata*	VU

Species	Status	Species	Status	Species	Status
Anacropora spinosa	EN	*Montipora friabilis*	VU	*L. glabra*	NE
Astreopora cucullata	VU	*M. frondens*	NE	*L. hawaiiensis*	LC
A. gracilis	LC	*M. gaimardi*	VU	*L. incrustans*	VU
A. listeri	LC	*M. granulosa*	NE	*L. kalayaanensis*	NE
A. myriophthalma	LC	*M. grisea*	LC	*L. mycetoseroides*	LC
A. ocellata	LC	*M. hispida*	LC	*L. papyracea*	LC
A. randalli	LC	*M. hoffmeisteri*	LC	*L. scabra*	LC
A. suggesta	LC	*M. incrassata*	NT	*L. solida*	LC
Enigmopora darveliensis	DD	*M. informis*	LC	*L. striata*	NT
Isopora brueggemanni	VU	*M. mactanensis*	VU	*L. troglodyta*	NE
I. crateriformis	VU	*M. maeandrina*	VU	*L. tubulifera*	LC
I. cuneata	VU	*M. malampaya*	VU	*L. yabei*	VU
I. palifera	NT	*M. marshallensis*	NE	*Pavona bipartita*	VU
I. togianensis	EN	*M. millepora*	LC	*P. cactus*	VU
Montipora aequituberculata	LC	*M. mollis*	LC	*P. clavus*	LC
M. alveopora	NE	*M. monasteriata*	LC	*P. danai*	VU
M. altasepta	VU	*M. nodosa*	NT	*P. decussata*	VU
M. angulata	VU	*M. palawanensis*	NT	*P. divaricata*	NE
M. australiensis	VU	*M. peltiformis*	NT	*P. duerdeni*	LC
M. cactus	VU	*M. samarensis*	VU	*P. explanulata*	LC
M. calcarea	VU	*M. spongodes*	LC	*P. foliata cf decussata*	VU
M. caliculata	VU	*M. spumosa*	LC	*P. frondifera*	LC
M. capitata	NT	*M. stellata*	LC	*P. gigantea*	LC
M. capricornis	VU	*M. tuberculosa*	LC	*P. maldivensis*	LC
M. cebuensis	VU	*M. turgescens*	LC	*P. minuta*	NT
M. cocosensis	VU	*M. turtlensis*	VU	*P. varians*	LC
M. confusa	NT	*M. undata*	NT	*P. venosa*	VU
M. corbettensis	VU	*M. venosa*	NT	*P. xarifae*	DD
M. crassituberculata	VU	*M. verruculosa*	VU	*Palauastrea ramosa*	NT
M. danae	LC	*M. verrucosa*	LC	*Stylocoeniella armata*	LC
M. delicatula	VU	*M. vietnamensis*	VU	*S. cocosensis*	VU
M. digitata	LC	*Coeloseris mayeri*	LC	*S. guentheri*	LC
M. efflorescens	NT	*Gardineroseris planulata*	LC	*S. pistillata*	NE
M. effusa	NT	*G. ponderosa*	LC	*Paracyathus stokesii*	NE

M. elschneri	NE	*Leptoseris amitoriensis*	NT	*Coscinaraea hahazimaensis*	VU
M. flabellata	VU	*L. explanata*	LC	*C. monile*	LC
M. florida	VU	*L. foliosa*	LC	*Australopsammia aurea*	NE
M. foliosa	NT	*L. fragilis*	NE	*Balanophyllia cumingii*	NE
M. foveolata	NT	*L. gardineri*	LC	*B. (Eupsammia) imperialis*	NE

Species	Status	Species	Status	Species	Status
Cladopsammia gracilis	NE	*Truncatoflabellum stokesi*	NE	*Podabacia crustacea*	LC
Dendrophyllia arbuscula	NE	*Cantharellus jebbi*	LC	*P. motuporensis*	NT
D. robusta	NE	*Ctenactis albitentaculata*	NT	*P. sinai*	DD
Duncanopsammia peltata	VU	*C. crassa*	LC	*Polyphyllia talpina*	LC
Leptosammia stokesiana	NE	*C. echinata*	LC	*Sandalolitha boucheti*	NE
Rhizopsammia verrilli	NE	*Cycloseris boschmai*	NE	*S. dentata*	LC
R. wettsteini	NE	*C. costulata*	LC	*S. robusta*	LC
Tubastraea coccinea	NE	*C. curvata*	VU	*Sinuorota hexagonalis*	LC
T. diaphana	NE	*C. cyclolites*	LC	*Zoopilus echinatus*	LC
T. faulkneri	NE	*C. distorta*	LC	*Heliopora coerulea*	VU
T. micranthus	NE	*C. explanulata*	NE	*Leptastrea aequalis*	VU
Turbinaria bifrons	VU	*C. fragilis*	LC	*L. bottae*	NT
T. crater	NE	*C. mokai*	LC	*L. purpurea*	LC
T. frondens	LC	*C. sinensis*	LC	*L. transversa*	LC
T. heronensis	VU	*C. sommervillei*	LC	*Acanthastrea brevis*	VU
T. frondens	LC	*C. tenuis*	LC	*A. echinata*	LC
T. irregularis	LC	*C. vaughani*	LC	*A. hemprichii*	VU
T. mesenterina	VU	*C. wellsi*	NE	*A. minuta*	NE
T. mollis	NE	*Danafungia horrida*	NE	*A. pachysepta*	NT
T. patula	VU	*D. scruposa*	NE	*A. rotundoflora*	NT
T. radicalis	NT	*Fungia fungites*	NT	*A. subechinata*	NT
T. reniformis	VU	*Halomitra clavator*	VU	*Australogyra zelli*	VU
T. stellulata	VU	*H. pileus*	LC	*Australophyllia wilsoni*	LC
Diploastrea heliopora	NT	*Heliofungia actiniformis*	VU	*Cynarina lacrymalis*	NT
Euphyllia cristata	VU	*Heliofungia fralinae*	LC	*Echinomorpha nishihirai*	NT
E. fimbriata	NE	*Herpolitha limax*	LC	*Echinophyllia aspera*	LC
E. glabrescens	NT	*Lithophyllon cf edwardsi*	NE	*E. echinoporoides*	LC
E. paraglabrescens	VU	*L. concinna*	LC	*E. glabra*	LC
Fimbriaphyllia ancora	VU	*L. ranjithi*	EN	*E. orpheensis*	LC
F. divisa	NT	*L. repanda*	LC	*E. patula*	LC

F. paraancora	VU	*L. scabra*	LC	*Homophyllia australis*	LC
F. paradivisa	VU	*L. spinifer*	LC	*H. bowerbanki*	VU
F. yaeyamensis	NT	*L. undulatum*	NT	*Lobophyllia agaricia*	LC
Galaxea alta	NE	*Lobactis scutaria*	LC	*L. corymbosa*	LC
G. astreata	VU	*Pleuractis granulosa*	LC	*L. dentata*	VU
G. explanata	NE	*P. gravis*	NE	*L. diminuta*	VU
G. fascicularis	NT	*P. moluccensis*	LC	*L. flabelliformis*	VU
G. horrescens	LC	*P. paumotensis*	LC	*L. hassi*	VU
G. paucisepta	NT	*P. taiwanensis*	VU	*L. hataii*	LC

Species	Status	Species	Status	Species	Status
Lobophyllia hemprichii	LC	*Dipsastrea laxa*	NT	*Goniastrea minuta*	NT
L. ishigakiensis	VU	*D. lizardensis*	NT	*G. pectinata*	LC
L. radians	LC	*D. maritima*	NT	*G. retiformis*	LC
L. recta	LC	*D. marshae*	NT	*G. stelligera*	NT
L. rowleyensis	NT	*D. matthaii*	NT	*Hydnophora exesa*	NT
L. robusta	LC	*D. pallida*	LC	*H. grandis*	LC
L. valenciennesii	LC	*D. rosaria*	VU	*H. microconos*	NT
L. vitiensis	NT	*D. rotumana*	LC	*H. pilosa*	LC
Micromussa lordhowensis	NT	*D. speciosa*	LC	*H. rigida*	LC
M. multipunctata	VU	*D. stelligera*	NT	*Leptoria irregularis*	VU
M. regularis	VU	*D. truncata*	LC	*L. phrygia*	NT
Oxypora echinata	LC	*D. veroni*	NT	*Merulina ampliata*	LC
O. crassispinosa	LC	*D. vietnamensis*	NT	*M. cylindrica*	LC
O. lacera	LC	*D. wisseli*	NE	*M. scabricula*	LC
Astraeosmilia curvata	VU	*Echinopora forskaliana*	NT	*M. togianensis*	NE
A. maxima	NT	*E. gemmacea*	LC	*Mycedium elephantotus*	LC
A. tumida	NT	*E. hirsutissima*	LC	*M. mancaoi*	LC
Astrea annuligera	NT	*E. horrida*	NT	*M. robokaki*	LC
A. curta	LC	*E. lamellosa*	LC	*M. spina*	DD
Boninastrea boninensis	DD	*E. mammiformis*	NT	*Orbicella annularis*	EN
Catalaphyllia jardinei	VU	*E. pacifica*	NT	*Oulophyllia bennettae*	NT
Caulastraea echinulata	VU	*Favites abdita*	NT	*O. crispa*	NT
C. furcata	LC	*F. acuticollis*	NT	*O. levis*	LC
Coelastrea aspera	LC	*F. chinensis*	NT	*Paragoniastrea australensis*	LC
C. palauensis	NT	*F. colemani*	NT	*P. russelli*	NT
Cyphastrea agassizi	VU	*F. complanata*	NT	*Paramontastraea salebrosa*	VU
C. chalcidicum	LC	*F. flexuosa*	NT	*Pectinia alcicornis*	VU
C. decadia	LC	*F. halicora*	NT	*P. crassa*	DD
C. japonica	LC	*F. magnistellata*	NT	*P. elongata*	NT
C. microphthalma	LC	*F. melicerum*	NT	*P. lactuca*	VU
C. ocellina	VU	*F. micropentagonus*	NT	*P. maxima*	EN
C. serailia	LC	*F. paraflexuosus*	NT	*P. paeonia*	NT
Dipsastraea albida	NT	*F. pentagona*	LC	*P. teres*	NT
D. amicorum	LC	*F. rotundata*	NT	*Physophyllia ayleni*	NT

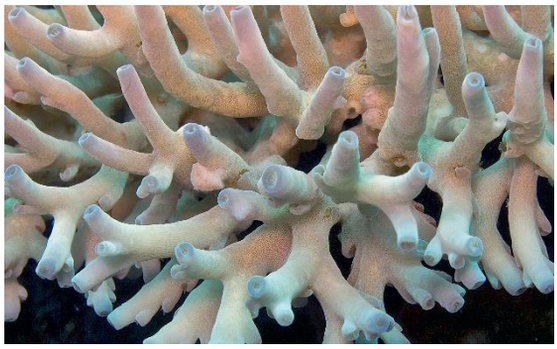
D. camranensis	NE	*F. spinosa*	VU	*Platygyra acuta*	NT
D. danae	LC	*F. stylifera*	NT	*P. carnosa*	NT
D. faviaformis	VU	*F. valenciennesi*	NT	*P. contorta*	LC
D. favus	LC	*Goniastrea edwardsi*	LC	*P. crosslandi*	NT
D. helianthoides	NT	*G. favulus*	NT	*P. daedalea*	LC

Species	Status	Species	Status	Species	Status
Platygyra lamellina	NT	*Psammocora columna*	LC	*Porites monticulosa*	LC
P. pini	LC	*P. exaesa*	NE	*P. murrayensis*	NT
P. ryukyuensis	NT	*Bernardpora stutchburyi*	LC	*P. negrosensis*	NT
P. sinensis	LC	*Goniopora cellulosa*	VU	*P. nigrescens*	VU
P. verweyi	NT	*G. ciliatus*	LC	*P. ornata*	EN
P. yaeyamaensis	VU	*G. columna*	NT	*P. P.*	NE
Trachyphyllia geoffroyi	NT	*G. diminuta*	DD	*P. pukoensis*	CR
Millepora dichotoma	NE	*G. djiboutiensis*	LC	*P. rus*	LC
M. exaesa	NE	*G. eclipsensis*	LC	*P. silimaniana*	VU
M. intricata	NE	*G. fruticosa*	LC	*P. solida*	LC
M. platyphylla	NE	*G. lobata*	NT	*P. stephensoni*	NT
M. tenera	NE	*G. norfolkensis*	LC	*P. superfusa*	NE
Oulastrea crispata	LC	*G. palmensis*	LC	*P. vaughani*	LC
Blastomussa loyai	EN	*G. pandoraensis*	LC	*Stylaraea punctata*	DD
B. merleti	LC	*G. pedunculata*	NT	*Psammocora contigua*	NT
B. wellsi	NT	*G. pendulus*	LC	*P. digitata*	NT
Nemenzophyllia turbida	VU	*G. planulata*	VU	*P. haimiana*	LC
Physogyra liechtensteini	VU	*G. savignyi*	LC	*P. nierstraszi*	LC
Plerogyra cauliformis	DD	*G. somaliensis*	LC	*P. profundacella*	LC
P. diabolotus	DD	*G. stokesi*	NT	*Culicia rubeola*	NE
P. eurysepta	NE	*G. tenella*	NT	*Pseudosiderastrea tayamai*	NT
P. multilobata	DD	*G. tenuidens*	LC	*Pachyseris foliosa*	LC
P. simplex	NT	*Porites annae*	NT	*P. gemmae*	NT
P. sinuosa	NT	*P. aranetai*	VU	*P. rugosa*	VU
Plesiastrea versipora	LC	*P. attenuata*	VU	*P. speciosa*	LC
Pocillopora acuta	NE	*P. australiensis*	LC	*Distichopora violacea*	NE
P. brevicornis	NE	*P. cocosensis*	VU	*Tubipora musica*	NT
P. damicornis	LC	*P. cumulatus*	VU	*Sinularia facile*	NE
P. grandis	NE	*P. cylindrica*	NT	*S. flexibillis*	NE
P. meandrina	LC	*P. densa*	NT	*S. grayi*	NE

P. solida	NE	*P. echinulata*	NT	*Dendronephthya binongkoensis*	NE
P. verrucosa	LC	*P. eridani*	NE	*D. klunzingeri*	NE
Seriatopora caliendrum	NT	*P. evermanni*	DD	*D.minima*	NE
S. hystrix	LC	*P. horizontalata*	VU	*D. quadrata*	NE
S. stellata	NT	*P. latistellata*	LC	*D. roemeri*	NE
Stylophora pistillata	NT	*P. lichen*	LC	*D. weberi*	NE
S. subseriata	LC	*P. lobata*	NT	*Laeta waheeda*	NE
Madracis asanoi	DD	*P. lutea*	LC	*Phenganax marumi*	NE
M. kirbyi	LC	*P. mayeri*	LC	*P. stokvisi*	NE

Endangered species

1) *Acropora suharsonoi*

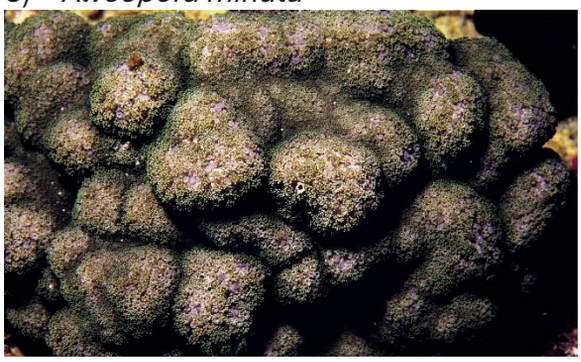


(obtained from www.coralsoftheworld.org)

2) *Alveopora excelsa*

(obtained from www.coralsoftheworld.org)

3) *Alveopora minuta*



(obtained from www.coralsoftheworld.org)

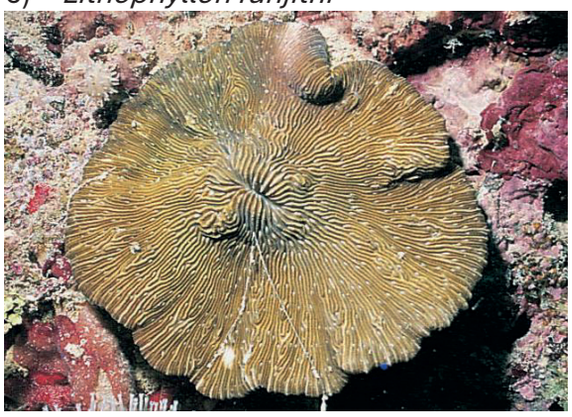
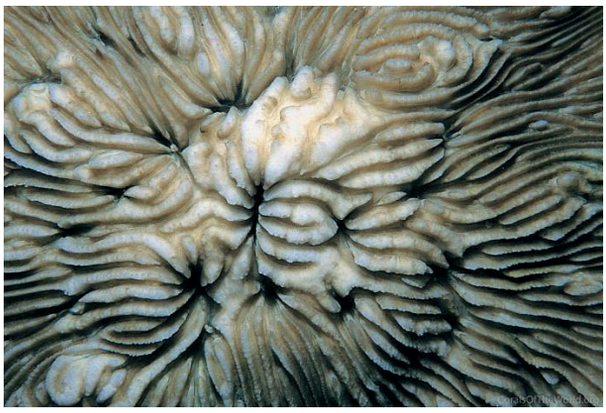
4) *Anacropora spinosa*

(obtained from www.coralsoftheworld.org)

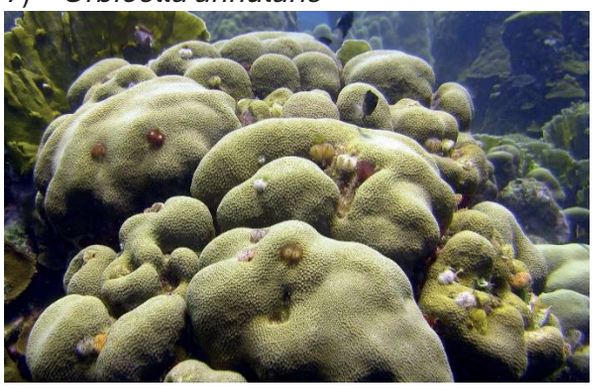
5) *Isopora togianensis*

(obtained from www.coralsoftheworld.org)

6) *Lithophyllon ranjithi*

7) *Orbicella annularis*



(obtained from www.coralsoftheworld.org)

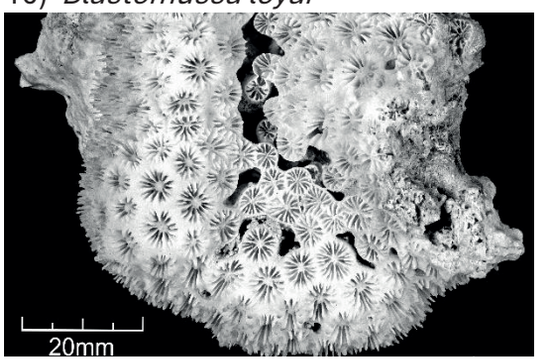
8) *Pectinia maxima*

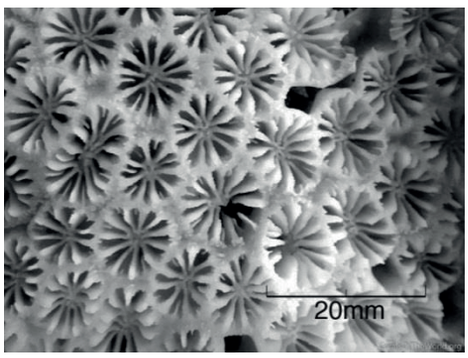
(obtained from www.coralsoftheworld.org)

9) *Porites ornata*

(obtained from www.coralsoftheworld.org)

10) *Blastomussa loyai*

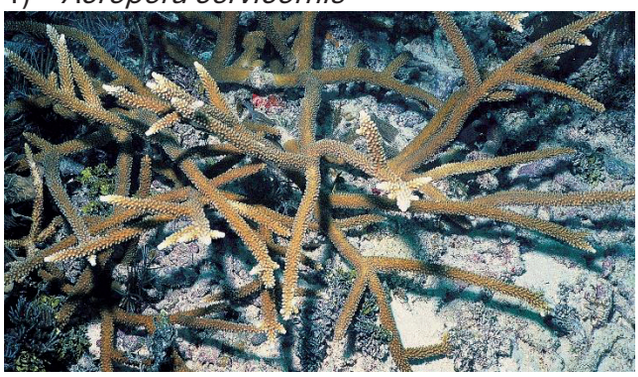




(obtained from www.coralsoftheworld.org)

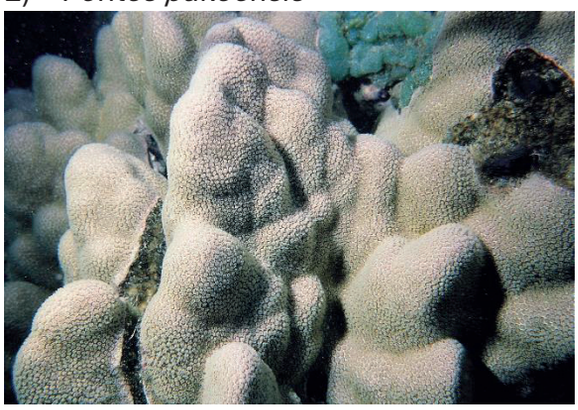
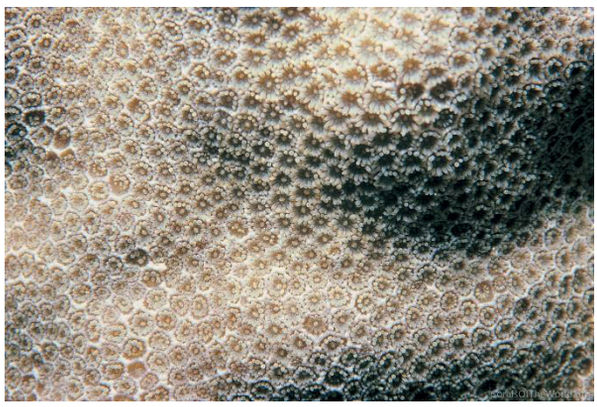
Critically Endangered species

1) *Acropora cervicornis*



(obtained from www.coralsoftheworld.org)

2) *Porites pukoensis*

(obtained from www.coralsoftheworld.org)

4.5 Publications on Fishes

In total, there were only 52 publications on fishes in Malaysia that were reviewed. The first study found were published by Ambak et al. (1986)[237] they recorded growth characteristics of Lizard Fish in the South China Sea. Publications on fishes in Malaysia were very scarce in the earlier periods. Until the year 1991, there was only 1 publication annually if there is any. It is not until 1994 that we begin to see a slight increase in the annual publications, even if there's a slight fluctuation. The highest record of publication was in 2005 where it covered Pahang, Terengganu, Kedah, Penang and Perak. Subsequently, it is observed that the decline in publications were steadily going downhill until 2009 and showed 1 publication annually until 2014.

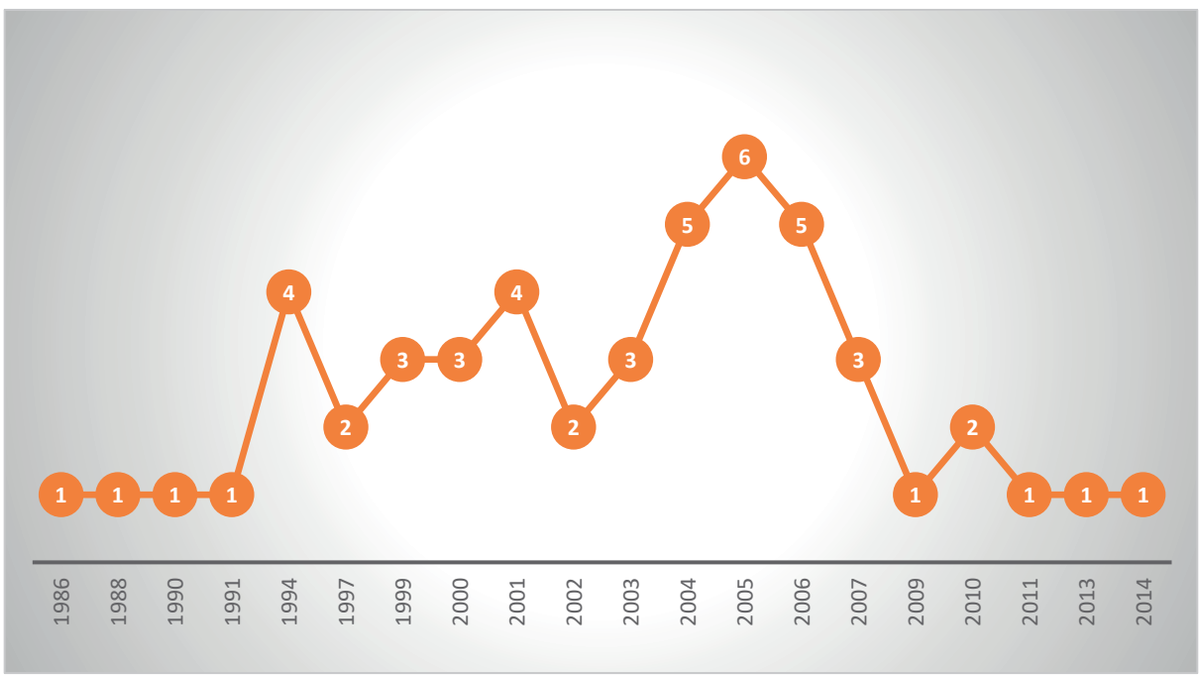


Figure 9. Number of publications on fishes in Malaysia by years.

Figure 10 shows the number of publications on fishes in diferent states of Malaysia. Terengganu recorded the most studies published (n=20; 28.57%), followed by Kedah (n=15; 21.43%) and Johor (n=8; 11.43%). The least studies were recorded in Selangor, Melaka and Kelantan (n=1; 1.43%).

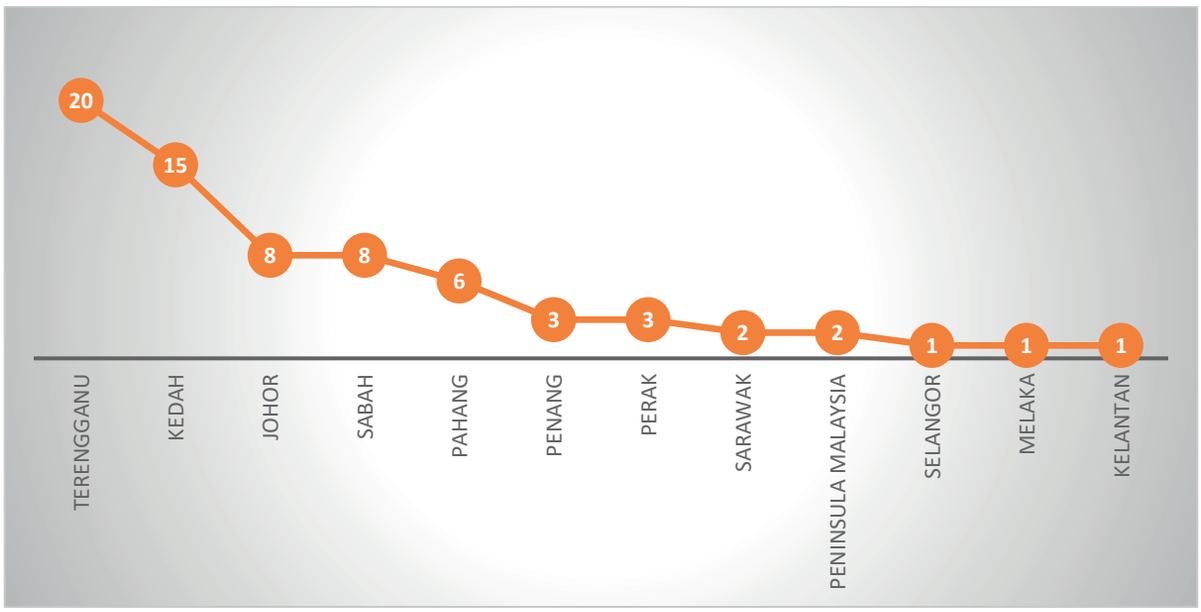


Figure 10. Number of publications on fishes at each state.

4.6 Abundance and Composition of Fishes in Malaysia

A total of 1065 species of fishes were documented in Malaysian waters throughout all 52 publications that were reviewed. These species made up the two Class; Actinopteri (1042 species; 97.84%) and Elasmobranchii (23 species; 2.16%). As the most common group of fish recorded, Actinopteri consisted of 111 families, where the largest family was Pomacentridae with 110 species (10.56%), followed by Labridae with 87 species (8.35%).

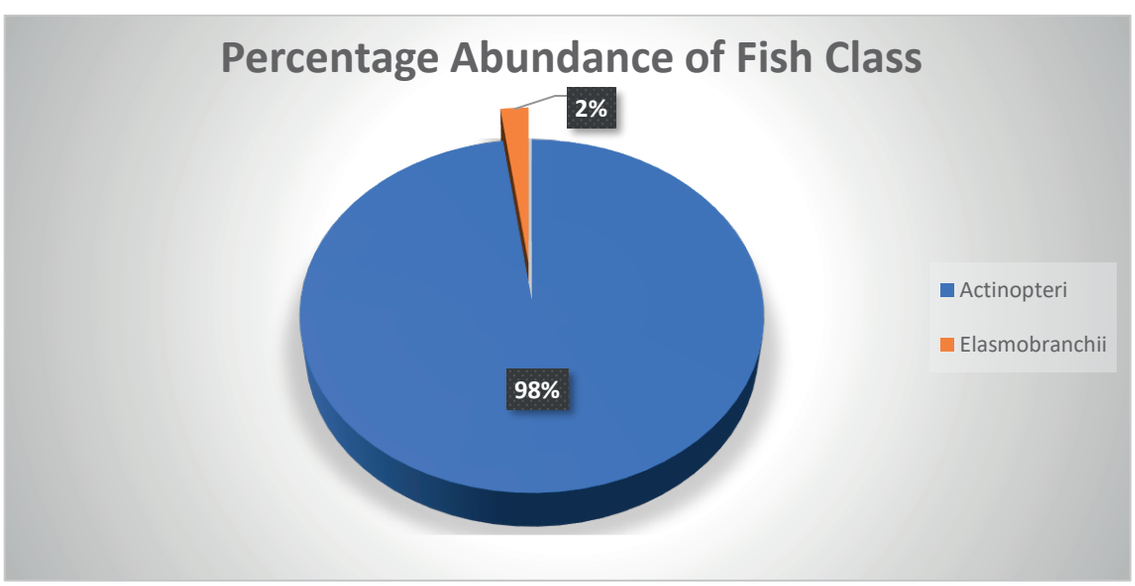


Figure 11. Percentage abundance of fish class.

Table 7: List of fish species in Malaysia.

Species	IUCN Status	Species	IUCN Status
Abalistes stellatus	LC	*Alepes djedaba*	LC
Ablennes hians	LC	*Alepes kleinii*	LC
Abudefduf abdominalis	LC	*Alepes melanoptera*	LC
Abudefduf bengalensis	LC	*Allenbatrachus grunniens*	NE
Abudefduf notatus	LC	*Aluterus monoceros*	LC
Abudefduf septemfasciatus	LC	*Aluterus scriptus*	LC
Abudefduf sexfasciatus	LC	*Amanses scopas*	LC
Abudefduf sordidus	LC	*Amblyeleotris diagonalis*	LC
Abudefduf vaigiensis	LC	*Amblyeleotris fasciata*	LC
Acanthocepola abbreviata	LC	*Amblyeleotris guttata*	LC
Acanthopagrus berda	LC	*Amblyeleotris gymnocephala*	LC
Acanthurus auranticavus	LC	*Amblyeleotris japonica*	DD
Acanthurus bariene	LC	*Amblyeleotris periophthalma*	LC
Acanthurus blochii	LC	*Amblyeleotris steinitzi*	LC
Acanthurus dussumieri	LC	*Amblyeleotris wheeleri*	LC
Acanthurus fowleri	LC	*Amblygaster leiogaster*	LC
Acanthurus grammoptilus	LC	*Amblygaster sirm*	LC
Acanthurus japonicus	LC	*Amblyglyphidodon aureus*	LC
Acanthurus leucosternon	LC	*Amblyglyphidodon curacao*	LC
Acanthurus lineatus	LC	*Amblyglyphidodon leucogaster*	LC
Acanthurus maculiceps	LC	*Amblygobius decussatus*	LC
Acanthurus mata	LC	*Amblygobius phalaena*	LC
Acanthurus nigricans	LC	*Amphiprion akallopisos*	LC
Acanthurus nigricauda	LC	*Amphiprion clarkii*	LC
Acanthurus nigrofuscus	LC	*Amphiprion ephippium*	LC
Acanthurus olivaceous	LC	*Amphiprion frenatus*	LC
Acanthurus pyroferus	LC	*Amphiprion melanopus*	LC
Acanthurus thompsoni	LC	*Amphiprion ocellaris*	LC
Acanthurus triostegus	LC	*Amphiprion percula*	LC
Acanthurus xanthopterus	LC	*Amphiprion perideraion*	LC
Acentrogobius nebulosus	LC	*Amphiprion polymnus*	LC
Acentrogobius viridipunctatus	LC	*Amphiprion sandaracinos*	LC
Acreichthys tomentosus	LC	*Anacanthus barbatus*	LC
Aeoliscus strigatus	DD	*Anampses caeruleopunctatus*	LC
Aesopia cornuta	LC	*Anampses lineatus*	DD
Aethaloperca rogaa	LC	*Anampses melanurus*	LC
Aetobatus narinari	EN	*Anampses meleagrides*	LC
Aetomylaeus maculatus	EN	*Anampses neoguinaicus*	LC
Alectis cilliaris	LC	*Anampses twistii*	LC
Alectis indica	LC	*Anodontostoma chacunda*	LC

Species	IUCN Status	Species	IUCN Status
Anomalops katoptron	LC	*Bodianus loxozonus*	LC
Antennarius striatus	LC	*Bodianus mesothorax*	LC
Antennatus nummifer	LC	*Bolbometopon muricatum*	VU
Anyperodon leucogrammicus	LC	*Bothus mancus*	LC
Aphareus furca	LC	*Brachypleura novaezeelandiae*	LC
Apistus carinatus	LC	*Brachypterois serrulata*	NE
Apogon coccineus	LC	*Brevitrygon walga*	NT
Apogon lineatus	LC	*Bryaninops erythrops*	LC
Apogonichthyoides niger	LC	*Bryaninops loki*	LC
Apolemichthys trimaculatus	LC	*Bryaninops yongei*	LC
Ariomma indica	NE	*Caesio caerulaurea*	LC
Arius maculatus	DD	*Caesio cuning*	LC
Arius venosus	NE	*Caesio lunaris*	LC
Arnoglossus aspilos	LC	*Caesio teres*	LC
Arothron hispidus	LC	*Caesio xanthonota*	LC
Arothron immaculatus	LC	*Callionymus filamentosus*	LC
Arothron mappa	LC	*Callionymus japonicus*	LC
Arothron nigropunctatus	LC	*Callionymus sagitta*	LC
Arothron stellatus	LC	*Callogobius sclateri*	LC
Aseraggodes dubius	LC	*Cantherhines dumerilii*	LC
Aspidontus taeniatus	LC	*Cantherhines pardalis*	LC
Atelomycterus marmoratus	NT	*Canthigaster bennetti*	LC
Atelopus japonicus	NE	*Canthigaster janthinoptera*	LC
Atropus atropos	LC	*Canthigaster solandri*	LC
Atrosalarias fuscus	LC	*Canthigaster valentini*	LC
Atule mate	LC	*Carangoides armatus*	LC
Aulostomus chinensis	LC	*Carangoides bajad*	LC
Aurigequula fasciata	LC	*Carangoides chrysophrys*	LC
Auxis thazard	LC	*Carangoides coeruleopinnatus*	LC
Balistapus undulatus	LC	*Carangoides equula*	LC
Balistoides conspicillum	LC	*Carangoides ferdau*	LC
Balistoides viridescens	LC	*Carangoides gymnostethus*	LC
Belonoperca chabanaudi	LC	*Carangoides hedlandensis*	LC
Blenniella bilitonensis	LC	*Carangoides malabaricus*	LC
Blenniella chrysospilos	LC	*Carangoides plagiotaenia*	LC
Blenniella periophthalmus	LC	*Carangoides praeustus*	LC
Bodianus anthioides	LC	*Carangoides talamparoides*	LC
Bodianus axillaris	LC	*Caranx ignobilis*	LC
Bodianus bimaculatus	LC	*Caranx lugubris*	LC
Bodianus diana	LC	*Caranx melampygus*	LC

Species	IUCN Status	Species	IUCN Status
Caranx sexfasciatus	LC	*Chaetodon kleinii*	LC
Caranx tille	LC	*Chaetodon larvatus*	LC
Carcharhinus amblyrhynchos	EN	*Chaetodon lineolatus*	LC
Carcharhinus dussumieri	EN	*Chaetodon lunula*	LC
Carcharhinus melanopterus	VU	*Chaetodon melannotus*	LC
Centriscus scutatus	LC	*Chaetodon meyeri*	LC
Centropyge bicolor	LC	*Chaetodon ocellicaudus*	DD
Centropyge bispinosa	LC	*Chaetodon octofasciatus*	LC
Centropyge eibli	LC	*Chaetodon ornatissimus*	LC
Centropyge heraldi	LC	*Chaetodon plebeius*	LC
Centropyge multispinis	LC	*Chaetodon punctatofasciatus*	LC
Centropyge nox	LC	*Chaetodon rafflesii*	LC
Centropyge tibicen	LC	*Chaetodon reticulatus*	DD
Centropyge vrolikii	LC	*Chaetodon selene*	LC
Cephalopholis argus	LC	*Chaetodon semeion*	LC
Cephalopholis aurantia	LC	*Chaetodon speculum*	LC
Cephalopholis boenak	LC	*Chaetodon triangulum*	LC
Cephalopholis cyanostigma	LC	*Chaetodon trifascialis*	NT
Cephalopholis formosa	LC	*Chaetodon trifasciatus*	LC
Cephalopholis leopardus	LC	*Chaetodon ulietensis*	LC
Cephalopholis microprion	LC	*Chaetodon unimaculatus*	LC
Cephalopholis miniata	LC	*Chaetodon vagabundus*	LC
Cephalopholis sexmaculata	LC	*Chaetodon wiebeli*	LC
Cephalopholis sonnerati	LC	*Chaetodontoplus conspicillatus*	LC
Cephalopholis spiloparaea	LC	*Chaetodontoplus melanosoma*	LC
Cephalopholis urodeta	LC	*Chaetodontoplus mesoleucus*	LC
Cetoscarus bicolor	LC	*Chaetodontoplus septentrionalis*	LC
Chaetodermis penicilligera	LC	*Champsodon nudivittis*	NE
Chaetodon adiergastos	LC	*Chanos chanos*	LC
Chaetodon assarius	LC	*Cheilinus chlorourus*	LC
Chaetodon auriga	LC	*Cheilinus fasciatus*	LC
Chaetodon auripes	LC	*Cheilinus oxycephalus*	LC
Chaetodon baronessa	LC	*Cheilinus trilobatus*	LC
Chaetodon bennetti	DD	*Cheilinus undulatus*	EN
Chaetodon burgessi	LC	*Cheilio inermis*	LC
Chaetodon citrinellus	LC	*Cheilodipterus artus*	LC
Chaetodon collare	LC	*Cheilodipterus intermedius*	NE
Chaetodon decussatus	LC	*Cheilodipterus isostigmus*	LC
Chaetodon ephippium	LC	*Cheilodipterus macrodon*	LC
Chaetodon guttatissimus	LC	*Cheilodipterus quinquelineatus*	LC

Species	IUCN Status	Species	IUCN Status
Cheiloprion labiatus	NE	*Chrysiptera oxycephala*	LC
Chelmon marginalis	LC	*Chrysiptera rollandi*	LC
Chelonodon patoca	LC	*Chrysiptera starcki*	LC
Chiloscyllium griseum	VU	*Chrysiptera talboti*	LC
Chiloscyllium indicum	VU	*Chrysiptera unimaculata*	LC
Chiloscyllium punctatum	NT	*Cirrhilabrus cyanopleura*	DD
Chirocentrus dorab	LC	*Cirrhitichthys falco*	LC
Chirocentrus nudus	LC	*Cirrhitichthys oxycephalus*	LC
Chlorurus bleekeri	LC	*Cirripectes filamentosus*	LC
Chlorurus bowersi	NT	*Conger myriaster*	LC
Chlorurus japanensis	LC	*Congresox talabonoides*	LC
Chlorurus microrhinos	LC	*Coradion altivelis*	LC
Chlorurus sordidus	LC	*Coradion chrysozonus*	LC
Choerodon anchorago	LC	*Coris aygula*	LC
Choerodon jordani	LC	*Coris batuensis*	LC
Choerodon schoenleinii	NT	*Coris dorsomacula*	LC
Choridactylus multibarbus	LC	*Coris gaimard*	LC
Chromis alpha	LC	*Coris pictoides*	LC
Chromis amboinensis	LC	*Coris variegata*	LC
Chromis analis	LC	*Corythoichthys amplexus*	LC
Chromis atripectoralis	LC	*Corythoichthys haematopterus*	LC
Chromis atripes	LC	*Crenimugil buchanani*	LC
Chromis cinerascens	LC	*Crenimugil crenilabis*	LC
Chromis dimidiata	LC	*Cromileptes altivelis*	VU
Chromis elerae	LC	*Crossosalarias macrospilus*	LC
Chromis lepidolepis	LC	*Cryptocentrus caeruleomaculatus*	LC
Chromis lineata	LC	*Cryptocentrus cinctus*	LC
Chromis margaritifer	LC	*Cryptocentrus fasciatus*	LC
Chromis opercularis	LC	*Cryptocentrus leptocephalus*	LC
Chromis retrofasciatus	LC	*Ctenochaetus binotatus*	LC
Chromis scotochiloptera	LC	*Ctenochaetus cyanocheilus*	LC
Chromis ternatensis	LC	*Ctenochaetus striatus*	LC
Chromis viridis	LC	*Ctenogobiops aurocingulus*	LC
Chromis weberi	LC	*Ctenogobiops pomastictus*	LC
Chromis xanthochira	LC	*Cyclichthys orbicularis*	LC
Chromis xanthura	LC	*Cymbacephalus beauforti*	LC
Chrysiptera biocellata	LC	*Cynoglossus arel*	DD
Chrysiptera brownriggii	LC	*Cynoglossus bilineatus*	LC
Chrysiptera caeruleolineata	LC	*Cynoglossus kopsii*	LC
Chrysiptera cyanea	LC	*Cynoglossus lingua*	LC

Species	IUCN Status	Species	IUCN Status
Cynoglossus puncticeps	LC	*Ecsenius yaeyamaensis*	LC
Cypselurus oligolepis	DD	*Elagatis bipinnulata*	LC
Dactyloptena orientalis	LC	*Eleutheronema tetradactylum*	DD
Dactyloptena papilio	NE	*Ellochelon vaigiensis*	LC
Dactylopus dactylopus	LC	*Elops machnata*	LC
Dascyllus aruanus	LC	*Enchelycore bayeri*	LC
Dascyllus carneus	LC	*Encrasicholina heteroloba*	LC
Dascyllus melanurus	LC	*Engyprosopon grandisquama*	LC
Dascyllus reticulatus	LC	*Engyprosopon multisquama*	LC
Dascyllus trimaculatus	LC	*Entomacrodus thalassinus*	LC
Decapterus kurroides	LC	*Ephippus orbis*	LC
Decapterus macrosoma	LC	*Epibulus insidiator*	LC
Decapterus maruadsi	LC	*Epinephelus areolatus*	LC
Decapterus russelli	LC	*Epinephelus bleekeri*	DD
Dendrochirus biocellatus	LC	*Epinephelus coioides*	LC
Dendrochirus zebra	LC	*Epinephelus corallicola*	LC
Dendrophysa russelii	LC	*Epinephelus diacanthus*	LC
Dentex angolensis	NT	*Epinephelus erythrurus*	LC
Deveximentum insidiator	NE	*Epinephelus fasciatus*	LC
Diademichthys lineatus	LC	*Epinephelus fuscoguttatus*	VU
Diagramma pictum	NT	*Epinephelus heniochus*	LC
Dichotomyctere fluviatilis	LC	*Epinephelus macrospilos*	LC
Diodon holocanthus	LC	*Epinephelus merra*	LC
Diodon hystrix	LC	*Epinephelus ongus*	LC
Diodon liturosus	NE	*Epinephelus polyphekadion*	VU
Diploprion bifasciatum	LC	*Epinephelus quoyanus*	LC
Diproctacanthus xanthurus	LC	*Epinephelus sexfasciatus*	LC
Dipterygonotus balteatus	LC	*Epinephelus tauvina*	DD
Dischistodus chrysopoecilus	LC	*Equulites elongatus*	NE
Dischistodus fasciatus	NE	*Equulites leuciscus*	LC
Dischistodus melanotus	LC	*Equulites lineolatus*	NE
Dischistodus perspiciliatus	LC	*Equulites oblongus*	NE
Dischistodus prosopotaenia	LC	*Eubleekeria jonesi*	NE
Drepane punctata	LC	*Eubleekeria splendens*	LC
Drombus ocyurus	NE	*Eugnathogobius siamensis*	LC
Echeneis naucrates	LC	*Euleptorhamphus viridis*	NE
Echidna nebulosa	LC	*Eupleurogrammus glossodon*	LC
Ecsenius bicolor	LC	*Euthynnus affinis*	LC
Ecsenius lineatus	LC	*Eviota prasina*	LC
Ecsenius midas	LC	*Exyrias bellissimus*	LC

Species	IUCN Status	Species	IUCN Status
Favonigobius aliciae	NE	*Halichoeres biocellatus*	LC
Favonigobius opalescens	NE	*Halichoeres chloropterus*	LC
Fistularia commersonii	LC	*Halichoeres chrysus*	LC
Fistularia petimba	LC	*Halichoeres hortulanus*	LC
Forcipiger flavissimus	LC	*Halichoeres leucoxanthus*	LC
Forcipiger longirostris	LC	*Halichoeres leucurus*	LC
Fusigobius duospilus	LC	*Halichoeres margaritaceus*	LC
Fusigobius inframaculatus	LC	*Halichoeres marginatus*	LC
Gazza achlamys	LC	*Halichoeres melanochir*	LC
Gazza minuta	LC	*Halichoeres melanurus*	LC
Gazza rhombea	NE	*Halichoeres nebulosus*	LC
Genicanthus melanospilos	LC	*Halichoeres nigrescens*	LC
Gerres erythrourus	LC	*Halichoeres ornatissimus*	LC
Gerres filamentosus	LC	*Halichoeres podostigma*	LC
Gerres longirostris	LC	*Halichoeres prosopeion*	LC
Gerres oyena	LC	*Halichoeres richmondi*	LC
Gnathanodon speciosus	LC	*Halichoeres scapularis*	LC
Gnathodentex aureolineatus	LC	*Halichoeres trimaculatus*	LC
Gnatholepis anjerensis	LC	*Halichoeres vrolikii*	LC
Gobiodon citrinus	LC	*Halieutaea stellata*	LC
Gobiodon quinquestrigatus	LC	*Hemiglyphidodon plagiometopon*	LC
Gomphosus varius	LC	*Hemigobius mingi*	NE
Gracila albomarginata	LC	*Hemigymnus fasciatus*	LC
Grammatobothus polyophthalmus	LC	*Hemigymnus melapterus*	LC
Grammatorcynus bilineatus	LC	*Hemipristis elongata*	VU
Grammistes sexlineatus	LC	*Hemiramphus far*	NE
Gunnellichthys monostigma	LC	*Hemitaurichthys polylepis*	LC
Gunnellichthys viridescens	LC	*Hemitaurichthys zoster*	LC
Gymnocranius elongatus	LC	*Heniochus acuminatus*	LC
Gymnocranius grandoculis	LC	*Heniochus chrysostomus*	LC
Gymnocranius griseus	LC	*Heniochus diphreutes*	LC
Gymnothorax buroensis	LC	*Heniochus monoceros*	LC
Gymnothorax enigmaticus	LC	*Heniochus pleurotaenia*	LC
Gymnothorax flavimarginatus	LC	*Heniochus singularius*	LC
Gymnothorax javanicus	LC	*Heniochus varius*	LC
Gymnothorax meleagris	LC	*Herklotsichthys punctatus*	LC
Gymnothorax pictus	LC	*Heteroconger hassi*	LC
Gymnothorax thyrsoideus	LC	*Heteropriacanthus cruentatus*	LC
Gymnothorax undulatus	LC	*Himantura undulata*	EN
Halichoeres argus	LC	*Hippocampus kuda*	VU

Species	IUCN Status	Species	IUCN Status
Hipposcarus longiceps	LC	*Lagocephalus lunaris*	LC
Hologymnosus annulatus	LC	*Lagocephalus sceleratus*	LC
Hologymnosus doliatus	LC	*Lagocephalus spadiceus*	LC
Hoplolatilus cuniculus	NE	*Lates calcarifer*	LC
Hoplolatilus fronticinctus	NE	*Leiognathus brevirostris*	NE
Hoplolatilus starcki	NE	*Leiognathus equulus*	LC
Hyporhamphus affinis	NE	*Leiognathus longispinis*	NE
Hyporhamphus dussumieri	NE	*Leiuranus semicinctus*	LC
Hyporhamphus quoyi	LC	*Lepidotrigla spiloptera*	LC
Ilisha filigera	DD	*Lepidozygus tapeinosoma*	LC
Ilisha kampeni	LC	*Leptojulis cyanopleura*	LC
Ilisha megaloptera	LC	*Lethrinus atkinsoni*	LC
Ilisha melastoma	LC	*Lethrinus erythropterus*	LC
Inegocia japonica	LC	*Lethrinus harak*	LC
Inimicus sinensis	LC	*Lethrinus lentjan*	LC
Istiblennius coronatus	NE	*Lethrinus mahsena*	EN
Istiblennius edentulus	LC	*Lethrinus microdon*	LC
Istiblennius lineatus	LC	*Lethrinus obsoletus*	LC
Istigobius decoratus	LC	*Lethrinus olivaceus*	LC
Istigobius goldmanni	LC	*Lethrinus ornatus*	LC
Istigobius ornatus	LC	*Lethrinus xanthochilus*	LC
Jaydia poeciloptera	NE	*Liachirus melanospilos*	LC
Jaydia truncata	NE	*Lobotes surinamensis*	LC
Johnius belangerii	LC	*Lutjanus argentimaculatus*	LC
Johnius carutta	LC	*Lutjanus biguttatus*	LC
Karalla daura	NE	*Lutjanus bohar*	LC
Koumansetta hectori	LC	*Lutjanus carponotatus*	LC
Kumococius rodericensis	LC	*Lutjanus decussatus*	LC
Kyphosus cinerascens	LC	*Lutjanus ehrenbergii*	LC
Kyphosus vaigiensis	LC	*Lutjanus fulviflamma*	LC
Labrichthys unilineatus	LC	*Lutjanus fulvus*	LC
Labroides bicolor	LC	*Lutjanus gibbus*	LC
Labroides dimidiatus	LC	*Lutjanus johnii*	LC
Labroides pectoralis	LC	*Lutjanus kasmira*	LC
Labropsis alleni	LC	*Lutjanus lutjanus*	LC
Labropsis manabei	LC	*Lutjanus malabaricus*	LC
Lactarius lactarius	DD	*Lutjanus monostigma*	LC
Laeops parviceps	LC	*Lutjanus quinquelineatus*	LC
Lagocephalus gloveri	DD	*Lutjanus rivulatus*	LC
Lagocephalus inermis	LC	*Lutjanus russellii*	LC

Species	IUCN Status	Species	IUCN Status
Lutjanus sebae	LC	*Naso annulatus*	LC
Lutjanus stellatus	NE	*Naso brachycentron*	LC
Lutjanus vitta	LC	*Naso brevirostris*	LC
Macolor macularis	LC	*Naso hexacanthus*	LC
Macolor niger	LC	*Naso lituratus*	LC
Macrodontogobius wilburi	LC	*Naso thynnoides*	LC
Macropharyngodon meleagris	LC	*Naso unicornis*	LC
Maculabatis gerrardi	EN	*Naso vlamingii*	LC
Malacanthus brevirostris	NE	*Naucrates ductor*	LC
Malacanthus latovittatus	NE	*Nebrius ferrugineus*	VU
Megalaspis cordyla	LC	*Nectamia bandanensis*	LC
Megalops cyprinoides	DD	*Nectamia fusca*	LC
Meiacanthus atrodorsalis	LC	*Nemapteryx caelata*	NE
Meiacanthus ditrema	LC	*Nematalosa nasus*	LC
Meiacanthus lineatus	LC	*Nemateleotris decora*	LC
Meiacanthus smithi	LC	*Nemateleotris magnifica*	LC
Melichthys niger	LC	*Nemipterus aurora*	LC
Melichthys vidua	LC	*Nemipterus balinensoides*	LC
Mene maculata	NE	*Nemipterus bathybius*	LC
Minous coccineus	LC	*Nemipterus furcosus*	LC
Minous monodactylus	LC	*Nemipterus hexodon*	LC
Minous pictus	NE	*Nemipterus japonicus*	LC
Minous trachycephalus	NE	*Nemipterus marginatus*	LC
Mobula birostris	EN	*Nemipterus mesoprion*	LC
Monacanthus chinensis	LC	*Nemipterus nematophorus*	LC
Monodactylus argenteus	LC	*Nemipterus nemurus*	LC
Monotaxis grandoculis	LC	*Nemipterus peronii*	LC
Mulloidichthys flavolineatus	LC	*Nemipterus tambuloides*	LC
Mulloidichthys vanicolensis	LC	*Nemipterus thosaporni*	LC
Muraenesox cinereus	LC	*Neoglyphidodon melas*	LC
Myripristis adusta	LC	*Neoglyphidodon nigroris*	LC
Myripristis berndti	LC	*Neoglyphidodon oxyodon*	LC
Myripristis botche	LC	*Neoglyphidodon thoracotaeniatus*	LC
Myripristis hexagona	LC	*Neoniphon opercularis*	LC
Myripristis kuntee	LC	*Neoniphon sammara*	LC
Myripristis murdjan	LC	*Neopomacentrus anabatoides*	LC
Myripristis pralinia	LC	*Neopomacentrus azysron*	LC
Myripristis violacea	LC	*Neopomacentrus bankieri*	LC
Myripristis vittata	LC	*Neopomacentrus cyanomos*	LC
Narcine maculata	VU	*Neopomacentrus filamentosus*	LC

Species	IUCN Status	Species	IUCN Status
Neopomacentrus violascens	LC	*Ozichthys albimaculosus*	LC
Neosynchiropus ocellatus	NE	*Palutrus scapulopunctatus*	LC
Neotrygon kuhlii	DD	*Pampus argenteus*	VU
Netuma bilineata	LC	*Pampus chinensis*	NE
Netuma thalassina	LC	*Paracaesio sordida*	LC
Novaculichthys taeniourus	LC	*Paracanthus hepatus*	NE
Nuchequula blochii	NE	*Paracentropyge multifasciata*	LC
Nuchequula gerreoides	DD	*Parachaetodon ocellatus*	LC
Odonus niger	LC	*Paracheilinus filamentosus*	LC
Ophichthus altipennis	LC	*Paracirrhites arcatus*	LC
Opisthopterus tardoore	LC	*Paracirrhites forsteri*	LC
Oplopomus oplopomus	LC	*Paraluteres prionurus*	LC
Osteogeneiosus militaris	NE	*Paramonacanthus choirocephalus*	LC
Osteomugil cunnesius	NE	*Paramonacanthus japonicus*	LC
Ostorhinchus aureus	LC	*Parapeneus cyclostomus*	NE
Ostorhinchus chrysopomus	LC	*Parapercis clathrata*	LC
Ostorhinchus compressus	LC	*Parapercis cylindrica*	LC
Ostorhinchus cookii	LC	*Parapercis filamentosa*	NE
Ostorhinchus cyanosoma	LC	*Parapercis pulchella*	LC
Ostorhinchus dispar	LC	*Parapercis snyderi*	LC
Ostorhinchus fasciatus	LC	*Parapercis xanthozona*	LC
Ostorhinchus griffini	LC	*Paraplagusia bilineata*	LC
Ostorhinchus hartzfeldii	LC	*Parapriacanthus ransonneti*	NE
Ostorhinchus nigrofasciatus	LC	*Parascolopsis tanyactis*	LC
Ostorhinchus novemfasciatus	LC	*Parascorpaena mcadamsi*	LC
Ostorhinchus sealei	NE	*Parastromateus niger*	LC
Ostorhinchus semilineatus	NE	*Pardachirus pavoninus*	LC
Ostorhinchus septemstriatus	NE	*Parupeneus barberinoides*	LC
Ostorhinchus taeniophorus	NE	*Parupeneus barberinus*	LC
Ostracion cubicus	LC	*Parupeneus ciliatus*	LC
Ostracion meleagris	NE	*Parupeneus heptacanthus*	LC
Ostracion solorense	NE	*Parupeneus indicus*	LC
Otolithes ruber	LC	*Parupeneus macronemus*	LC
Oxycheilinus celebicus	LC	*Parupeneus multifasciatus*	LC
Oxycheilinus diagramma	LC	*Parupeneus pleurostigma*	LC
Oxycheilinus mentalis	LC	*Parupeneus trifasciatus*	LC
Oxycheilinus orientalis	LC	*Pateobatis jenkinsii*	VU
Oxycirrhites typus	LC	*Pegasus laternarius*	DD
Oxymonacanthus longirostris	VU	*Pempheris oualensis*	NE
Oxyurichthys papuensis	LC	*Pempheris schwenkii*	NE

Species	IUCN Status	Species	IUCN Status
Pempheris vanicolensis	NE	*Plectroglyphidodon dickii*	NT
Pennahia anea	LC	*Plectroglyphidodon fasciolatus*	LC
Pennahia macrocephalus	LC	*Plectroglyphidodon leucozonus*	LC
Pentapodus bifasciatus	LC	*Plectropomus areolatus*	VU
Pentapodus caninus	LC	*Plectropomus laevis*	LC
Pentapodus emeryii	LC	*Plectropomus leopardus*	LC
Pentapodus setosus	LC	*Plectropomus maculatus*	LC
Pentapodus trivittatus	LC	*Plectropomus oligacanthus*	LC
Pentaprion longimanus	LC	*Plesiops coeruleolineatus*	LC
Pervagor janthinosoma	LC	*Plicofollis layardi*	NE
Pervagor melanocephalus	LC	*Plotosus canius*	NE
Petroscirtes variabilis	LC	*Plotosus lineatus*	LC
Photoblepharon palpebratum	LC	*Polydactylus sextarius*	NE
Photolateralis stercorarius	NE	*Pomacanthus annularis*	LC
Photopectoralis bindus	DD	*Pomacanthus imperator*	LC
Pictichromis diadema	LC	*Pomacanthus semicirculatus*	LC
Plagiotremus phenax	LC	*Pomacanthus sexstriatus*	LC
Plagiotremus rhinorhyncos	LC	*Pomacanthus xanthometopon*	LC
Planiliza macrolepis	LC	*Pomacentrus adelus*	NE
Planiliza subviridis	LC	*Pomacentrus alexandrae*	NE
Planiliza tade	DD	*Pomacentrus alleni*	LC
Platax batavianus	NE	*Pomacentrus amboinensis*	LC
Platax orbicularis	LC	*Pomacentrus auriventris*	LC
Platax pinnatus	NE	*Pomacentrus bankanensis*	LC
Platax teira	LC	*Pomacentrus bintanensis*	NE
Platybelone platyura	NE	*Pomacentrus brachialis*	NE
Platycephalus indicus	DD	*Pomacentrus chinensis*	NE
Plectorhinchus albovittatus	NE	*Pomacentrus chrysurus*	LC
Plectorhinchus celebicus	NE	*Pomacentrus coelestis*	LC
Plectorhinchus chaetodonoides	NE	*Pomacentrus cuneatus*	NE
Plectorhinchus chubbi	DD	*Pomacentrus grammorhynchus*	LC
Plectorhinchus chyrsotaenia	NE	*Pomacentrus lepidogenys*	NT
Plectorhinchus flavomaculatus	NE	*Pomacentrus littoralis*	NE
Plectorhinchus gibbosus	LC	*Pomacentrus moluccensis*	LC
Plectorhinchus lessonii	NE	*Pomacentrus nagaskiensis*	NE
Plectorhinchus lineatus	NE	*Pomacentrus nigromarginatus*	LC
Plectorhinchus obscurus	NE	*Pomacentrus pavo*	LC
Plectorhinchus polytaenia	LC	*Pomacentrus philippinus*	LC
Plectorhinchus sordidus	LC	*Pomacentrus reidi*	LC
Plectorhinchus vittatus	LC	*Pomacentrus simsiang*	LC

Species	IUCN Status	Species	IUCN Status
Pomacentrus stigma	NE	*Pseudodax moluccanus*	LC
Pomacentrus tripunctatus	LC	*Pseudomonacanthus macrurus*	LC
Pomacentrus vaiuli	LC	*Pseudorhombus arsius*	LC
Pomadasys argenteus	LC	*Pseudorhombus diplospilus*	LC
Pomadasys argyreus	LC	*Pseudorhombus elevatus*	LC
Pomadasys kaakan	LC	*Pseudorhombus malayanus*	LC
Pomadasys maculatus	LC	*Pseudorhombus quinquocellatus*	LC
Premnas biaculeatus	LC	*Pseudotriacanthus strigilifer*	LC
Priacanthus blochii	LC	*Pseudochromis caudalis*	LC
Priacanthus hamrur	LC	*Pteragogus cryptus*	LC
Priacanthus tayenus	LC	*Ptereleotris evides*	LC
Priolepis cincta	LC	*Ptereleotris heteroptera*	LC
Pristiapogon exostigma	LC	*Ptereleotris microlepis*	LC
Pristiapogon fraenatus	LC	*Pterocaesio chrysozona*	LC
Pristiapogon kallopterus	LC	*Pterocaesio lativittata*	LC
Pristicon rhodopterus	LC	*Pterocaesio marri*	LC
Pristicon trimaculatus	LC	*Pterocaesio pisang*	LC
Pristipomoides filamentosus	LC	*Pterocaesio randalli*	NE
Pristipomoides multidens	LC	*Pterocaesio tile*	LC
Pristipomoides typus	LC	*Pterois antennata*	LC
Pristotis jerdoni	LC	*Pterois radiata*	LC
Psammoperca waigiensis	NE	*Pterois russelli*	LC
Psettodes erumei	DD	*Pterois volitans*	LC
Pseudamia hayashii	NE	*Pygoplites diacanthus*	LC
Pseudanthias bicolor	LC	*Rachycentron canadum*	LC
Pseudanthias dispar	LC	*Rastrelliger brachysoma*	DD
Pseudanthias huchtii	LC	*Rastrelliger faughni*	DD
Pseudanthias lori	LC	*Rastrelliger kanagurta*	DD
Pseudanthias pleurotaenia	LC	*Repomucenus virgis*	NE
Pseudanthias randalli	LC	*Rhabdamia gracilis*	NE
Pseudanthias smithvanizi	LC	*Rhincodon typus*	EN
Pseudanthias squamipinnis	LC	*Rhinecanthus aculeatus*	LC
Pseudanthias tuka	LC	*Rhinecanthus rectangulus*	LC
Pseudobalistes flavimarginatus	LC	*Rhinecanthus verrucosus*	LC
Pseudocheilinus evanidus	LC	*Rhynchobatus djiddensis*	CR
Pseudocheilinus hexataenia	LC	*Rhynchorhamphus malabaricus*	NE
Pseudocheilinus octotaenia	LC	*Rhynchostracion nasus*	NE
Pseudochromis fuscus	LC	*Rogadius pristiger*	LC
Pseudochromis ransonneti	NE	*Salarias fasciatus*	LC
Pseudocoris yamashiroi	LC	*Samaris cristatus*	LC

Species	IUCN Status	Species	IUCN Status
Sardinella frimbriata	LC	*Scolopsis taenioptera*	LC
Sardinella gibbosa	LC	*Scolopsis trilineata*	LC
Sargocentron caudimaculatum	LC	*Scolopsis vosmeri*	LC
Sargocentron cornutum	LC	*Scomberoides commersonnianus*	LC
Sargocentron diadema	LC	*Scomberoides lysan*	LC
Sargocentron microstoma	LC	*Scomberoides tol*	LC
Sargocentron praslin	LC	*Scomberomorus commerson*	NT
Sargocentron rubrum	LC	*Scomberomorus guttatus*	DD
Sargocentron seychellense	NE	*Scorpaena neglecta*	NE
Sargocentron spiniferum	LC	*Scorpaenodes scaber*	DD
Sargocentron tiere	LC	*Scorpaenodes varipinnis*	LC
Sargocentron violaceum	LC	*Scorpaenopsis cirrosa*	NE
Saurida longimanus	LC	*Scorpaenopsis diabolus*	LC
Saurida micropectoralis	LC	*Scorpaenopsis oxycephala*	LC
Saurida tumbil	LC	*Scorpaenopsis venosa*	DD
Saurida undosquamis	LC	*Secutor ruconius*	NE
Scarus dimidiatus	LC	*Selar boops*	LC
Scarus flavipectoralis	LC	*Selar crumenophthalmus*	LC
Scarus forsteni	LC	*Selaroides leptolepis*	LC
Scarus frenatus	LC	*Seriola rivoliana*	LC
Scarus ghobban	LC	*Seriolina nigrofasciata*	LC
Scarus globiceps	LC	*Setipinna breviceps*	LC
Scarus hypselopterus	NT	*Siganus argenteus*	LC
Scarus niger	LC	*Siganus canaliculatus*	LC
Scarus oviceps	LC	*Siganus corallinus*	LC
Scarus prasiognathos	LC	*Siganus guttatus*	LC
Scarus psittacus	LC	*Siganus javus*	LC
Scarus quoyi	LC	*Siganus lineatus*	LC
Scarus rivulatus	LC	*Siganus magnificus*	LC
Scarus rubroviolaceous	LC	*Siganus puellus*	LC
Scarus schlegeli	LC	*Siganus punctatus*	LC
Scarus spinus	LC	*Siganus spinus*	LC
Scarus tricolor	LC	*Siganus stellatus*	LC
Scatophagus argus	LC	*Siganus vermiculatus*	LC
Scolopsis affinis	LC	*Siganus virgatus*	LC
Scolopsis bilineata	LC	*Siganus vulpinis*	LC
Scolopsis ciliata	LC	*Sillago aeolus*	NE
Scolopsis lineata	LC	*Sillago ingenuua*	NE
Scolopsis margaritifera	LC	*Sillago sihama*	LC
Scolopsis monogramma	LC	Siphamia tubifer	LC

Species	IUCN Status	Species	IUCN Status
Sirembo jerdoni	LC	*Taeniurops meyeni*	VU
Solenostomus cyanopterus	LC	*Telatrygon zugei*	VU
Solenostomus paradoxus	LC	*Temera hardwickii*	VU
Sorsogona tuberculata	LC	*Tentoriceps cristatus*	NE
Sphaeramia orbicularis	LC	*Terapon jarbua*	LC
Sphyraena barracuda	LC	*Terapon theraps*	LC
Sphyraena flavicauda	LC	*Tetrosomus gibbosus*	LC
Sphyraena forsteri	LC	*Thalassoma amblycephalum*	LC
Sphyraena jello	LC	*Thalassoma hardwicke*	LC
Sphyraena obtusata	LC	*Thalassoma jansenii*	LC
Sphyraena putnamae	LC	*Thalassoma lunare*	LC
Sphyraena qenie	LC	*Thalassoma lutescens*	LC
Sphyrna lewini	CR	*Thalassoma quinquevittatum*	LC
Stegastes albifasciatus	LC	*Thryssa hamiltonii*	LC
Stegastes lacrymatus	NE	*Thryssa mystax*	LC
Stegastes lividus	LC	*Thryssa setirostris*	LC
Stegastes nigricans	LC	*Thunnus orientalis*	NT
Stegastes obreptus	NE	*Torpedo fuscomaculata*	DD
Stegostoma fasciatum	EN	*Torpedo marmorata*	VU
Stethojulis bandanensis	LC	*Torquigener pallimaculatus*	LC
Stethojulis interrupta	LC	*Toxotes jaculatrix*	LC
Stethojulis strigiventer	LC	*Trachinocephalus myops*	LC
Stethojulis trilineata	LC	*Trachinotus baillonii*	LC
Stolephorus commersonnii	LC	*Trachinotus blochii*	LC
Stolephorus dubiosus	LC	*Trachyrhamphus bicoarctatus*	LC
Stolephorus indicus	LC	*Triacanthus biaculeatus*	LC
Stolephorus insularis	DD	*Triaenodon obesus*	VU
Strongylura incisa	NE	*Trichiurus lepturus*	LC
Sufflamen bursa	LC	*Trimma tevegae*	LC
Sufflamen chrysopterum	LC	*Tripodicthys oxycephalus*	NE
Sufflamen frenatum	LC	*Trixiphichthys weberi*	NE
Suggrundus macracanthus	LC	*Tylosurus crocodilus*	LC
Synanceia verrucosa	LC	*Upeneus japonicus*	NE
Synodus hoshinonis	LC	*Upeneus luzonius*	NE
Synodus variegatus	LC	*Upeneus moluccensis*	LC
Taeniamia fucata	LC	*Upeneus sulphureus*	LC
Taeniamia macroptera	LC	*Upeneus sundaicus*	LC
Taeniamia zosterophora	LC	*Upeneus tragula*	LC
Taenianotus triacanthus	LC	*Uranoscopus oligolepis*	LC
Taeniura lymma	LC	*Uraspis helvola*	LC

Species	IUCN Status
Uraspis uraspis	LC
Valenciennea helsdingenii	LC
Valenciennea longipinnis	LC
Valenciennea muralis	LC
Valenciennea puellaris	LC
Valenciennea randalli	LC
Valenciennea sexguttata	LC
Valenciennea strigata	LC
Variola louti	LC
Verulux cypselurus	LC
Wetmorella albofasciata	LC
Xanthichthys auromarginatus	LC
Xiphasia setifer	LC
Xiphocheilus typus	LC
Yarica hyalosoma	LC
Zanclus cornutus	LC
Zapogon evermanni	LC
Zebrasoma scopas	LC
Zebrasoma veliferum	LC
Zoramia leptacantha	LC

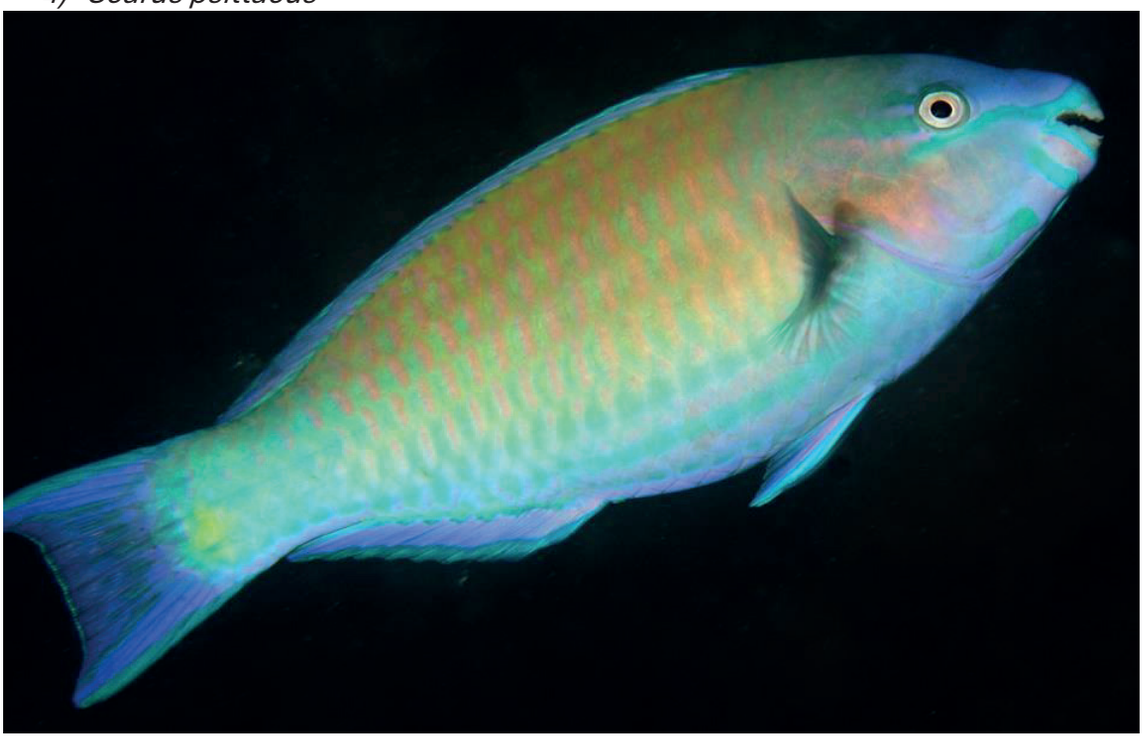
Commercially important fish

1) *Epinephelus areolatus*

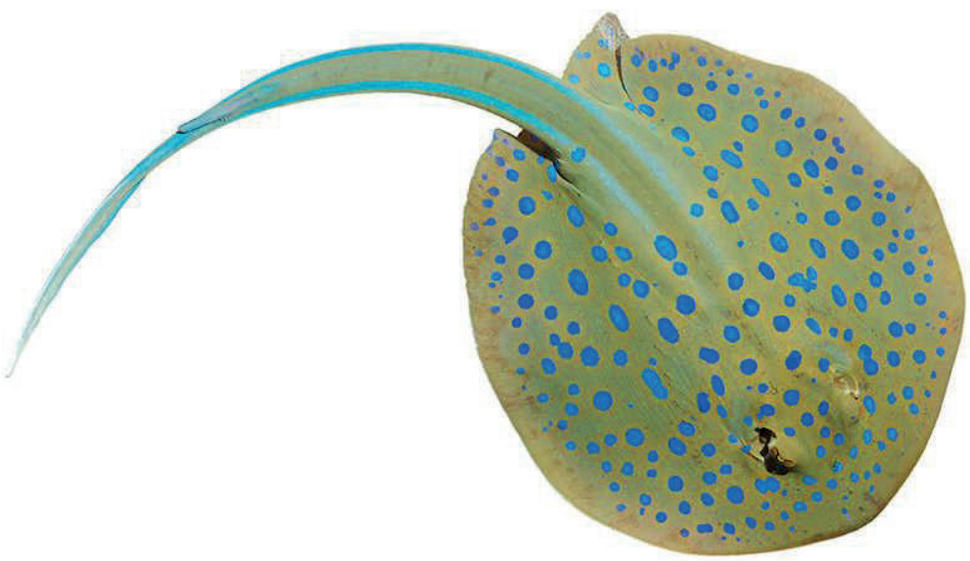
2) *Epinephelus coioides*

3) *Amphiprion ocellaris*

4) *Scarus psittacus*



5) *Taeniura lymma*



5.0 GAP ANALYSIS

Several gaps among the studies have been noted throughout reviewing and extracting data from the previous studies on coral reefs. To begin with, there were insufficient inventory list of coral reefs on species level. Many studies reported family name instead of species list. This however made evaluation process trickier without the list of endemic, endangered and "ecological resilience" to be used as reliable datasets.

Next, there were lacks of continuous or long-term monitoring on benthic covers and the changes in coral reefs structures. References in the forms of videos and photos using quadrat and transect in tourist attraction site would be beneficial for long-term monitoring process. Aside from that, long-term data collection on the physical parameters of the waters were also lacking. Data such as seawater temperature, turbidity, chlorophyll concentration and nutrient level are crucial to helps us better understand and manage these delicate ecosystems.

Furthermore, there are also few data or studies on the connectivity between coral reefs either within Marine Protected Areas (MPA) or among MPAs itself. Next, data on the effects of monsoon season on coral reefs biological response and survivability, as well as data on areas that were not gazetted as MPAs such as coastlines and fisheries intended area remains one of the biggest gaps in coral reef studies.

To end with, fewer research and publications at well known areas such as Pulau Pangkor, Melaka and Pulau Perak were very little. This might be due to limited taxonomist on fish and coral reefs.

5.0 DISCUSSION

This study has disclosed the baseline data of the coral reefs and fish community in the waters of Malaysia. In short, starting from the year 2000, there's a significant steady increase in numbers of publications where the highest number of publications were recorded in 2016. Both Sabah and Terengganu have the most publications recorded, with the advantage of having many sites that are favourable for researchers. Generally, the coral cover in Malaysia were in 'Fair' condition. Meanwhile, publications on fishes were the highest in 2005 although there was slight increase since year 1994, and fluctuated in the subsequent years.

6.1 Proposing Potentially New Marine Protected Area

Based on data collected throughout present study, few areas were selected to be proposed as MPAs. East Coast of Peninsular Conservation Zone were picked thanks to multiple usages of the area;

i. Total no-take zone
ii. Tourist zone
iii. Reserve zone (offshore)
iv. Open zone

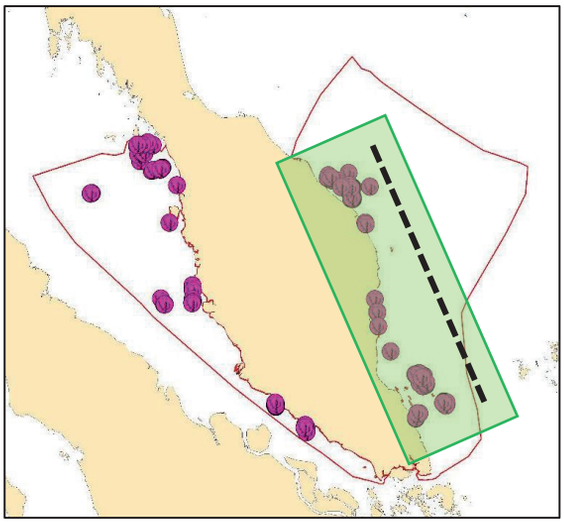


Figure 11. Proposed area for new MPA in East Coast of Peninsular Conservation Zone.

Lastly is Tun Mustapha Park and Luconia shoal National Park. Rig-to-Reef Initiative were started in order to increase the artificial reefs and new conservation areas especially in nearshore of Sarawak and Northeast of Sabah.

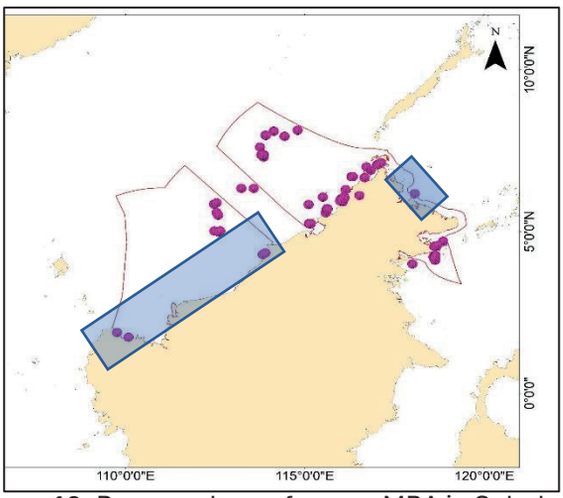


Figure 12. Proposed area for new MPA in Sabah and Sarawak.

Recommendation

Based on what was brought to light during this study, a few recommendations are proposed. First of all, coral reef areas with high resilience reefs should be identified. Secondly, long-term coral reefs monitoring on biological and physical aspects should be constructed and implemented. Numbers of coral reef restoration programmes should also be increased by local stakeholders. Last but not least, identify and build up a centre for species type and DNA information on coral reefs and reef fishes.

REFERENCES

1. Inniss, L., Simcock, A., Ajawin, A. Y., Alcala, A. C., Bernal, P., Calumpong, H. P., Araghi, P. E., Green, S. O., Harris, P., Kamara, O.K., Kohata, K., Marschoff, E., Martin, G., Ferreira, B. P., Park, C., Payet, R. A., Rice, J., Rosenberg, A., Ruwa, R., Tuhumwire, J.T., Gaever, S. V., Wang, J., & Węsławski, J. M. (2016). The first global integrated marine assessment. *United Nations. Accessed at on 5th February*.
2. Quéré, L., Moriarty, R., Andrew, R. M., Canadell, J. G., Sitch, S., Korsbakken, J. I., Friedlingstein, P., Peters, G. P., Andres, R. J., Boden, T. A., Houghton, R. A., House, J. I., Keeling, R. F., Tans, P. A., Arneth, A., Bakker, D. C. E., Barbero, L., Bopp, L., Chang, J., Chevallier, F., Chini, L. P., Ciais, P., Fader, M., Feely, R.A., Gkritzalis, T., Harris, I., Hauck, J., Ilyina, T., Jain, A. K., Kato, E., Kitidis, V., Goldewijk, K. K., Koven, C., Landschützer, P., Lauvset, S. K., Lefèvre, N., Lenton, A., Lima, I. D., Metzl, N., Millero, F., Munro, D. R., Murata, A., Nabel, J. E. M. S., Nakaoka, S., Nojiri, Y., O'Brien, K., Olsen, A., Ono, T., Pérez, F. F., Pfeil, B., Pierrot, D., Poulter, B., Rehder, G., Rödenbeck, C., Saito, S., Schuster, U., Schwinger, J., Séférian, R., Steinhoff, T., Stocker, B. D., Sutton, A. J., Takahashi, T., Tilbrook, B., van der Lan-Luijkx, I. T., van der Werf, G. R., van Heuven, S., Vandemark, D., Viovy, N., Wiltshire, A., Zaehle, S., & Zeng, N. (2015). Global carbon budget 2015. *Earth System Science Data*.
3. Chou, L., Wilkinson, C. C., Licuanan, W., Alino, P. P., Cheshire, A. A., Loo, M. G. K., Tangjaitrong, S., Sudara, S., Ridzwan, A. R., & Soekarno, S. S. (1995, January). Status of coral reefs in the ASEAN region. In Proceedings, Third ASEAN-Australia Symposium on Living Coastal Resources, Chulalongkorn University, Bangkok, Thailand, 16-20 May 1994. Volume 1. Status Reviews-pages: 1-10. Australian Institute of Marine Science (AIMS).
4. Karim, A. K. A., & Ramli, M. N. (2003). Pelancongan dan Alam Sekitar: Taman Laut Malaysia. Trade liberalization and agricultural sector in Malaysia. Bangi, Selangor: Fakulti Ekonomi UKM.
5. Kay, A. M., & Liddle, M. J. (1989). Impact of human trampling in different zones of a coral reef flat. Environmental management, 13(4), 509-520.
6. Hawkins, J. P., & Roberts, C. M. (1993). Effects of recreational scuba diving on coral reefs: trampling on reef-flat communities. Journal of Applied Ecology, 25-30.
7. Juhi, Z. S., Mubin, N. A. A. A., Jonik, M. G. G., Salleh, S., & Mohammad, M. (2021). Impact of short-term light variability on the photobiology of turbid water corals. Journal of Sea Research, 175, 102088.
8. Mahadi, M., Zulfigar, Y., & Tan, A. S. H. (2004). The distribution of soft coral genus Dendronephthya (Alcyonacea: Nephtheidae) at Pemanggil Island in South China Sea, Malaysia. Marine science into the new millennium: new perspective and Phang, et al., challenges. Kuala Lumpur, Malaysia: University of Malaya, 103-124.
9. Lau, Y. W., & Reimer, J. D. (2019). A first phylogenetic study on stoloniferous octocorals off the coast of Kota Kinabalu, Sabah, Malaysia, with the description of two new genera and five new species. ZooKeys, 872, 127.
10. Waheed, Z., & Hoeksema, B. W. (2013). A tale of two winds: species richness patterns of reef corals around the Semporna peninsula, Malaysia. Marine Biodiversity, 43(1), 37-51.
11. Montagne, A., Naim, O., Tourrand, C., Pierson, B., & Menier, D. (2013). Status of coral reef communities on two carbonate platforms (Tun Sakaran Marine Park, East Sabah, Malaysia). *Journal of Ecosystems*, *2013*.
12. Xin, L. H., Cheliah, A., Yee, C. S., Hyde, J., Cob, Z. C., & Adzis, K. A. A. (2013). Comparison of Acropora formosa coral growth in natural habitat condition between Tioman Island and Pangkor Island, Malaysia. *Journal of Science and Technology in the Tropics*, *9*(1), 31-45.
13. Waheed, Z., & Hoeksema, B. W. (2014). Diversity patterns of scleractinian corals at Kota Kinabalu, Malaysia, in relation to exposure and depth. *Raffles Bulletin of Zoology*, *62*.

14. Rani, M. H., Saad, S., Khodzari, M. F. A., Ramli, R., & Yusof, M. H. (2015). Scleractinian coral recruitment density in coastal water of Balok, Pahang, Malaysia. *Jurnal Teknologi*, *77*(25).
15. Khodzori, M. F. A., Saad, S., Nordin, N. F. H., Salleh, M. F., Rani, M. H., Yusof, M. H., & Noor, N. M. (2015). Diversity and distribution of Euphyllidae corals in Tioman Island: emphasis on the genetic variation of Euphyllia cristata. *Jurnal Teknologi*, *77*(24).
16. Chelliah, A., Amar, H. B., Hyde, J., Yewdall, K., Steinberg, P. D., & Guest, J. R. (2015). First record of multi-species synchronous coral spawning from Malaysia. *PeerJ*, *3*, e777.
17. Waheed, Z., Benzoni, F., Van Der Meij, S. E., Terraneo, T. I., & Hoeksema, B. W. (2015). Scleractinian corals (Fungiidae, Agariciidae and Euphylliidae) of Pulau Layang-Layang, Spratly Islands, with a note on Pavona maldivensis (Gardiner, 1905). *ZooKeys*, (517), 1.
18. Waheed, Z., van Mil, H. G., Syed Hussein, M. A., Jumin, R., Golam Ahad, B., & Hoeksema, B. W. (2015). Coral reefs at the northernmost tip of Borneo: an assessment of scleractinian species richness patterns and benthic reef assemblages. *PloS one*, *10*(12), e0146006.
19. Safuan, M., Wee, H. B., Ibrahim, Y. S., Idris, I., & Bachok, Z. (2016). Current status on community structure of coral reefs around west coast of Peninsular Malaysia using coral video transect technique. *Journal of Sustainability Science and Management Special Issue*, (1), 107-117.
20. Mohammad, M., Apandi, Z. N. I., Marican, H. A. W., Kamphol, N., Mubin, N. A. A. A., Salleh, S., & Ismail, M. N. (2016). The identification of octocorals from the northern region of Straits of Malacca. *Tropical Life Sciences Research*, *27*(supp1), 87.
21. Xin, L. H., Adzis, K. A. A., Hyde, J., & Cob, Z. C. (2016). Growth performance of Acropora formosa in natural reefs and coral nurseries for reef restoration. *AACL Bioflux*, *9*(5).
22. Muhammad Faiz, M. H., Saad, S., Mukai, Y., & Ahmad, Z. (2017). Relationship between adult abundance and successive coral recruitment density in the Tioman Island Marine Park, Malaysia. *Zoology and Ecology*, *27*(3-4), 328-334.
23. Saad, S., & Khodzori, F. A. (2017). Species diversity and abundance of Euphylliidae (Cnidaria: Anthozoa: Scleractinia) corals in Tioman, Redang and Payar Islands, Peninsular Malaysia. *Borneo Journal of Marine Science and Aquaculture (BJoMSA)*.
24. Shahbudin, S., Akmal, K. F., Faris, S., Normawaty, M. N., & Mukai, Y. (2017). Current status of coral reefs in Tioman Island, Peninsular Malaysia. *Turkish Journal of Zoology*, *41*(2), 294-305.
25. Akmal, K. F., Shahbudin, S., Hadry, N. N. F., Ulwan, K. S. K. A., & Amira, M. Z. K. (2017). Taxonomic status of Euphylliidae corals in Peninsular Malaysia based on morphological structures and phylogenetic analyses using mitochondrial COI gene. *Russian Journal of Marine Biology*, *43*(2), 118-126.
26. Safuan, C. D. M., Ali, A., Zainol, Z., Ali, A., Akhir, M. F. M., Muslim, A. M., & Bachok, Z. (2018). A baseline assessment of coral reef in Malacca Straits, Malaysia. *Ocean Science Journal*, *53*(2), 275-283.
27. Safuan, C. D. M., Ismail, K., Khalil, I., Ali, A., Chong, W. S., Chan, A. A., Ismail, M. N., Md Repin, I., & Bachok, Z. (2018). Quantification of coral reef benthos for coral health assessment in Labuan Marine Park, Malaysia. *J. Sustain. Sci. Manag*, *13*, 101-112.
28. Akmal, K. F., Shahbudin, S., Faiz, M. H. M., & Hamizan, Y. M. (2019). Diversity and abundance of scleractinian corals in the East Coast of peninsular Malaysia: a case study of Redang and Tioman Islands. *Ocean Science Journal*, *54*(3), 435-456.
29. Hanapiah, M. F. M., Saad, S., Ahmad, Z., Yusof, M. H., & Khodzori, M. F. A. (2019). Assessment of benthic and coral community structure in an inshore reef in Balok, Pahang, Malaysia. *Biodiversitas Journal of Biological Diversity*, *20*(3), 872-877.
30. Ismail, M. S., & Khoo, M. L. (2019). Community structure of coral reefs in Pulau Mertang, Johor, Malaysia. *Sains Malaysiana*, *48*(11), 2335-2342.

31. Khodzori, F. A., Saad, S., & Mohammad Noor, N. (2019). Coral community structure in Payar Island Marine Park, Malaysia. *Journal of Sustainability Science and Management*, *14*(1), 29-39.
32. Browne, N., Braoun, C., McIlwain, J., Nagarajan, R., & Zinke, J. (2019). Borneo coral reefs subject to high sediment loads show evidence of resilience to various environmental stressors. *PeerJ*, *7*, e7382.
33. Crehan, O., Mair, J., Yii, S. H., Safuan, C. D. M., & Bachok, Z. (2019). Effect of Tourism and Sedimentation on Coral Cover and Community Structure. *Tropical Life Sciences Research*, *30*(2).
34. Ismail, M. S., & Goeden, G. B. (2020). Assessment of coral reefs community health in Pulau Berhala, Pahang, Malaysia. *Journal of PeerScientist*, *2*(1), e1000017.
35. Hanapiah, M. F. M., Saad, S., Ahmad, Z., Yusof, M. H., Khodzori, M. F. A., & Rosli, M. K. (2020). Broadcast spawning pattern and pelagic larvae duration of Acropora Cytherea and A. Clathrata from inshore reef area in Kuantan coastal region. *Science*, *4*(2), 32-36.
36. Saleh, E., Kiat, Y. T., Geng, C. N., Masidi, A. M., & Joseph, J. (2020). Inventory of Marine Fauna on Reef Balls Structures of Selingan Island, Sandakan, Sabah, Malaysia. *Journal of Tropical Biology & Conservation (JTBC)*, *17*, 203-216.
37. Safuan, C. D. M., Roseli, N. H., Bachok, Z., Akhir, M. F., Xia, C., & Qiao, F. (2020). First record of tropical storm (Pabuk-January 2019) damage on shallow water reef in Pulau Bidong, south of South China Sea. *Regional Studies in Marine Science*, *35*, 101216.
38. Saad, S., Khodzori, F. A., & Rani, H. (2021). Spatial and Temporal Variation of Scleractinian Coral Recruitment in Balok Coastal Waters and Bidong Island, Malaysia. *Malaysian Journal of Applied Sciences*, *6*(1), 1-14.
39. Lee, J., & Mohamed, C. A. R. (2011). Accumulation of settling particles in some coral reef areas of Peninsular Malaysia. *Sains Malaysiana*, *40*(6), 549-554.
40. Teh, L. C., Teh, L. S., & Chung, F. C. (2008). A private management approach to coral reef conservation in Sabah, Malaysia. *Biodiversity and conservation*, *17*(13), 3061-3077.
41. Nakajima, R., Yoshida, T., Othman, B. H. R., & Toda, T. (2009). Diel variation of zooplankton in the tropical coral-reef water of Tioman Island, Malaysia. *Aquatic Ecology*, *43*(4), 965-975.
42. Nakajima, R., Yoshida, T., Othman, B. H. R., & Toda, T. (2008). Diel variation in abundance, biomass and size composition of zooplankton community over a coral-reef in Redang Island, Malaysia. *Plankton and Benthos Research*, *3*(4), 216-226.
43. Comley, J., Walker, R., Wilson, J., Ramsay, A., Smith, I., Raines, P., & Parks, M. (2004). Malaysia coral reef conservation project: Pulau Redang. *Report to the Department of Marine Parks, Malaysia. Retrieved May*, *12*, 2014.
44. Tan, C. H., & SF, H. (2011). First observed severe mass bleaching in Malaysia, Greater Coral Triangle. *Galaxea, Journal of Coral Reef Studies*, *13*(1), 27-28.
45. Toda, T., Okashita, T., Maekawa, T., Alfian, B. A. A. K., Rajuddin, M. K. M., Nakajima, R., Chen, W., Takahashi, K. T., Othman, B. H. R., & Terazaki, M. (2007). Community structures of coral reefs around Peninsular Malaysia. *Journal of Oceanography*, *63*(1), 113-123.
46. Asner, G. P., Martin, R. E., & Mascaro, J. (2017). Coral reef atoll assessment in the South China Sea using Planet Dove satellites. *Remote Sensing in Ecology and Conservation*, *3*(2), 57-65.
47. Ismail, M. S., Ilias, Z., Ismail, M., Goeden, G. B., Yap, C. K., Al-Mutairi, K. A., & Al-Shami, S. A. (2022). Coral health assessment in Malaysia: a case study of Pulau Anak Datai, Langkawi. *Environmental Science and Pollution Research*, 1-12.
48. Wood, E., & Dipper, F. (2008, July). What is the future for extensive areas of reef impacted by fish blasting and coral bleaching and now dominated by soft corals? A case study from

Malaysia. In *Proceedings of the 11th International Coral Reef Symposium, Fort Lauderdale (USA)* (pp. 410-414).
49. Yong, H. L., Mustapa, N. I., Lee, L. K., Lim, Z. F., Tan, T. H., Usup, G., Gu, H., Litaker, R. W., Tester, P. A., Lim, P. T., & Leaw, C. P. (2018). Habitat complexity affects benthic harmful dinoflagellate assemblages in the fringing reef of Rawa Island, Malaysia. *Harmful Algae*, *78*, 56-68.
50. Tun, K., Chou, L. M., Cabanban, A., Tuan, V. S., Suharsono, T. Y., Sour, K., & Lane, D. (2005). Status of coral reefs, coral reef monitoring and management in Southeast Asia 2004.
51. Nakajima, R., Tanaka, Y., Yoshida, T., Fujisawa, T., Nakayama, A., Fuchinoue, Y., Othman, B. H. R., & Toda, T. (2015). High inorganic phosphate concentration in coral mucus and its utilization by heterotrophic bacteria in a Malaysian coral reef. *Marine Ecology*, *36*(3), 835-841.
52. Waheed, Z., Han, D., & Hussein, M. A. S. (2021). Mapping coral reef using photogrammetry technique: A preliminary study at Pulau Udar Besar, Sabah, Malaysia. *Borneo Journal of Marine Science and Aquaculture (BJoMSA)*, *5*(2), 70-74.
53. White, A. T. (1986). Marine reserves: How effective as management strategies for Philippine, Indonesian and Malaysian coral reef environments?. *Ocean Management*, *10*(2), 137-159.
54. Wetzelhuetter, C., Chelliah, A., & Chen, S. Y. (2014). Coastal Ecosystem: Coral reef environment-monitoring of coral reefs in the marine parks of Terengganu and Tioman, Malaysia, using reef check methods. *Coastal Ecosystems*, 75.
55. Nakajima, R., Tsuchiya, K., Nakatomi, N., Yoshida, T., Tada, Y., Konno, F., Toda, T., Kuwahara, V. S., Hamasaki, K., Othman, B. H. R., Segaran, T. C., & Effendy, A. W. M. (2013). Enrichment of microbial abundance in the sea-surface microlayer over a coral reef: implications for biogeochemical cycles in reef ecosystems. *Marine Ecology Progress Series*, *490*, 11-22.
56. Wee, H. B., Reimer, J. D., Safuan, M., Saidin, J., Tan, C. H., & Bachok, Z. (2017). Zoantharian abundance in coral reef benthic communities at Terengganu Islands, Malaysia. *Regional Studies in Marine Science*, *12*, 58-63.
57. Zhang, L. Y., Chung, S. S., & Qiu, J. W. (2016). Ecological carrying capacity assessment of diving site: A case study of Mabul Island, Malaysia. *Journal of environmental management*, *183*, 253-259.
58. Tan, T. H., Lim, P. T., Mujahid, A., Usup, G., & Leaw, C. P. (2013). Benthic harmful dinoflagellate assemblages in a fringing reef of Sampadi Island, Sarawak, Malaysia. *Mar. Res. Indonesia*, *38*(2), 11-21.
59. Hoeksema, B. W., & Waheed, Z. (2012). Onset of autotomy in an attached Cycloseris coral. *Galaxea, Journal of Coral Reef Studies*, *14*(1), 25-26.
60. Tan, C. H., Safuan, C. D. M., Idris, I., Noor, M. R. H. M., Samshuri, M. A., Kamarudin, N., Zaidi, P. N., Jaafar, S. N., & Baird, A. H. (2020). Multispecific synchronous coral spawning on Pulau Bidong, Malaysia, South China Sea. *Bull. Mar. Sci*, *96*, 193-194.
61. Harborne, A., Fenner, D., Barnes, A., Beger, M., Harding, S., & Roxburgh, T. (2000). Status report on the coral reefs of the east coast of Peninsula Malaysia. *Report Prepared to Department of Fisheries Malaysia, Kuala Lumpur, Malaysia*, 361-369.
62. Mazlan, A. G., Zaidi, C. C., Wan-Lotfi, W. M., & Othman, B. H. R. (2005). On the current status of coastal marine biodiversity in Malaysia.
63. Takabayashi, M., Carter, D., Lopez, J., & Hoegh-Guldberg, O. (2003). Genetic variation of the scleractinian coral Stylophora pistillata, from western Pacific reefs. *Coral Reefs*, *22*(1), 17-22.

64. Kalimutho, M., Ahmad, A., & Kassim, Z. (2007). Isolation, characterization and identification of bacteria associated with mucus of Acropora cervicornis coral from Bidong island, Terengganu, Malaysia. *Malaysian Journal of Science*, *26*(2), 27-39.
65. Chou, L. M., Yeemin, T., Yaman, A. R. B. G., Vo, S. T., & Alino, P. (2009). Coral reef restoration in the South China Sea. *Galaxea, Journal of Coral Reef Studies*, *11*(2), 67-74.
66. Chen, F., Wu, J., Liu, J., Hu, Y., Chen, X., Lim, P. E., Abdullah, W. M. A., Sjafrie, N. D. M., & Adirianto, B. (2019). Comparison of social-value cognition based on different groups: The case of Pulau Payar in Malaysia and Gili Matra in Indonesia. *Ocean & Coastal Management*, *173*, 1-9.
67. Hoeksema, B. W., & Waheed, Z. (2011). Size-dependent dispersal by Goniopora stokesi corals at Semporna, eastern Sabah, Malaysia. *Galaxea, Journal of Coral Reef Studies*, *13*(1), 9-10.
68. Hossain, M. S., Muslim, A. M., Nadzri, M. I., Teruhisa, K., David, D., Khalil, I., & Mohamad, Z. (2020). Can ensemble techniques improve coral reef habitat classification accuracy using multispectral data?. *Geocarto International*, *35*(11), 1214-1232.
69. Lee, Y. L., Affendi, Y. A., Tajuddin, B. H., Yusuf, Y. B., Kee Alfan, A. A., & Anuar, E. A. (2005). A post-tsunami assessment of coastal living resources of Langkawi Archipelago, Peninsular Malaysia.
70. Ahmad, S. A., & Hanley, N. (2009). Willingness to pay for reducing crowding effect damages in marine parks in Malaysia. *The Singapore Economic Review*, *54*(01), 21-39.
71. van der Meij, S. E., & Hoeksema, B. W. (2013). Distribution of gall crabs inhabiting mushroom corals on Semporna reefs, Malaysia. *Marine Biodiversity*, *43*(1), 53-59.
72. Nakajima, R., Nakayama, A., Yoshida, T., Kushairi, M. R. M., Othman, B. H. R., & Toda, T. (2010). An evaluation of photo line-intercept transect (PLIT) method for coral reef monitoring. *Galaxea, Journal of Coral Reef Studies*, *12*(1), 37-44.
73. Lee, J. N., & Mohamed, C. A. R. (2009). Trace metal contents in the Porites corals of Peninsular Malaysia.
74. Hyde, J., Chen, S. Y., & Chelliah, A. (2013). Five Years of Reef Check Monitoring Data for Tioman, Perhentian and Redang Island. *Malaysian Journal of Science*, *32*, 117-126.
75. Noordin Raja Omar, R. M., Eng Kean, C., Wagiman, S., Mutalib Mat Hassan, A., Hussein, M., Bidin Raja Hassan, R., & Omar Mat Hussin, C. (1994). Design and construction of artificial reefs in Malaysia. *Bulletin of Marine Science*, *55*(2-3), 1050-1061.
76. Jonsson, D. (2002). An inventory of coral reefs in the Langkawi archipelago, Malaysia: assessment and impact study of sedimentation. *Undergraduate Thesis, Department of Animal Ecology, Uppsala University, Sweden*.
77. Hoeksema, B. W., & Waheed, Z. (2011). Initial phase of autotomy in fragmenting Cycloseris corals at Semporna, eastern Sabah, Malaysia. *Coral Reefs*, *30*(4), 1087-1087.
78. Nakajima, R., Yoshida, T., Fuchinoue, Y., Okashita, T., Maekawa, T., Kushairi, M. R. M., Othman, B. H. R., & Toda, T. (2013). Sedimentation impacts on the growth rates of the scleractinian coral Acropora formosa from fringing reefs of Tioman Island, Malaysia. *Sains Malaysiana*, *42*(9), 1201-1205.
79. Lau, C. M. (2014). *Fish and trophic connectivity across coral reef and mangrove habitats of north eastern Langkawi Island, Peninsular Malaysia/Lau Chai Ming* (Doctoral dissertation, University of Malaya).
80. Kvernevik, T. I., Zambri Mohd Akhir, M., & Studholme, J. (2002). A low-cost procedure for automatic seafloor mapping, with particular reference to coral reef conservation in developing nations. *Hydrobiologia*, *474*(1), 67-79.
81. Ho, N. A. J., & Kassem, K. R. (2009). *Reef Status of Semporna Priority Conservation Area*. Kota Kinabalu: WWF-Malaysia.
82. Lau, C. M., Kee-Alfian, A. A., Affendi, Y. A., Hyde, J., Chelliah, A., Leong, Y. S., Low, Y. L., Yusop, P. A. M., Leong, V. T., Halimi, A. M., Shahir, Y. M., Ramdhan, R. M., Lim, A. G., &

Zainal, N. I. (2019). Tracing coral reefs: A citizen science approach in mapping coral reefs to enhance Marine Park management strategies. *Frontiers in Marine Science*, *6*, 539.
83. Adzis, K. A. A., Amri, A. Y., Oliver, J., & Mohamed, C. A. R. (2009). Effective and maximum quantum yield of the lace coral Pocillopora damicornis (Anthozoa: Scleractinia: Pocilloporidae) in Pulau Tioman, Malaysia. *Journal of Science and Technology in the Tropics*, *5*(1), 13-17.
84. Mustapha, M. A., Lihan, T., & Khalid, L. I. (2014). Coral reef and associated habitat mapping using ALOS satellite imagery. *Sains Malaysiana*, *43*(9), 1363-1371.
85. White, A. T. (1984). *Marine parks and reserves: Management for Philippine, Indonesian and Malaysian coastal reef environments (protected areas, coral reef)*. University of Hawai'i at Manoa.
86. Ong, C. K., Lee, J. N., & Tanzil, J. T. I. (2021). Skeletal Growth Rates in Porites lutea Corals from Pulau Tinggi, Malaysia. *Water*, *14*(1), 38.
87. Lachs, L., Johari, N. A. M., Le, D. Q., Safuan, C. D. M., Duprey, N. N., Tanaka, K., Tan. C. H., Ory, N. C., Bachok, Z., Baker, D. M., Kochzius, M., & Shirai, K. (2019). Effects of tourism-derived sewage on coral reefs: isotopic assessments identify effective bioindicators. *Marine pollution bulletin*, *148*, 85-96.
88. Rahman, A., Ashraf, M., Ghazali, F., Rusli, M., Hazmi, M., Aziz, N., & Asma, W. I. (2019). Marine protected areas in peninsular Malaysia: shifting from political process to Co-management. *J. Pol. & L.*, *12*, 22.
89. Mustajap, F., Saleh, E., Madin, J., & Hamid, S. A. (2015). Marine habitat mapping at Labuan Marine Park, Federal Territory of Labuan, Malaysia. *Ocean Science Journal*, *50*(2), 291-298.
90. Hoeksema, B. W., Waheed, Z., & de Voogd, N. J. (2014). Partial mortality in corals overgrown by the sponge Terpios hoshinota at Tioman Island, Peninsular Malaysia (South China Sea). *Bulletin of marine science*, *90*(4), 989-990.
91. Hoeksema, B. W., Waheed, Z., & Alamaru, A. (2013). Out of sight: aggregations of epizoic comb jellies underneath mushroom corals. *Coral Reefs*, *32*(4), 1065-1065.
92. Scaps, P. (2009). New associations between the scallop Pedum spondyloideum (Bivalvia, Pteriomorphia: Pectiniidae) and scleractinian corals from the northeastern coast of Borneo (Malaysia). *Zool Stud*, *48*, 492.
93. Ahmad Zubir, A. A., Yusof, Y., & Muhamad Nor, M. A. A. (2015). Physical and Chemical Characteristics of Corals from Bidong Island, Terengganu, Malaysia. In *Advanced Materials Research* (Vol. 1112, pp. 555-558). Trans Tech Publications Ltd.
94. Hoeksema, B. W., & Waheed, Z. (2012). It pays to have a big mouth: mushroom corals ingesting salps at northwest Borneo. *Marine Biodiversity*, *42*(2), 297-302.
95. Robert, R., Lee, D. J., Rodrigues, K. F., Hussein, M. A., Waheed, Z., & Kumar, S. V. (2016). Consolidated Checklist of Hard Corals of the Genus Acropora Oken, 1815 (Scleractinia: Acroporidae) in North Borneo, East Malaysia. *Zootaxa*, *4200*(2), zootaxa-4200.
96. Huang, D., Hoeksema, B. W., Affendi, Y. A., Ang, P. O., Chen, C. A., Huang, H., Lane, D. J. W., Licuanan, W. Y., Vibol, O., Vo, S. T., Yeemin, T., & Chou, L. M. (2016). Conservation of reef corals in the South China Sea based on species and evolutionary diversity. *Biodiversity and Conservation*, *25*(2), 331-344.
97. Adzis, K. A. A., Amri, A. Y., Hyde, J., Maidin, N., Repin, I. M., Ling, A. S., & Mohamed, C. A. R. (2012). In situ measurement of photosynthetic capacity in scleractinian corals (Acropora formosa and Pocillopora damicornis) during the 2010 massive coral reef bleaching event in Pulau Tioman, Malaysia. *INSTRUCTIONS TO CONTRIBUTORS*, *76*, 85.
98. Szereday, S., & Amri, A. Y. (2021). Successive bleaching events (2019-2020) in Northeast Peninsular Malaysia revealed selective thermal acclimatization and susceptibility of hard corals at biophysical reef scale. *bioRxiv*.

99. Lee, Y. L., Mohamed, M. I., Bujang, J. S., & Ali, J. H. (2005). *Ecology of scleractinian corals in the waters of Port Dickson and their tolerance to sedimentation* (Doctoral dissertation, Universiti Putra Malaysia).
100. Kanisan, D. P., Quek, Z. B., Oh, R. M., Afiq-Rosli, L., Lee, J. N., Huang, D., & Wainwright, B. J. (2022). Diversity and Distribution of Microbial Communities Associated with Reef Corals of the Malay Peninsula. *Microbial Ecology*, 1-12.
101. Cheheltani, N. (2011). Impact of marina construction on scleractinian corals in Kampung Tekek, Tioman Island, Malaysia.
102. Qaralleh, H. (2012). Antimicrobial activities of selected sponges and corals of costal waters of Malaysia.
103. Chan, B. K., Tan, J. C., & Ganmanee, M. (2020). Living in a growing host: Growth pattern and dwelling formation of the scallop Pedum spondyloideum in massive Porites spp. corals. *Marine Biology*, *167*(7), 1-12.
104. Waheed, Z., & Hoeksema, B. W. (2012). Coral-mimicking corallimorpharians on the reefs of Kota Kinabalu, Malaysia. *Coral Reefs*, *31*(2), 519-519.
105. van der Meij, S. E., Fransen, C. H., Pasman, L. R., & Hoeksema, B. W. (2015). Phylogenetic ecology of gall crabs (Cryptochiridae) as associates of mushroom corals (Fungiidae). *Ecology and Evolution*, *5*(24), 5770-5780.
106. Marican, H., Edros, R., Mohammad, M., & Salleh, S. (2016). Antimicrobial activity of tropical soft corals found in the Northern Straits of Malacca. *International Journal of Engineering Technology and Sciences*, *3*(2), 1-10.
107. Shahbudin, S., Hafiz, Z. H., John, B. A., Kamaruzzaman, B. Y., & Jalal, K. C. A. (2011). Distribution and Diversity of Corals on Artificial Reefs at Pasir Akar and Teluk Kalong, Redang Island, Malaysia. *Journal of Applied Sciences*, *11*(2), 379-383.
108. Juhi, Z. S., Mubin, N. A. A. A., Jonik, M. G. G., Salleh, S., & Mohammad, M. (2021). Impact of short-term light variability on the photobiology of turbid water corals. *Journal of Sea Research*, *175*, 102088.
109. Vairappan, C. S., Zanil, I. I., Kamada, T., & Palaniappan, M. (2012). Isopropyl (ene)-type cembrene diterpene an important secondary metabolite in soft coral Sinularia flexibilis of Tun Sakaran Marine Park, Malaysia. *Journal of Tropical Biology & Conservation (JTBC)*.
110. Van Der Meij, S. E. (2014). A new species of Opecarcinus Kropp & Manning, 1987 (Crustacea: Brachyura: Cryptochiridae) associated with the stony corals Pavona clavus (Dana, 1846) and P. bipartita Nemenzo, 1980 (Scleractinia: Agariciidae). *Zootaxa*, *3869*(1), 44-52.
111. Gan, S. H., Waheed, Z., Chung, F. C., Spiji, D. A., Sikim, L., Saleh, E., & Tan, C. H. (2021). In situ observations of coral spawning and spawn slick at Lankayan Island, Sabah, Malaysia. *Marine Biodiversity*, *51*(1), 1-7.
112. Tan, Y. T. R., Wainwright, B. J., Afiq-Rosli, L., Ip, Y. C. A., Lee, J. N., Nguyen, N. T. H., Pointing, S. B., & Huang, D. (2020). Endosymbiont diversity and community structure in Porites lutea from Southeast Asia are driven by a suite of environmental variables. *Symbiosis*, *80*(3), 269-277.
113. Mokhtar, M. B., Praveena, S. M., Aris, A. Z., Yong, O. C., & Lim, A. P. (2012). Trace metal (Cd, Cu, Fe, Mn, Ni and Zn) accumulation in Scleractinian corals: a record for Sabah, Borneo. *Marine pollution bulletin*, *64*(11), 2556-2563.
114. Amri, A. Y., Tajuddin, B. H., Lee, Y. L., Adzis, K. A., & Yusuf, Y. (2008). Scleractinian coral diversity of Kg Tekek, Pulau Tioman marine park. *IOES monograph series: Natural History of The Pulau Tioman Group of Islands. Institute of Ocean and Earth Sciences, University of Malaya, Kuala Lumpur*, 53-68.
115. Aileen, T. S. H., Ismail, A. I., & Yasin, Z. (2009). Diversity of Family Fungiidae in Malaysian Waters. *Publications of the Seto Marine Biological Laboratory. Special Publication Series.*, *9*, 15-24.

116. Lane, D. J., & Hoeksema, B. W. (2016). Mesophotic mushroom coral records at Brunei Darussalam support westward extension of the Coral Triangle to the South China Sea waters of Northwest Borneo. *Raffles Bulletin of Zoology*, *64*, 204-212.
117. Robert, R., Rodrigues, K. F., Waheed, Z., & Kumar, S. V. (2019). Extensive sharing of mitochondrial COI and CYB haplotypes among reef-building staghorn corals (Acropora spp.) in Sabah, North Borneo. *Mitochondrial DNA Part A*, *30*(1), 16-23.
118. Waheed, Z., Adnan, F. A. F., Hwa, L. C. H., & Hashim, S. R. M. (2007). Status of coral reefs and sedimentation at Kota Kinabalu: a preliminary study at Gaya Bay and Sepangar Bay. *Borneo Journal of Marine Science and Aquaculture*, 27-43.
119. Ditlev, H. (2003). New scleractinian corals (Cnidaria: Anthozoa) from Sabah, North Borneo. Description of one new genus and eight new species, with notes on their taxonomy and ecology. *Zoologische Mededelingen*, *77*, 193-219.
120. Abdullah, A. L. (2017). Spatial inequality: evaluating diversity of hermatypic corals in similar reef settings of north Langkawi. *Int J Latest Res Sci Technol*, *4*(5), 33-39.
121. Mohamed, M. I. H., & Badaruddin, Z. (1988). Coral reef morphology and ecology of the Malaysian East Coast Islands. In *Proceedings, 6th International Coral Reef Congress, Townsville* (pp. 349-53).
122. Pilcher, N. J., & Cabanban, A. S. (2000). *The status of coral reefs in Sabah, Labuan and Sarawak, East Malaysia*. Australian Institute of Marine Science.
123. Harborne, A., Fenner, D., Barnes, A., Beger, M., Harding, S., & Roxburgh, T. (2000). Status report on the coral reefs of the east coast of Peninsula Malaysia. *Report Prepared to Department of Fisheries Malaysia, Kuala Lumpur, Malaysia*, 361-369.
124. Mahadi, M., Zulfigar, Y., & Tan, A. S. H. (2004). The distribution of soft coral genus Dendronephthya (Alcyonacea: Nephtheidae) at Pemanggil Island in South China Sea, Malaysia. *Marine science into the new millennium: new perspective and Phang, et al., challenges. Kuala Lumpur, Malaysia: University of Malaya*, 103-124.
125. Yasin, Z., & Shau-Hwai, A. T. (2008). Detailed Profiling of the Coral Reefs in Pulau Aur, Johor Darul Takzim.
126. Lau, C. M., Affendi, Y. A., & Chong, V. C. (2009). Effect of jetty pillar orientation on scleractinian corals. *Malaysian Journal of Science*, *28*(2), 161-170.
127. Affendi, Y. A. (2005). Coral Reefs of North East Pulau Langkawi. *Malaysian Journal of Science, 24*, 145 – 158.
128. Affendi, Y. A., Tajuddin, B. H., Lin, Y. A., & Adzis, K. A. A. (2008). Corals of Pulau Perak: after 46 years of scientific solitude. *Malaysian Journal of Science*, *27*(3), 75-81.
129. Bakus, G. J., Nishiyama, G., Hajdu, E., Mehta, H., Mohammad, M., Pinheiro, U. D. S., Sohn, S. A., Pham, T. K., Yasin, Z., Hwai, T. S., Karam, A., & Hanan, E. (2007). A comparison of some population density sampling techniques for biodiversity, conservation, and environmental impact studies. *Biodiversity and conservation*, *16*(9), 2445-2455.
130. UNEP. (2004). Coral Reefs in the South China Sea. UNEP/GEF/SCS Technical Publication No. 2.
131. Awang, D., Zakaria, M., & Aziz, M. A. (2011). Living Coral Reef Resources of Sarawak, with Special Reference Kuching Area.
132. Wood, C. R. (1994). Hard corals of the Sipadan reef. *Pulau Sipadan: Reef life and ecology. Technical report, WWF Project Number MYS*, *233*(92), 29 - 52.
133. Rezai, H., Ibrahim, H. M., Idris, B. A. G., & Kushairi, M. R. M. (1999). Some effects of submarine pipeline construction on the sessile zoobenthic community of Redang Island. *Hydrobiologia*, *405*, 163-167.
134. Harding, S., Comley, J., Helgeveld, M., Coltman, N., & Raines, P. (2003). Malaysia reefs and islands conservation project 2003. Report of the marine pilot phase. A collaborative

project between the Marine Parks Section, Department of Fisheries, Government of Malaysia and Coral Cay Conservation.
135. Comley, J., Walker, R., Wilson, J., Ramsay, A., Smith, I., Raines, P., & Parks, M. (2004). Malaysia coral reef conservation project: Pulau Redang. *Report to the Department of Marine Parks, Malaysia. Retrieved May*, *12*, 2014.
136. Wilkinson, C., Souter, D., & Goldberg, J. (2005). *Status of coral reefs in tsunami-affected countries: 2005*. Australian Institute of Marine Science; Global Coral Reef Monitoring Network.
137. Bujang, J. S., Hj Mohamed, M. I., Theem, L. A., Mohd Shazili, N. A. (1997). *Assessment of The Impact of Large and Small Scale Development on the Coastal Environment of Pulau Redang.* WWF Malaysia.
138. Andersson, K. (2002). A study of coral reef fishes along a gradient of disturbance in the Langkawi Archipelago, Malaysia. *Undergraduate thesis, Uppsala University, Uppsala*.
139. Wilkinson, C. (2008). Status of coral reefs of the world: 2008. Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre, Townsville, Australia, 296p.
140. Adzis, K. A. A., Toda, T., & Ross, O. H. (2006). Preliminary Results of Coral Recruitment in Pulau Redang.
141. Khor, H. M., & Mohd Zaki, M. S. (2001). *Composition and Distribution of Benthic Life Forms In The Coral Reefs at Bidong Island, Malaysia; A Preliminary Study*.
142. Jen-Nie, L., Adzis, K. A. A., & Ross, O. H. (2006). Community Structure of Coral Reefs in Pulau Tioman.
143. Lim, L. C. (1998). *Carrying capacity assessment of pulau payar marine park*. WWF Malaysia.
144. Zulfigar, H. Y., Satien, K. T., Alan, G., & Reungchai, T. (2000). Colonization of artificial substrate on the coral reef at Pulau Payar in the Straits of Malacca. In *Proceedings of National Symposium on Pulau Payar Marine Park*. Fisheries Research Institute.
145. Hii, Y. S., Soo, C. L., & Liew, H. C. (2009). Feeding of scleractinian coral, Galaxea fascicularis, on Artemia salina nauplii in captivity. *Aquaculture International*, *17*(4), 363-376.
146. Yusuf, Y., & Ali, A. B. (2004). The use of butterflyfish (Chaetodontidae) as bioindicator in coral reef ecosystems. *Biomonit Trop Coast Ecosys*, 175-183.
147. Yap, K. (2017). An Attempt Using Hydro-Acoustic Approach for Rapid Coral Reef Mapping in Malaysia.
148. Akmal, K. F., & Shahbudin, S. (2020). Baseline assessment of coral health and disease in Tioman Island Marine Park, Malaysia. *Community Ecology*, *21*(3), 285-301.
149. Saleh, M. S. M., & Hasan, N. N. N. (2014). Ecotourism and coral reef: Analysis of Coral Reef Conservation Awareness among stakeholders in Perhentian Island, Malaysia. *American Journal of Tourism Management*, *3*(1A), 7-12.
150. Hanapiah, M. F. M., Saad, S., & Ahmad, Z. (2020). Dispersal pattern of coral larvae In Kuantan coastal waters, Malaysia. *Science Heritage Journal (GWS)*, *4*(1), 13-18.
151. Muslim, A. M., Chong, W. S., Safuan, C. D. M., Khalil, I., & Hossain, M. S. (2019). Coral reef mapping of UAV: A comparison of sun glint correction methods. *Remote Sensing*, *11*(20), 2422.

152. Ong, P., Hitam, M. S., Bachok, Z., & Din, M. S. C. (2019). Estimation of Sand Distribution in Coral Reef Environment using Colour Segmentation and Colour Thresholding Methods. *Universiti Malaysia Terengganu Journal of Undergraduate Research*, *1*(3), 96-104.

153. Pradhan, B., & Suleiman, Z. (2009). Landcover mapping and spectral analysis using multi-sensor satellite data fusion techniques: case study in Tioman Island, Malaysia. *Journal of Geomatics*, *3*(2), 71-78.
154. Kuwahara, V. S., Nakajima, R., Othman, B. H. R., Kushairi, M. R. M., & Toda, T. (2010). Spatial variability of UVR attenuation and bio-optical factors in shallow coral-reef waters of Malaysia. *Coral Reefs*, *29*(3), 693-704.
155. Muhammad Faiz, M. H., Shahbudin, S., & Mukai, Y. (2017). Coral recruitment success and sessile benthic colonisation estimation in Tioman Island Marine Park, Malaysia. *Journal of Coastal Conservation*, *21*(6), 883-891.
156. Safuan, M., Boo, W. H., Siang, H. Y., Chark, L. H., & Bachok, Z. (2015). Optimization of coral video transect technique for coral reef survey: comparison with intercept transect technique. *Open Journal of Marine Science*, *5*(04), 379.
157. Wee, H. B., Liew, H. C., Bachok, Z., & Reimer, J. D. (2015). Vertical distribution of zooxanthellate zoantharians on coral reefs of Terengganu Islands, Malaysia. *Platax*, *2015*, 29-37.
158. Hasan, R. C. (2014). Analysis of acoustic signal from RoxAnn echosounder and side scan sonar for coral reef identification.
159. Saleh, M. S. M., & Hasan, N. N. N. (2014). Sustainable tourism: a multi-stakeholder involvement in coral reefs conservation in Malaysia. *International Journal of Physical and Social Sciences*, *4*(3), 158.
160. Mohd, M. H., Rahman, M. A. A., Nazri, M. N., Tan, C. H., Mohamad, Y., Lim, C. S., ... & Kim, D. K. (2020). Reefing viability index for Rigs-to-Reefs (R2R) in Malaysia. *The Scientific World Journal*, *2020*.
161. Hossain, M. S., Muslim, A. M., Nadzri, M. I., Sabri, A. W., Khalil, I., Mohamad, Z., & Beiranvand Pour, A. (2021). Coral habitat mapping: A comparison between maximum likelihood, Bayesian and Dempster–Shafer classifiers. *Geocarto International*, *36*(11), 1217-1235.
162. Affendi, Y. A. (2011). *Coral ecology of a unique continental island of Pulau Perak, Kedah, Malaysia/Affendi Yang Amri* (Doctoral dissertation, University of Malaya).
163. Tajam, J., & Mokhtar, M. (2019). Marine Habitat Distribution and Substrate Composition of Dangli Group of Islands, Langkawi UNESCO Global Geopark, Kedah, Malaysia. *International Journal of Oceans and Oceanography*, *13*(1), 37-56.
164. Abdul Mubin, N. A. A., Jonik, M. G. G., Kamphol, N., Juhi, Z. S., Mohammad, M., & Salleh, S. (2021). In situ photosynthetic performance of Porites lutea inhabiting contrasting habitats of the Northern Straits of Malacca (NSoM), Malaysia. *Marine and Freshwater Behaviour and Physiology*, *54*(4), 149-167.
165. Normah S, Ismail MS, Md. Nizam I, Zaidnuddin I and Goeden GB. Occurrence and Distribution of an Invasive Octocoral, Carijoa riisei in Malaysia's Marine Park of Pulau Payar. Austin Environ Sci. 2021; 6(2): 1060.
166. Mohamed, F. (2014). *Study on the impact of anthropogenic pressure on coral reefs around Cape Rachado, Malacca and recommendations to improve its management/Mohamed Faizan* (Doctoral dissertation, University of Malaya).
167. Nasir, M., Yasin, Z., Shau-Hwai, A. T., Adlim, M., & Munira, M. A. (2012). Determination of seasonal skeletal growth layers in Porites lutea colonies from Teluk Nyior reefs, Langkawi Island, Malaysia. *Aquaculture, Aquarium, Conservation & Legislation*, *5*(1), 40-43.
168. Krawczyk, H., Zinke, J., Browne, N., Struck, U., McIlwain, J., O'Leary, M., & Garbe-Schönberg, D. (2020). Corals reveal ENSO-driven synchrony of climate impacts on both terrestrial and marine ecosystems in northern Borneo. *Scientific reports*, *10*(1), 1-14.
169. Abdullah, A. L., Yasin, Z., Shutes, B. R., & Fitzsimons, M. (2011). SEDIMENT FALLOUT RATES IN TANJUNG RHU CORAL REEFS. *Kajian Malaysia: Journal of Malaysian Studies*, *29*(2).

170. Zawawi, N. A., Liew, M. S., Shawn, L. E., Alaloul, W. S., Toloue, I., Mohd, M. H., Rahman, M. A. A., Nazri, M. N., Tan, C. H., Mohamad, Y., Lim, C.S., Mustapa, B., Shaari, H., Hii, Y. S., Ali, M. N. A., Thiyauddin, M. I., & Abdul Karim, M. (2019, December). Potential of Offshore Structure as Artificial Reefs in Shallow Tropical Water. In *SPE Symposium: Decommissioning and Abandonment*. OnePetro.
171. Santodomingo, N., Perry, C., Waheed, Z., bin Syed Hussein, M. A., Rosedy, A., & Johnson, K. G. (2021). Marine litter pollution on coral reefs of Darvel Bay (East Sabah, Malaysia). *Marine Pollution Bulletin*, *173*, 112998.
172. Maidin, N., Manjaji-Matsumoto, B. M., Asdari, M. R., Bavoh, E. M., Junsin, N., & Justine, V. T. (2022). Effects of coral contact rate on the coral cover (pre and post Covid-19's pandemic movement control order) in Tunku Abdul Rahman Park, Malaysia. *Malaysian Journal of Sustainable Environment*, *9*(1), 1-18.
173. Lau, Y. W., & Reimer, J. D. (2019). A first phylogenetic study on stoloniferous octocorals off the coast of Kota Kinabalu, Sabah, Malaysia, with the description of two new genera and five new species. *ZooKeys*, *872*, 127.
174. Liew, C. K. H. (2010). *Status of Sea Turtle Resources and Coral Reefs of Maliangin Island Sanctuary, Kudat, Sabah, Malaysia* (Doctoral dissertation, Universiti Malaysia Sabah).
175. Loh, I. H., Chong, J. L., & Baird, M. H. (2018). The conservation of coral reefs through mangrove management. *Biodiversity*, *19*(1-2), 95-100.
176. Yeo, B. H. (2004). The recreational benefits of coral reefs: A case study of Pulau Payar Marine Park, Kedah, Malaysia. *Economic valuation and policy priorities for sustainable management of coral reefs*, 108-117.
177. Hamid, R., Ahmad, A., & Usup, G. (2016). Pathogenicity of Aeromonas hydrophila isolated from the Malaysian Sea against coral (Turbinaria sp.) and sea bass (Lates calcarifer). *Environmental Science and Pollution Research*, *23*(17), 17269-17276.
178. Doshi, A., Pascoe, S., Thébaud, O., Thomas, C. R., Setiasih, N., Tan, C. H., True, J., Schuttenberg, H. Z., & Heron, S. F. (2012). Loss of economic value from coral bleaching in SE Asia.
179. Mizubayashi, K., Kuwahara, V. S., Segaran, T. C., Zaleha, K., Effendy, A. W. M., Kushairi, M. R. M., & Toda, T. (2013). Monsoon variability of ultraviolet radiation (UVR) attenuation and bio-optical factors in the Asian tropical coral-reef waters. *Estuarine, Coastal and Shelf Science*, *126*, 34-43.
180. Chak, S. T., Dumont, C. P., Adzis, K. A. A., & Yewdall, K. (2018). Effectiveness of the removal of coral-eating predator Acanthaster planci in Pulau Tioman Marine Park, Malaysia. *Journal of the Marine Biological Association of the United Kingdom*, *98*(1), 183-189.
181. Pradhan, B., & Kabiri, K. (2012). Spectral and spatial resolution analysis of multi sensor satellite data for coral reef mapping: Tioman Island, Malaysia. *39th COSPAR Scientific Assembly*, *39*, 1533.
182. Muhammad Hamizan, Y., Shahbudin, S., Hadry, N. F., Mahfuzah, Y., Rafindde, R., Mohd Fikri Akmal, K., & Mohd Husaini, R. (2015). THE POTENTIAL OF ARTIFICIAL LIVE ROCK AS SUBTRATE FOR CORAL SPAT AND EPIBENTHIC ORGANISMS. *Jurnal Teknologi*, *77*(25).
183. Salleh, N. M., Saharuddin, A. H., Aman, A. A. S., & Loke, K. B. (2017). Selection of artificial reef placement sites by using evidential reasoning. *Marine Artificial Reef Research and Development*, 251-264.
184. Kvernevik, T. I., Zambri Mohd Akhir, M., & Studholme, J. (2002). A low-cost procedure for automatic seafloor mapping, with particular reference to coral reef conservation in developing nations. *Hydrobiologia*, *474*(1), 67-79.
185. Tkachenko, K. S., Wu, B. J., Fang, L. S., & Fan, T. Y. (2007). Dynamics of a coral reef community after mass mortality of branching Acropora corals and an outbreak of anemones. *Marine Biology*, *151*(1), 185-194.

186. HUNG, E. W. F. (1990). Artificial reef development and management in Malaysia.
187. Nickerson-Tietze, D. J. (2000). Scientific characterization and monitoring: its application to integrated coastal management in Malaysia. *Ecological applications*, *10*(2), 386-396.
188. Emang, D., Lundhede, T. H., & Thorsen, B. J. (2016). Funding conservation through use and potentials for price discrimination among scuba divers at Sipadan, Malaysia. *Journal of environmental management*, *182*, 436-445.
189. Zhang, L. (2016). *Carrying capacity assessment of diving sites in Hong Kong and Malaysia* (Doctoral dissertation, Hong Kong Baptist University).
190. Idris, M. S., Jean, K. S., & Zakariya, R. A. Z. A. K. (2009). Hyperspectral discrimination and separability analysis of coral reef communities in redang island. *Journal of Sustainability Science and Management*, *4*(2), 36-43.
191. Awalludin, E. A., Hitam, M. S., Yussof, W. N. J. H. W., & Bachok, Z. (2017, September). Modification of canny edge detection for coral reef components estimation distribution from underwater video transect. In *2017 IEEE International Conference on Signal and Image Processing Applications (ICSIPA)* (pp. 413-418). IEEE.
192. Kamarumtham, K., Ahmad, Z., Halid, N. H., Saad, S., Fikri, M., Khodzori, A., Yusof, M. A., & Hanafiah, M. F. M. (2016). Diversity and distribution of coral lifeforms in Tioman Island. *Transactions on Science and Technology*, *3*(2-2), 367-373.
193. Saharuddin, A. H., Ali, A., Lokman, M. H., & Salihin, W. (2012, May). Recent development and management of artificial reefs (ARs) in Malaysia. In *2012 Oceans-Yeosu* (pp. 1-23). IEEE.
194. Aziz, N., Muhammad, Z., Ghazali, F., Talaat, W. I. A. W., & Saputra, J. (2019). Marine Spatial Planning: the way forward for sustainable development of Central Terengganu, Malaysia. *Journal of Southwest Jiaotong University*, *54*(4).
195. Harding, S., Lowery, C., & Oakley, S. (2000, October). Comparison between complex and simple reef survey techniques using volunteers: is the effort justified. In *Proceedings of the 9th international coral reef symposium. International Coral Reef Society, Bali* (pp. 883-889).
196. Yusof, Z. B. (2021). MARINE REHABILITATION AND RESEARCH CENTRE AT PERHENTIAN KECIL ISLAND, TERENGGANU. *Design Ideals Journal*, *3*(2).
197. Williams, W. M., Viner, A. B., & Broughton, W. J. (1987). Nitrogen fixation (acetylene reduction) associated with the living coral Acropora variabilis. *Marine Biology*, *94*(4), 531-535.
198. A'ziz, A. N. A., Minhat, F. I., Pan, H. J., Shaari, H., Saelan, W. N. W., Azmi, N., Abdul Manaf, O. A. R., & Ismail, M. N. (2021). Reef foraminifera as bioindicators of coral reef health in southern South China Sea. *Scientific reports*, *11*(1), 1-13.
199. Chou, L. M., Tuan, V. S., Philreefs, Y. T., Cabanban, A., Suharsono, & Kessna, I. (2002). Status of Southeast Asia coral reefs. *Status of coral reefs of the world*, 123-152.
200. Lee, W. S., & Lin, C. Y. (2018). Mapping of tropical marine benthic habitat: Hydroacoustic classification of coral reefs environment using single-beam (RoxAnn™) system. *Continental Shelf Research*, *170*, 1-10.
201. Muslim, A. M., Komatsu, T., & Dianachia, D. (2012, November). Evaluation of classification techniques for benthic habitat mapping. In *Remote Sensing of the Marine Environment II* (Vol. 8525, pp. 175-183). SPIE.
202. Jusoff, K. (2009). Mapping of Sabah Islands using airborne hyperspectrometer. *Journal of Geography and Geology*, *1*(1), 2.
203. AW, S. L. (2013). Establishing limits of acceptable change (LAC) for anthropogenic development on Mabul Island, Sabah, Malaysia. *Galaxea, Journal of Coral Reef Studies*, *15*(Supplement), 411-417.

204. Abdullah, A. L., Anscelly, A. A., Mohamed, J., & Yasin, Z. (2016). Conservation of Pulau Payar Marine Park and Optical Remote Sensing Models. *KEMANUSIAAN: The Asian Journal of Humanities*, *23*.
205. Ishii, T., Kamada, T., Phan, C. S., & Vairappan, C. S. (2018). Chabrolene, a Novel Norditerpene from the Bornean Soft Coral Nephthea sp. *Sains Malaysiana*, *47*(2), 319-322.
206. Phan, C. S., Ng, S. Y., Kamada, T., & Vairappan, C. S. (2016). Two new lobane diterpenes from a Bornean soft coral Sinularia sp. *Natural Product Communications*, *11*(7), 1934578X1601100708.
207. Rezai-Marnani, H. (1998). *Some Effects of Subsea Water Pipeline Construction on Sessile Benthic Community Structure of Redang Island, Malaysia* (Doctoral dissertation, Universiti Putra Malaysia).
208. Mazlan, A. G., Mei Yee, N., Kee Alfian, A. A., & Aziz, A. (2006). Linking the feeding regime of Chaetodon octofasciatus to the coral health in Redang Island, Malaysia.
209. Safuan, C. D. M., Ashraf, A. R. M., Tan, C. H., Jaafar, S. N., Yusop, P. A. M., Lai, R. K., Ismail, M. N., Chan, A. A., Md Repin, I., Wee, H. B., & Bachok, Z. (2021). Coral health status assessment in Malaysia islands; looking towards Marine Spatial Planning. *Ocean & Coastal Management*, *213*, 105856.
210. Kaie, N. N. A. B. M. (2012). *Colonisation of Artificial Reef Balls in Talang-Satang National Park, Sematan, Sarawak* (Doctoral dissertation, Universiti Malaysia Sarawak).
211. Husaini, R. (2016). Spatio-temporal Variation of Scleractinian Coral Recruitment in Balok Coastal Waters and Bidong Island, Malaysia. *MSc diss., International Islamic University Malaysia*.
212. Jamil, T., Mazlin, M., & Sukarno, W. (2017). Mini review of coral reefs status in Langkawi UNESCO Global Geopark (LUGG), Malaysia. *Ecol Environ Conserv Pap*, *23*(2), 662-674.
213. Hamzah, S. B., Ying, A. S., Samion, M. K. H., & Mohamad, M. F. (n.d.). Purposed Planned Artificial Reef As Tool To Aid Re-Establishment Of New Marine Habitat In Pulau Tioman.
214. Abidin, S. Z. Z., & Mohamed, B. (2014). A review of SCUBA diving impacts and implication for coral reefs conservation and tourism management. In *SHS Web of Conferences* (Vol. 12, p. 01093). EDP Sciences.
215. Chew, C. W. (2005). *Coral Cover and Abundance of Groupers (family Serranidae) in the Shallow Waters of Lankayan Island, Sabah* (Doctoral dissertation, Universiti Malaysia Sabah).
216. Malaysia, R. C. (2007). Annual survey report. *Kuala Lumpur, Malaysia*.
217. Malaysia, R. C. (2008). Annual survey report. *Kuala Lumpur, Malaysia*.
218. Malaysia, R. C. (2009). Annual survey report. *Kuala Lumpur, Malaysia*.
219. Malaysia, R. C. (2010). Annual survey report. *Kuala Lumpur, Malaysia*.
220. Malaysia, R. C. (2011). Annual survey report. *Kuala Lumpur, Malaysia*.
221. Malaysia, R. C. (2012). Annual survey report. *Kuala Lumpur, Malaysia*.
222. Malaysia, R. C. (2013). Annual survey report. *Kuala Lumpur, Malaysia*.
223. Malaysia, R. C. (2014). Annual survey report. *Kuala Lumpur, Malaysia*.
224. Malaysia, R. C. (2015). Annual survey report. *Kuala Lumpur, Malaysia*.
225. Malaysia, R. C. (2016). Annual survey report. *Kuala Lumpur, Malaysia*.
226. Malaysia, R. C. (2017). Annual survey report. *Kuala Lumpur, Malaysia*.
227. Malaysia, R. C. (2018). Annual survey report. *Kuala Lumpur, Malaysia*.
228. Malaysia, R. C. (2019). Annual survey report. *Kuala Lumpur, Malaysia*.
229. Malaysia, R. C. (2020). Annual survey report. *Kuala Lumpur, Malaysia*.
230. Affendi, Y. A., & Rosman, F. R. (2011). Current knowledge on sclerectinian coral diversity of Peninsular Malaysia. Malaysia's marine biodiversity: inventory and current status. Department of Marine Park Malaysia, Putrajaya, 21-31.

231. Waheed, Z., Rahman, R. A. & Ariff A. J. (2011). The Status of Hard Coral Diversity in Sabah. Malaysia's Marine Diversity: Inventory and Current Status, 1-11.
232. Idid, M. R., Palaniveloo, K.,Phang, S. M., Yaman, A. R. G. & Chan, A. A. (2019). Biodiversity Expedition in Melaka & Negeri Sembilan: Proposal for New Marine Parks, Department of Fisheries Malaysia, Ministry of Agriculture and Agro-based Industry, Malaysia, 6-31.
233. Choo, P. S., Ismail, I., Chee, P. E. & Chuan, T. T. (2002). Workshop on the Impact of Development on the Coastal Fisheries off South-west Penang Island. 63-67.
234. Saleh, E., Daud, N. R., Mustajap, F & Aung, T. (2011). Underwater Acoustic Survey of Mantanani Islands, Kota Belud, Sabah. Mantanani Island Marine Research Expedition 2013. 9-32.
235. Ismail, M. S., Ling, K. M., Ilias, Z., Ismail, M. N., Pau, S. S. N., Zainee, N. F. A., Jamaludin, M. R. & Repin, I. M. (2021). Laporan Kajian Penentuan Kawasan Baharu Yang Berpotensi Dijadikan Kawasan Perlindungan Sumber (MPA) di Perairan Perak, Jabatan Perikanan Malaysia, Kementerian Pertanian & Industri Makanan, Malaysia, 7-17.
236. Bachok, Z., Nor, A. M. & Repin, I. M. (2021). Post Covid Marine Life Status at Marine Park Islands of Terengganu Report, Department of Fisheries Malaysia, Ministry of Agriculture and Food Industry, 6-35.
237. Ambak, M. A., Mohsin, A. K. M., & Said, M. Z. (1986). Growth Characteristics of Lizard Fish (Fam : Synodontidae) in the South China Sea. Pertanika, 9(2), 261–263.
238. Ambak, M. A., Mohsin, A. K. M., & Said, M. Z. M. (1988). Preliminary estimates of growth and mortality in Nemipterus bathybus Snyder (Pisces: Nemipteridae) from the coast off Sarawak, South China Sea. Pertanika., 11(3), 487–490.
239. Zaki, M., Said, M., & Ambak, M. A. (1990). Colour pattern as an additional aid to the identification of Nemipterus species and their relationship. Pertanika Journal of Tropical Agricultural Science, 13(1), 17–26.
240. Rusul, G., Dahan, M. M., & Dollah, M. (1991). A Survey of Microbiological Quality of Fish Sold in Two Local Wet Markets. Pertanika Journal of Tropical Agricultural Science, 14(3), 243–247.
241. Sin, T. M., Teo, M. M., Ng, P. K., Chou, L. M., & Khoo, H. W. (1994). The damselfishes (Pisces: Osteichthyes: Pomacentridae) of Peninsular Malaysia and Singapore: systematics, ecology and conservation. Hydrobiologia, 285(1), 49-58.
242. Zaki, M., Mohsin, A. K., & Ambak, M. A. (1994). Reproductive Characteristics of Nemipterus peronii (Valenciennes) from the East Coast of Peninsular Malaysia. Pertanika J. Trop. Agric. Sci., 17(1), 1–5.
243. Wood, E. (1994). Pulau Sipadan: Reef Life and Ecology. WWF.
244. Said, M. Z., Mohsin, A. K. ., & Ambak, M. . (1994). Food and Feeding Habits of Nemipterus peronii (Valenciennes) from the South China Sea. Pertanika Journal of Tropical Agricultural Science, 17(2), 125–131.
245. Ibrahim, S., Ambak, M., & Kawamura, G. (1997). Night-time movement of fish in coastal waters of Terengganu. Pertanika Journal of Tropical Agricultural Science, 20(1), 83–86.
246. Bujang, S.J., Hj. Mohamed, M.I., Law, A.T., Mohd Shazili, N.A., Lim, L.C., & Salam, M.N.A. (1997). Assessment of the Impact of Large and Small Scale Development on the Coastal Environment of Pulau Redang.
247. Vidthayanon, C. (1999). Species composition and diversity of fishes in the South China Sea, Area I: Gulf of Thailand and east coast of Peninsular Malaysia. In Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea, Area I: Gulf of Thailand and Peninsular Malaysia, 24-26 November 1997, Bangkok, Thailand (pp. 172-240). Training Department, Southeast Asian Fisheries Development Center.
248. Isa, M. M., Arshad, A. H. H. A., & Basir, S. (1999). Distribution, abundance and biological studies of economically important fishes in the South China Sea, Area I: East coast of Peninsular Malaysia. In Proceedings of the First Technical Seminar on Marine Fishery

Resources Survey in the South China Sea, Area I: Gulf of Thailand and Peninsular Malaysia, 24-26 November 1997, Bangkok, Thailand (pp. 147-155). Training Department, Southeast Asian Fisheries Development Center.
249. Zaidnuddin, I., & Abdul Razak, L. (1999). Fish standing stock at the artificial reefs of Pulau Payar, Kedah. International Conference on the Straits of Malacca, 191–198.
250. Harborne, A., Fenner, D., Barnes, A., Beger, M., Harding, S., & Roxburgh, T. (2000). Status report on the coral reefs of the east coast of Peninsula Malaysia. Report Prepared to Department of Fisheries Malaysia, Kuala Lumpur, Malaysia, 361-369.
251. Harding, S. P., Lowery, C., Colmer, M., & Oakley, S. G. (2000). A PRELIMINARY SPECIES CHECKLIST OF REEF FISH FOR THE BANGGI CHANNEL, PULAU BANGGI, SABAH.
252. Yusri, Y., Shamala, S. P., & Azizah, S. (2000). Anemone fish (Amphiprion spp.) of the Pulau Payar group of islands. In Proceedings of National Symposium on Pulau Payar Marine Park. Fisheries Research Institute.
253. Liew, H.C., Soh, L.W., & Chan, E. H. (2001). The feeding of coral reef fishes ny tourists in Marine Parks. National Symposium on Marine Park and Islands in Terengganu: Towards Sustainable Usage and Management of Islands.
254. Hussain, M.Z. (2001). Pembahagian Nic Spesis Ikan Kerapu Di Ekosistem Terumbu Karang, Pulau Payar, Kedah [Bachelor's Dissertation, Universiti Sains Malaysia].
255. Yusuf, Y. B., Mohd-Norizam, M., Ali, A. B., & Zaidnuddin, I. (2001, February). Coral reef fish of some selected sites at Pulau Redang Marine Park, Terengganu: a brief study. In Proceeding of National Symposium on Marine Park and Terengganu Islands (pp. 12-13).
256. Yusuf, Y., & Ali, A. B. (2001). Butterflyfish (Chaetodontidae) of Pulau Payar Marine Park. In Proceedings of National Symposium on Pulau Payar Marine Park (Vol. 173).
257. "Yusuf, Y. and Ali, A. (2002). The Coral Reef Fish Community: A Comparative Study between
258. Marine Parks and Non-protected Areas . In Ali, A., C.S.M. Rawi, M. Mansor, R. Nakamura, S.
259. Ramakrishna and T. Mundkur (Eds.), 2002. The Asian Wetlands: Bringing Partnerships Into
260. Good Wetland Practices. Penerbit Universiti Sains Malaysia,Penang.2002. pp. 311-316."
261. Andersson, K. (2002). A study of coral reef fishes along a gradient of disturbance in the Langkawi Archipelago, Malaysia. Undergraduate thesis, Uppsala University, Uppsala.
262. Ogawa, Y. (2003). Migration, growth and feeding habit of John's snapper (Lutjanus johnii) and Duskytail grouper (Epinephelus bleekeri) in Merbok mangrove brackish river. JIRCAS Working Report, 35, 1–10.
263. Harding, S., Comley, J., Helgeveld, M., Coltman, N., & Raines, P. (2003). Malaysia reefs and islands conservation project 2003. Report of the marine pilot phase. A collaborative project between the Marine Parks Section, Department of Fisheries, Government of Malaysia and Coral Cay Conservation.
264. Palaniappan, S. ., Azizah, M. N. S., & Yusuf, Y. (2003). Notes on the Occurrence of Amphiprion (Perciformes: Pomacentridae) in Peninsular Malaysia. Asian Fisheries Science, 16(3), 235–240. https://doi.org/10.33997/j.afs.2003.16.3.006
265. Comley, J., Walker, R., Wilson, J., Ramsay, A., Smith, I., Raines, P., & Parks, M. (2004a). Malaysia coral reef conservation project: Pulau Payar. Report to the Department of Marine Parks, Malaysia. Retrieved May, 12, 2014.
266. Comley, J., Walker, R., Wilson, J., Ramsay, A., Smith, I., Raines, P., & Parks, M. (2004b). Malaysia coral reef conservation project: Pulau Redang. Report to the Department of Marine Parks, Malaysia. Retrieved May, 12, 2014.
267. Daw, T. (2004). Reef fish aggregations in Sabah, East Malaysia. Western Pacific fisher survey series, 5.
268. Ibrahim, S., Muhammad, M., & Ambak, M. A. (2004). Distribution of Food Items of Six Commercially Important Demersal Fishes in the South China Sea. 27(1), 31–38.

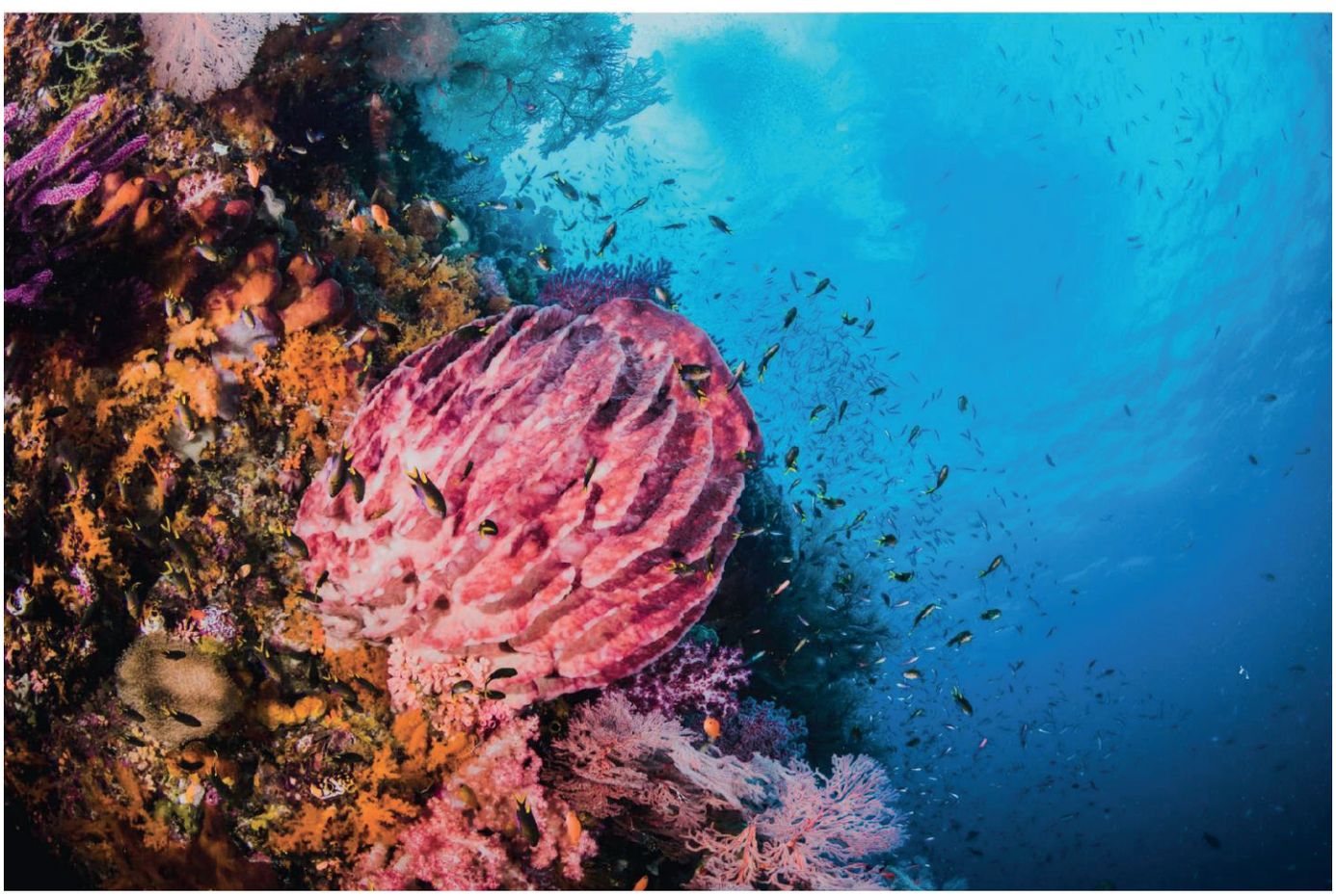
269. Yusuf, Y. and A. B. Ali, (2004). The use of butterflyfish (Chaetodontidae) as bioindicator in coral reef ecosystems. p 175- 183 in Phang, S., -M. and M. T. Brown (eds.). Biomonitoring of tropical coastal ecosystems. University of Malaya Maritime Research Center (UMMReC), Kuala Lumpur.
270. Yusuf, Y. U. S. R. I., Yang Amri, A., Kee Alfian, A. A., Tajuddin, B. H., & Lee, Y. L. (2005). Coral reef fish diversity of Kg Tekek, Pulau Tioman Marine Park.
271. Lee, Y. L., Affendi, Y. A., Tajuddin, B. H., Yusuf, Y. B., Kee Alfan, A. A., & Anuar, E. A. (2005). A post-tsunami assessment of coastal living resources of Langkawi Archipelago, Peninsular Malaysia.
272. Ghaffar, M. A., Ng, M. Y., Aziz, K. A. A., & Arshad, A. (2005). Linking the feeding regime of Chaetodon octofasciatus to the coral health in Redang Island, Malaysia. Coastal Marine Science, 30(1), 276-282.
273. Kua, B. C. (2005). Influence of Temperature on the Occurance of Cryptocaryoniasis in Marine Culture Fish in Holding Tanks. Malaysian Applied Biology, 4(1), 13–17.
274. Teh, L., Cabanban, A. S., & Sumaila, U. R. (2005). The reef fisheries of Pulau Banggi, Sabah: a preliminary profile and assessment of ecological and socio-economic sustainability. Fisheries Research, 76(3), 359-367.
275. Chong, V. C., Ng, Y. P., Hairi, B. J., Ooi, A. L., Chew, L. L., Amirah, M., & Affendi, B. N. (2005). Update of the fishes of mangrove and coastal waters of Northeastern Langkawi. Malaysian Journal of Science, 24, 167-184.
276. Gambang, A.C., Awang, D., Annie, L.P.K., & Muda, O. (2006). Fish Community of Pulau Layang Layang.
277. Sallehudin, J., & Phang, L. E. (2005). Growth of Siakap (Lates calcarifer) on Different Commercials Diets Culture in Cage. Malaysian Fisheries Journal, 4(1), 18–23.
278. Yusuf, Y. (2006). Kajian Ikan Terumbu Karang dan Taburannya di Taman Laut Pulau Payar, Kedah.
279. Bujang, J. S., Zakaria, M. H., & Arshad, A. (2006). Distribution and significance of seagrass ecosystems in Malaysia. Aquatic Ecosystem Health & Management, 9(2), 203-214.
280. Mazlan, A. G., & Seah, Y. G. (2006). Meristic and Length-Weight Relationship of Ponyfishes (Leiognathidae) in the Coastal PONYFISHES (LEIOGNATHIDAE) IN THE COASTAL WATER. Malaysia Applied Biology, 35(1), 27–36.
281. Teh, L. S. L., Zeller, D., Cabanban, A., Teh, L. C. L., & Sumaila, U. R. (2007). Seasonality and historic trends in the reef fisheries of Pulau Banggi, Sabah, Malaysia. Coral Reefs, 26(2), 251-263.
282. "Yusuf, Y., Y.A. Affendi, B. H. Tajuddin and A. A. Kee Alfian, (2007). Coral Reef Fishes of Pulau
283. Perak, Westernmost Island of Peninsular Malaysia. p. 277-284 in A.J. Mydin, A.R. Gor Yaman, R.
284. Omar, N. Ahmad, G. Usop, K.R. Mohamed and F.K. Sahrani. (Editors). Proceedings of the Conference on Marine Ecosystem of Malaysia. Department of Marine Park, Putrajaya."
285. Ghazali, S. M., Nurulhuda, M. P., Wan Mohd Afiq, W. A., & Ghaffar, M.A. (2007). Pencirian Komunikasi Akustik Ikan Inggu (Amphiprion ocellaris) di Pulau Perhentian.
286. "Yusri Yusuf, Affendi Yang Amri and Rosman Abdullah, (2009). Fishes of a 'neglected' coral reef area: Pulau Pangkor, Perak. Pp. 39-42. In Hee et al., (eds.). Proceeding of the Simposium Biologi
287. Malaysia: Harnessing the potential of biodiversity. Faculty of Sciences, UPM,Serdang."
288. Oh, S. Y., Arshad, A., Pang, S. P., & Amin, S. M. N. (2010). Catch Composition of Estuarine Set Bag Net Fishery in the Coastal Area of Pontian, Johor, Peninsular Malaysia. Journal of Biological Sciences, 10(3), 247–250.
289. Yew, M.T. (2010). Butterfly Fish as Bioindicator of Coral Reef Health at Lang Tengah Island, Terengganu [Bachelor's Dissertation, Universiti Malaysia Terengganu].

290. Ali, A., Gambang, A. C. & Khiok, A. L. P. (2011). Chondrictyan Biodiversity in Malaysia & Brunei Darussalam. Malayssia Marine Biodiversity: Inventory & Current Status. 33-43.
291. Ransangan, J. & Madin, J. (2013). Commercially Important Marine Fish & Invertebrate Species Landed by Fisherman in Mantanani Island. Mantanani Island Marine Research Expedition 2013. 107-118.
292. Ghaffar, M. A., Yee, N. M., & Rusli, N. A. (2014). Bio-ecology of Sand Goby Species of the Redang Marine Park Island, Terengganu, Malaysia. Ecosystem Marine Malaysia: Peluang & Penyelidikan Terkini, 14, 141-150.
293. Ghaffar, M. A., & Mohamed, J. (n.d.). Komuniti Ikan Blennid di Taman Laut Pulau Redang Terengganu Malaysia.
294. Souter, D., Planes, S., Wicquart, J., Logan, M., Obura, D., & Staub, F. (eds) (2021). Status of coral reefs of the world: 2020 report. Global Coral Reef Monitoring Network (GCRMN) and International Coral Reef Initiative (ICRI).
295. Asian Development Bank (2014). State of The Coral Triangle: Malaysia.
296. Reef Check Malaysia (2022, February 25). Reef check Malaysia releases 2021 annual survey report. Reef Check. https://www.reefcheck.org/reef-check-malaysia-releases-2021-annual-survey-report/
297. The status of Fishery Resources. FAO. (n.d.). https://www.fao.org/3/cc0461en/online/sofia/2022/status-of-fishery-resources.html
298. World Wildlife Fund. (n.d.). What is overfishing? facts, effects and overfishing solutions. WWF. https://www.worldwildlife.org/threats/overfishing

CHAPTER 2

MARINE INVERTEBRATES

Wan Mohd Rauhan Wan Hussin
Mohd Hanafi Idris
Che Zulkifli Che Ismail
Nur Fazne Ibrahim
Fatin Sharmimi Muhammad



1.0 INTRODUCTION

As a megadiverse country which lies on the Sunda shelf platform, Malaysia's natural ecosystems of terrestrial, freshwater, marine and estuary harbour a diverse array of floral and faunal communities. The biodiversity hotspot in Malaysia allows the nation to be recognised as one of the 12 mega-biodiversity countries, with an estimation of plethora of species from vascular plants (15,000 species), mammals (306 species), birds (742 species), amphibians (242 species), reptiles (567 species), freshwater fish (over 449 species), marine fish (over 1,616 species) and invertebrates (more than 150,000 species) have been documented (KETSA, 2006). These wealth data have qualified this biodiversity-rich country to ratify the Convention on Biological Diversity (CBD) in 1994, with the goals of having equitable sharing of benefits from biological resources and promoting the biodiversity conservation as an integral part of sustainable development.

Biodiversity in general is an abbreviation of the term "biological diversity" and it pools the concepts of plants and animals as genetic resources, together with the diversity of species and habitats in which they sheltered in (KETSA, 2006). As a whole, the biodiversity refers to the totality and variety of living organisms, inhabiting a variety of complex and productive ecosystems on earth. In the case of a marine realm, the living organisms range from the smallest prokaryotes to the large marine mammals, with certain species adapted well to the some of the most extreme environment (Cochrane et al., 2016).

In Malaysia, where the Exclusive Economic Zone (EEZ) overlaps with the Coral Triangle Region, this area is believed to have the greatest diversity of marine life in the world, covering the areas of coral reefs, mangrove forests, mud flats, seagrass and sandy beaches. All these ecosystems are complete with an ecological aspect of the relationships between the marine organisms and their habitats such as physiological processes, predator-prey relationships, trophic webs, competition and resource partitioning (Cochrane et al., 2016). Both the biological and ecological aspects eventually contribute to the healthy biodiversity and play an important role in maintaining and defining the productive marine ecosystems. In a large-scale aspect, the marine ecosystem offers several important ecological services such as the pollution and flood controls, storm protection, habitat for species, recycling of nutrients, carbon sequestration and shoreline stabilization (Barbier, 2017). In some unique marine habitats, these areas act as important stores of genetic materials and possess educational and scientific research values. Above all the ecosystems present in Malaysian territory, the coral reef area is the most structurally complex and taxonomically diverse marine ecosystems, providing habitat for tens of thousands of associated fishes and invertebrates.

Marine invertebrate communities, particularly the benthic organisms, are largely comprised of macroinvertebrates between the size of 500µm and 1mm, such as the annelids (polychaetes), molluscs (gastropods and bivalves), crustaceans (amphipods, shrimps and crabs), and echinoderms (sea cucumbers and brittle stars). Such organisms which largely found in the soft-bottom substrates and relatively easy to collect, are biologically greatly diverse, especially on the continental shelf. Besides playing a vital role in maintaining the sediment and water quality of the areas, macrobenthos are also an important and major food source for bottom-feeding fish, invertebrates and birds. The significant support to the aquatic food web largely

contributes to the ecosystem stability and the sustenance of fishery resources (Rabaoui, 2019).

Ecologically, the benthic communities are a great bio-indicator species, as compared to the fish and plankton, as they are susceptible to the pollutant exposure, received prolonged contact with the accumulated contaminants over time, and mostly sedentary species (Young et al., 2014). Furthermore, besides the long lifespan of the organisms which successfully provide a sufficient record of environmental quality, their reactions to the surroundings also are relatively quick and has provided graded responses to the various stressor intensities. All these characteristics eventually have made them to commonly used as targets in biological assessment and monitoring of environmental quality (Araujo-Leyva et al., 2020). Briefly, the changes on the species composition, abundance, diversity and density of the benthic communities will determine the health status of the area.

Marine invertebrates, especially bottom-dwelling species are susceptible the various natural and anthropogenic threats such as climate change, alien invasive species, habitat degradation and destruction, overexploitation and harvesting and water pollution. Climate change is one of the central issues that concern the biodioversity and ecosystem function of marine invertebrates. This is exacerbarted by the warming of oceans, causes the oceans to become more acidic and subsequently affecting many organisms, particularly the calcifying species (Byrne, 2011). While global warming has been imposing problem on marine ecosystems for a long time, a more recent pressing issue causes detrimental impacts on marine invertebrates is plastic pollution. In contrast to ocean warming that occurs globally, plastic pollution is rather a more regional problem, at least for Malaysia. According to a study, Malaysia was the 8th top plastic polluter in 2021 (Tan et al, 2022). This is very alarming as plastic, especially microplastics and nanoplastics debris may affect the development, behaviour, response, food intake and consequently may cause mortality of marine invertebrates. Moreover, the accumulation of microplastics and nanoplastics accumulate in the sediment ecosystem may be several orders of magnitudes higher compared to the other part of the ocean (Haegerbaeumer et al., 2019).

In a global scale, the marine invertebrate studies, in relation to ecosystem-based status are widely covered. However, in Malaysia, despite the location of this country which lies on the Coral Triangle Region with global marine biodiversity hotspot, the diversity and species composition of marine groups, particularly the invertebrates remain overlooked and unknown. In fact, there is a significant gap in knowledge exists on the marine biodiversity as most studies are incomprehensive and focus only the small and specific regional areas only. Most research also exclusively reported the basic information of the distribution and assemblage of marine invertebrates in different Malaysian states, without representing the information from the whole country. In addition, the data coverage of those organisms is still incomplete even though numerous ecological functions have been identified.

The exploration and digging of information regarding the marine invertebrate revealed that, the data found are mostly fragmented and scattered across agencies and research institutes. Some data are unpublished and some remained as internal circulation document. No compilation of updated data and published information on the marine invertebrate species checklist are available. These has leads to a challenge to configure overall analysis on marine invertebrate trajectory in Malaysian water. All these

shortcomings and the lack of trained taxonomists also have further contributed to the weak database of marine invertebrate studies in Malaysia.

The data gathered from this project hopefully will bridge the gap of knowledge and provide the scientific evidence of number and diversity of marine invertebrate fauna available in Malaysian water, regardless the ecosystems they lived in. The outcomes of this research also will expectantly lead to the precise decision making by the policymakers and scientists for further study and conservation approach of the less covered sites.

2.0 OBJECTIVES

This report aims to:

1) Document and analyse the variety of marine invertebrate data from the previous studies in Malaysian waters.
2) Produce a comprehensive inventory of marine invertebrate in Malaysia according to location (by state)
3) Determine the gap of knowledge and the need for further researches, in particular to protected areas.
4) Identify the potential areas to be gazetted as Marine Protected Areas (MPAs) in Malaysia.

3. 0 METHODOLOGY

3.1 Types of references

This desktop study is based exclusively on the secondary data, collected from various resources (Figure 1). An extensive bibliographic search was conducted using two different sources, the physical source and softcopy sources. The physical sources include the hardcopies of reading materials such as books, reports and theses, obtained from the libraries of Sultanah Nur Zahirah (PSNZ) of Universiti Malaysia Terengganu (UMT), the library of the Southeast Asian Fisheries Development Center (SEAFDEC) of Kuala Terengganu and personal collection of several researchers in UMT. The softcopy data were mainly obtained from online resources from the established indexing databases such as Web of Science (WoS), Scopus and Google Scholar, as well as common web search engine, the Google.

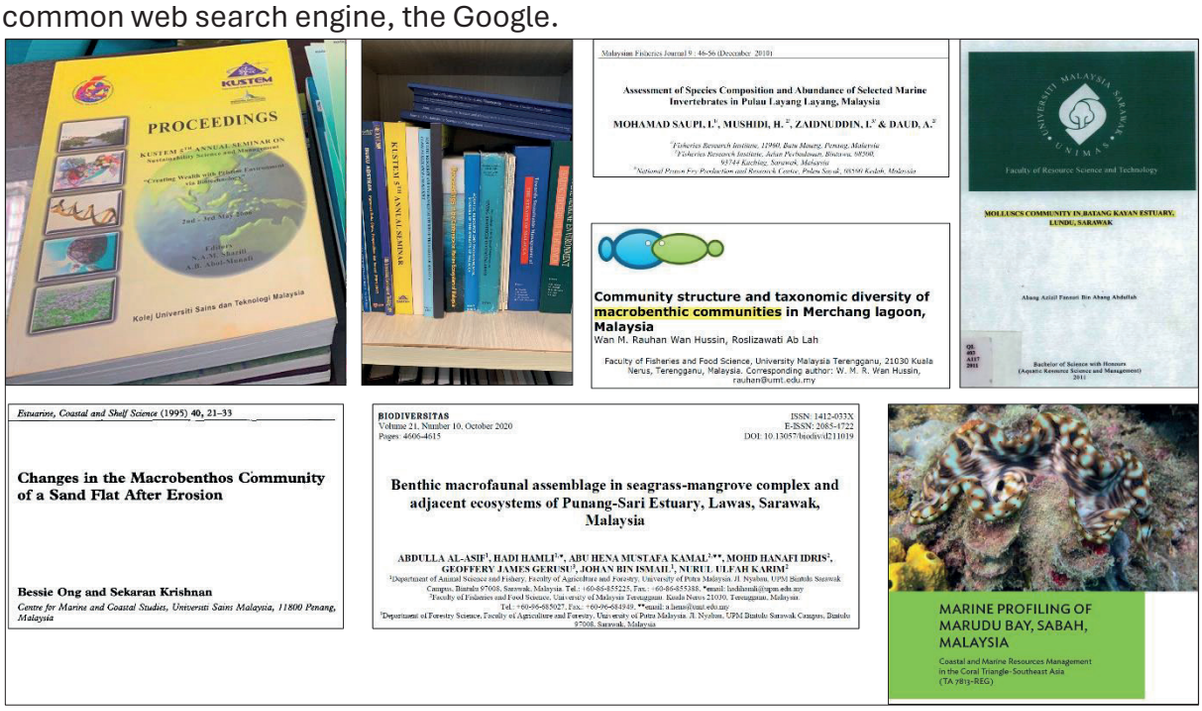


Figure 1: Some of the hardcopy and softcopy references used in this study

3.2 Identification and screening of references

This desktop study commenced in August 2021 with preliminary study to identify the trend in study on marine invertebrates in Malaysia. The information identified in this stage are locations and years to determine the spatial and temporal gaps in previous studies. Upon identifying the gaps, the collection of secondary data of previous studies were carried out in September 2021. Data collections were carried out throughout this project with the focus was in September 2021 – October 2021.

The physical books, reports and theses were gathered in this study without pre-selection step. All physical sources deemed to be appropriate and suitable were collected and screened to select parts or topics related to marine invertebrates. Meanwhile, the enumeration of softcopy data was mainly carried out online based on keywords in the search engine selecting the option “Article title, Abstract, and Keywords”, limiting it to the cut-off region of Malaysian waters. In the first step of online sources, the document type chosen in search strategy include ‘article’, ‘conference paper’, ‘symposium’, ‘proceeding’ and ‘review’. The results obtained were refined by

searching the articles using general keyword based on organism. The searching was later narrow down using specialised keyword. Details of the search keywords are in Table 1.

Table 1. The general and specialised keywords used for online articles search.

Topic	Keyword
	General keyword
Organisms	invertebrates, marine invertebrates, benthic, benthos, microbenthic, macrobenthos, meiobenthic, meiobenthos, macrofauna, meiofauna, bentik, bentos, makrobentos, meiobentos.
	Specialised keyword
Organisms	Annelida, Mollusca, Echinodermata, Arthropoda, Cnidaria, Crustacea, Bivalvia, Gastropoda, Anelida, Moluska, Ekinodermata, Artropoda, Krustasia, shell, bivalve, gastropod, worm, starfish, brittle star, sea urchin, shrimp, crab, kerang, cacing, tapak sulaiman, timun laut, udang, ketam
Habitats	estuary, wetlands, seagrass, lagoon, coral reefs, rocky shore, coastal water, coast, beach, island, mangrove, paya, tanah bencah, rumput laut, lagun, laguna, terumbu karang, batu karang, pantai berbatu, pesisir pantai, pantai, pulau, paya bakau.

Initially, a higher number of articles was found in the first step as the articles were not restricted to biology or ecology but related to all disciplines of studies. Therefore, the articles were further screened by reading titles and abstracts followed by the elimination of the articles that were irrelevant to the objectives. Such irrelevant articles were for instance;

i. Optimum dose of sea cucumber (*Stichopus chloronotus*) extract for wound healing;
ii. Oyster culture in Malaysia: opportunities and challenges; and
iii. Neurological disorder brain model: a lesson from marine worms (Annelida: Polychaeta)

In the third and last step, the remaining articles were thoroughly screened and the references eligible for the project were considered. The important criteria for considering articles was that previous researches were concerning the Malaysian marine ecosystems only (detailed ecosystems as mentioned in Table 1 above), accessible through online database and the articles must be clearly addressing the species composition of invertebrates. For the reading materials of articles and hardcopies, both can be in either Malay or English languages, as long as the contents are relevant to the objectives. The articles related to freshwater river and tributaries were excluded. Additionally, the references in the selected papers were used to find articles that the team could have missed during the searching strategy.

3.3 Focus organisms

Although the duty of this Focus Group is to gather information on marine invertebrates, the present study focuses on macrobenthos (or macrofauna), with a superficial focus on meiobenthos (meiofauna). In other word, the focus is on the animals living in soft bottom habitat. This was done for a better delivery to the public and to address the concern on the organisms' function as the proxy of environmental condition. In addition, such focus was also determined to avoid redundancy with another Focus Group that works on coral (also part of marine invertebrates). The selection of macrobenthos as the main organism was discussed and approved by the Department of Fisheries Malaysia (DOF) in preliminary workshop on 25th October 2021.

3.4 Reference collection and organisation

Initially, approximately a total of 160 references were discovered in relation to the marine invertebrate studies in Malaysian water. However, after refining the articles by inducting further keywords of 'diversity, distribution, species composition and population of marine macrobenthos/macrofauna/meiobenthos/meiofauna', the number of references obtained were 148. Most of the references came from the online sources and contributed by studies from the local universities in Malaysia.

The references were recorded in MS Excel spreadsheet and organised according to information on area, habitat, types of study, methods, benthic composition and citation (Table 2). From this categorisation, data in the references were then expanded to present further information such as percentage abundance and density score. It is worth to note that there are discrepancies among the references where some previous studies identified the benthos to the species level, while the other only managed to identify to higher levels such as family and class. The other difference was the group of benthos, such that some studies covered all types of benthos while others focused on specific phyla (for instance, Annelida, Arthropoda). The discrepancies have made data comparison for entire references not possible, but instead, such comparisons were made among selected references.

Besides arranging the information according to categories, an overall information regarding entire list of species correspond to the areas was also recorded. In addition, the functional information on each species or the lowest taxonomic level (depending on the original references) were also collected for further analysis (not in this report). The functional traits provide a general ecological framework for understanding and modelling the community and ecosystem responses to the biotic and abiotic forcing. It covers the information of morphological, , physiological, structural, , or behavioural characteristics of an individual and are considered relevant to the response of those organisms to the environment.

Table 2. Categories for reference organisation.

Information Categories	Examples
1. Area	Queensbay (Penang) Offshore Pekan-Dungan
2. Coordinates	Lat. 5.332022 Lon. 100.309172 Lat. 3.908056 Lon. 103.928611
3. Habitat	Coastal water Soft bottom of continental shelf
4. Types of study	Macrobenthos all phyla Polychaeta
5. Methods	Hand corer Smith-McIntyre grab
6. Number of species	
7. Total abundance	
8. Most dominant species	
9. Citation	

3.5 Information for geospatial mapping

For geospatial mapping of the study sites, only references with completed coordinates were included in the analysis of study. Whereas for study areas with a wider geographical region and without the coordinates data, such as the data obtained from the scientific cruises, only the starting and end points were taken into the consideration. The coordinates were standardised to decimal format and subjected to the analyses and mapping in an open-source desktop geographic information system application, the QGis (QGis, 2022).

4.0 RESULTS / DATA ANALYSIS

In most literatures where the basic information on species composition of marine macrobenthos and meiobenthos is provided, the assemblage of the organisms was further determined (species richness, abundance, density and percentage) according to the 1) year of the published data 2) different locations of the study sites (particularly the states in Malaysia) and 3) habitats or ecosystems. Such analyses were carried out using MS Excel spreadsheet.

4.1 Yearly publications on marine invertebrates

The earliest single publication found was in the year 1974 by A. Sasekumar on the distribution of macrofauna on a Malayan Mangrove shore (Sasekumar, 1974) (Figure 2). In the early years, marine invertebrate research in Malaysia showed a very minimum progress in terms of number of published studies. Following Sasekumar's 1974 study, the next published work published only after 7 years by Purchon and Purchon (1981). This was however on different approach than Sasekumar's work where the later published work was not on general taxa of marine invertebrates, but rather focused on Mollusca only. In 1989, two 'new' studies came out by Nakao et al. (1989) on the macrobenthos and sedimentary environments in Selangor and Terengganu estuary, under the collaboration between Hokkaido University and Universiti Pertanian Malaysia. In general, the marked increases in the published works on marine invertebrates was only recorded starting in the early 2000s, particularly starting from 2002 to the year 2021, with the patterns fairly fluctuated over times (Figure 3).

Figure 2. The earliest recorded work by Sasekuma (1974) was published in the Journal of Animal Ecology

The highest record of marine invertebrate studies was documented in the year 2014 with a total number of 14 publications altogether, covering several states of Selangor, Johor, Sarawak and Kedah. A substantial decrease was in 2015 with only 5 published studies. The fluctuation patter continued in 2016 with a sharp increase of the number of studies with 12 published articles. The number was consistent for 3-year duration until 2018, before it recorded another slump in 2020 with only 7 publications on the ecological study of macrobenthos. It is unsure how such fluctuation occurred over the years, but this might have been due to many factors. The limited factor that mainly contributed to the low number of studies could possibly be the funding. As benthic or seabed studies are very costly and require a good support logistically (Gray and Elliott, 2009), inadequate financial support would have deterred the opportunity for researchers to carry out research in this topic. Moreover, macrobenthic study is one small part of a big research niche of marine biology or marine

ecology; where topics such as coral reefs, marine pollution and marine fishes have been topic of interests of many researchers too. This means, although the government might have given a huge amount of funds, benthic ecologists still have to compete with the other ecologists in terms of funding application.

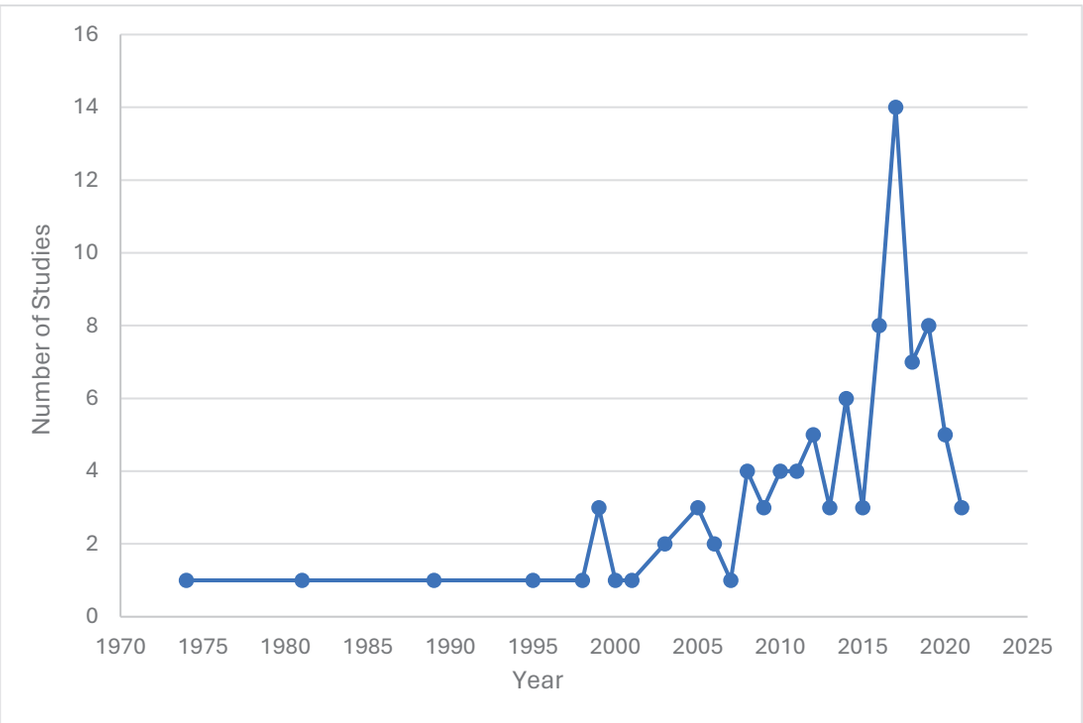


Figure 3: Number of marine invertebrate studies in Malaysia by year

4.2 Locations of studies on marine invertebrates

The references collected in this project are on studies conducted in all 13 states in Malaysia (Figure 4). This also includes large spatial scale studies conducted in the entire East coast region of Peninsular Malaysia. Terengganu contributed to the highest percentage of marine invertebrate studies (n=37; 21.64%), followed by Johor (n=26; 15.20%) and Selangor which shared the same number of studies as Pulau Pinang, Sabah and Sarawak (n= 16; 9.36%). The lowest percentage of marine invertebrate studies was represented by Perlis (n=1; 0.58%). This particular reference was a proceeding paper by Shariff et al. (2000), focusing on the distribution of gastropods in different ecosystems of mudflats, mangrove and sandy shores of Kuala Perlis. A total of three studies have been conducted in the Exclusive Economic Zone (EEZ) of the East coast of Peninsular Malaysia, through the scientific cruises in the year 1997, 1998 and 2021, focusing on the marine benthos of all phyla. In brief, half of the states in Malaysia documented more than 10 publications of marine invertebrate studies individually, while the other states of Negeri Sembilan, Melaka, Perak, Kelantan, Perlis, and Kedah, recorded less than 10 publications, individually.

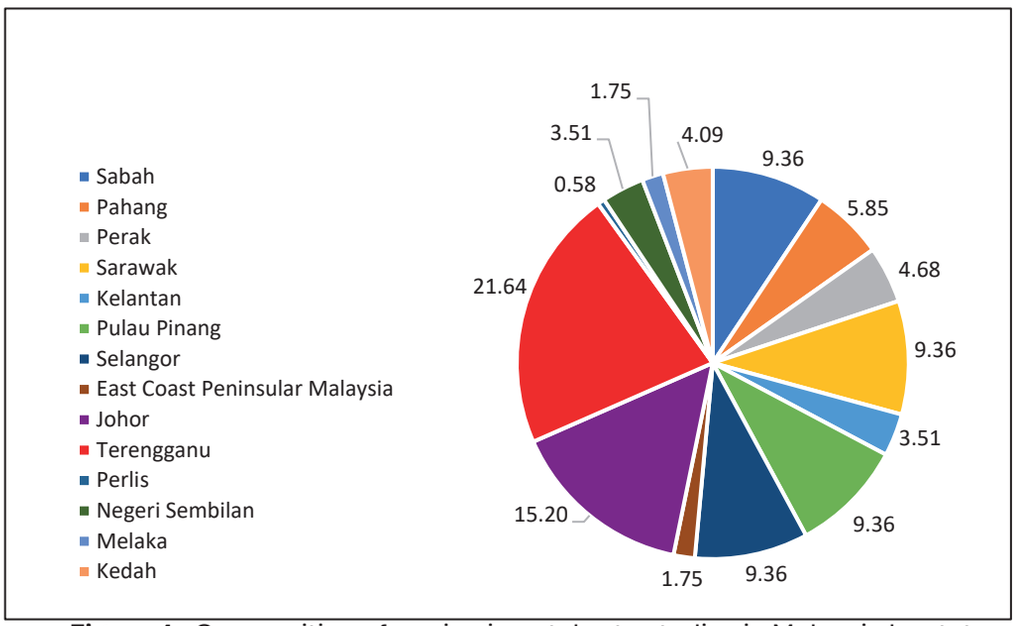


Figure 4: Composition of marine invertebrate studies in Malaysia by states

The dominance of Terengganu in terms of the most studied state is not of a surprise. This is due to this state houses a university with a niche area focusing on fisheries and marine resources; both of which are related to marine invertebrates. Before the establishment of the Universiti Malaysia Terengganu (UMT) as the pillar of marine and fisheries related studies, the foundation in this niche area has been laid by the Universiti Putra Malaysia (UPM) through its Fisheries and Marine Science Centre (which was later became UMT). The high number of marine research in Terengganu has been due to the privilege given by the Terengganu State Government to UMT to utilise a former Vietnamese refugee island, Pulau Bidong as a research station. Pulau Bidong is not gazetted as marine park, but instead gazetted as recreational island with limited activities permitted, including a small part of the island given to UMT.

In Terengganu, apart from Bidong Island, most of the published data on marine invertebrate studies came from Setiu Wetlands. Although unlisted as one of the RAMSAR sites in Malaysia, Setiu wetlands, Terengganu is greatly blessed with 10 different interconnected ecosystems of BRIS (Beach ridges interspersed with swales), coastal forest, river, sea, beach, mudflat, lagoon, estuary, island and mangrove forest (Salim et al., 2020). All these inter-related ecosystems offer a variety of ecological, social and economic benefits to the local population and organisms in the wetland areas. The diversity of ecosystems offers various opportunities and perspectives to study, hence the high number of published works in Terengganu. Unfortunately, many developments have been carried out in this area which have caused coastal erosion and sedimentation to gradually have occurred. The subsequent destruction of habitat and population decline of the aquatic animals have hitherto attracted attentions from the researchers to study more on the adverse effects of those developments in Setiu Wetlands, Terengganu.

In Johor, most of the marine invertebrate studies were conducted in Merambong and Tanjung Adang shoals, leads by many researches from all over universities in Malaysia. These two shoals mainly vegetated by as many as 10 species of seagrass, namely *Enhalus acoroides, Thalasia hemprichii, Halophila ovalis,* and etc and this productive and complex ecosystem had harboured a vast array of marine organisms

such as gastropods, bivalves, polychaetes, echinoderms and sponges. It is hypothesized that these two shoals have attracted the attention of many researchers due to the exposure of the shoals to shipping port, industrial and agriculture development (Shi et al., 2014). In addition, the anthropogenic factors of over-fishing, construction and land reclamation also had hooked the attentions of many researchers to study the effects of those activities on the condition and healthiness of the seagrass bed, which indirectly affecting the marine organism population.

4.3 Habitat types in marine invertebrate studies

In relation to the different habitats and ecosystems covered, the coastal water around Malaysia recorded the highest percentage of marine invertebrate studies (n= 38, 23.75%), followed by mangrove (n= 33, 20.63%) and intertidal + subtidal areas which shared the same data as the estuary ecosystem (n= 16; 10% individually) (Figure 3). The lowest record of marine invertebrate studies is represented by delta (n= 2; 1.25%), with the studies being conducted in Klang-Langat delta of Selangor and Tumpat delta of Kelantan, focusing on the shrimp communities. A few other unique habitats of marine invertebrates have been documented from several studies, comprising of the atoll, nesting ground of horseshoe crab, shrimp pond and nursery ground as well as aquaculture ponds, which pooled together as data 'others'.

In coral areas, studies concentrating on the marine invertebrates received less attention as compared to the more prominent organisms living in those areas, such as the coral fishes and different types of stunning coral species. A fact to be highlighted is that coral reefs are archetypical benthic ecosystem, which found in warm, oligotrophic, and shallow depth of tropical waters (Vinithkumar, 2008). The coral reefs are basically formed by diverse groups of organisms and are considered as rainforest of the sea, as no other natural area can be equal to them due to their colour, sheer beauty of forms and designs.

Figure 5 shows an almost similar percentage of marine invertebrate studies in coral areas and seagrass bed (6.25%; 6.875%, respectively). This finding is somehow parallel with the fact that the coral reefs are strongly associated to the other ecosystems such as seagrass meadows and seaweeds. Besides giving protection and mitigation effects of the normal hydrodynamics and storm conditions on the seagrass meadow and reef lagoon, the coral reefs also provide a sheltered condition to the seagrass areas. This sheltered condition then could enhance the particulate organic matter and sediment trapping effects by the seagrass canopies and thus, facilitate the organic carbon storing in the seagrass sediment. In brief, the capacity of the tropical seagrass meadows as a blue carbon sink are greatly enhanced by the coral reefs, through the wave dissipation that facilitates the sediment accumulation (Guerra-Vargas, 2020). A fact to be pointed out is, as the coral reefs occur in tropical waters of impoverished phytoplankton content, with a diverse fauna that flourished in oligotrophic waters, the high productivity of the coral ecosystems are undeniable, like the seagrass beds itself.

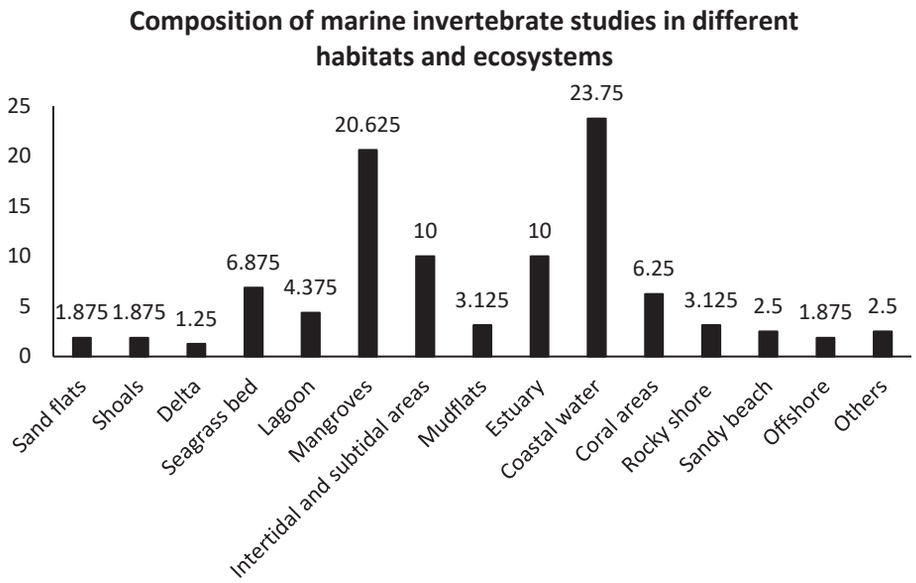


Figure 5: Composition of marine invertebrate studies in different habitats and ecosystems in Malaysian water

4.4 Distribution of marine invertebrate studies

Figure 6 shows the composition of marine invertebrate studies in different habitats and ecosystems around Malaysian waters. The studies fairly converge at the west Malaysia (the East and West coasts of Peninsular Malaysia), as compared to the east Malaysia (Sabah and Sarawak), with the most of studies concentrating on the coastal region. The east coast of Peninsular Malaysia basically consists of straight sandy formation in the north and a series of hook or spiral-shaped bays to the south. While the west coast of Peninsular Malaysia comprises mainly of the mud, with limited areas of pocket sandy beaches. In Sarawak and Sabah, the coastlines are about equally divided between sandy beaches and mud coast (Abdullah, 1993).

The coastal region of Malaysia with a land area of about 4.43 million hectares or 13% of the total land mass in Malaysia, has a special socio-economic and environmental significance. Besides supports a large percentage of the population, the area also is the centre of the economic activities encompassing the urbanization, agriculture, fisheries, aquaculture, oil and gas exploitation, transportation and communication, recreation, etc (Abdullah, 1993). The mangrove wetlands, nearshore waters, islands and coral reefs areas around the coastal region, has successfully supported a viable marine fishery industry in Malaysia. It was reported that approximately 42% of the capture fisheries along the west coast of Peninsular Malaysia were mangrove-related species. The fishery catches are highly supported by the marine invertebrate which act as main food sources for the commercial fishes.

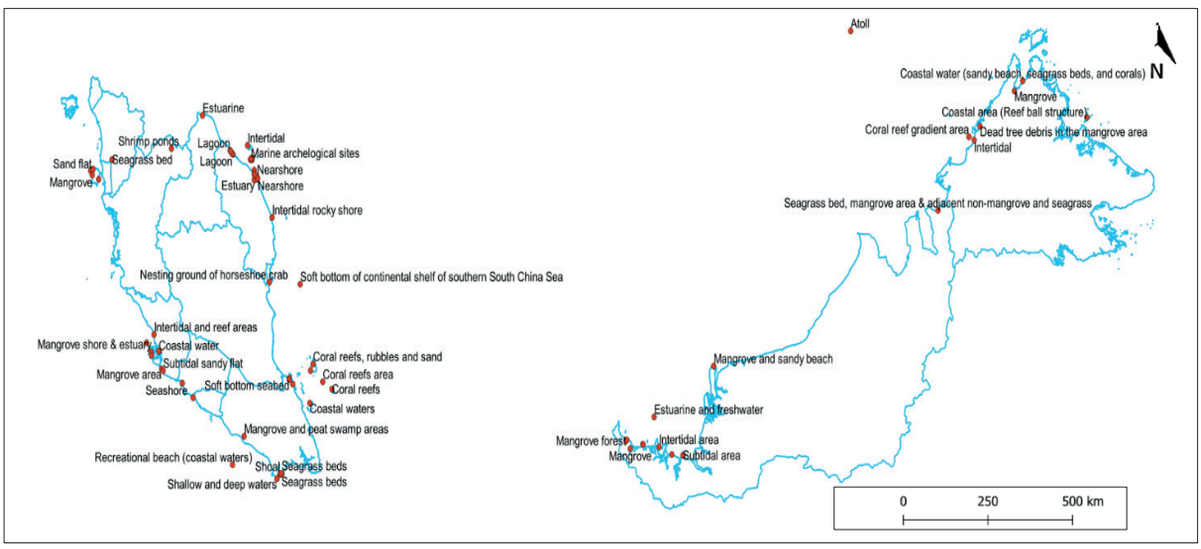


Figure 6: Map of Malaysia (left: Peninsular region and right: Sabah and Sarawak), comprising the marine invertebrate studies in different habitats and ecosystems based on the states in Malaysia

According to the data obtained, studies focusing on the marine invertebrates at seagrass beds are mostly conducted in Sungai Pulai estuary, Johor, specifically at Merambong and Tanjung Adang shoals, with moderate level of diversity was found. These two sites are located in the western site of the Johor Straits and have gained much attention by the researchers from all over universities in Malaysia due to some issues. As compared to the mangrove and coastal areas, the macrobenthos studies in seagrass beds are far lower, possible because of the declining in the seagrass area itself. Among the activities attributed to the seagrass declines are the sediment runoff from cleared land flowing into coastal areas covering meadows; and discharge of unreated domestic sewage effluent, runoff fertilizer and outflow of animal waste; all rich in nutrients promoting large algal blooms that cover the seagrass and thus decreasing the plants' photosynthesis capability (Japar Sidik et al. 2006).

In Sungai Pulai estuary itself, an increasing in the human population and a rapid development along the straits (e.g. port expansion, industrial and agriculture development) (Shi et al., 2014) have urge the researchers to carry out more studies to increase the public awareness on the risks of these activities to the marine ecosystems. The marine invertebrate studies then can be very useful in evaluating the status of the environment along the population gradient.

4.5 Composition of marine invertebrates in Malaysian water

From the 148 literatures obtained, the basic information of species composition of marine invertebrate was recorded either in the numerical forms of abundance (n), density (no. of organisms/m^2), or percentage composition (%) with some references applied the sighting frequency form (%), and basic statistics of diversity (H') and Evenness (J'). However, for this project, the data analysis has been decided to treat those values separately as a whole new one, and excluded the statistical analysis, due to the

standardisation and relevancy of the data, with the focus lies on the top three dominant species from each study.

Out of 148 references found, a total of 36, 14, and 18 references provided full information on the assemblage of marine invertebrates, based on the abundance, density and percentage composition, respectively. A complete list of references is shown in the appendix.

4.5.1 Overall abundance of marine invertebrates

Only 76 out of 148 studies provide data to species level. These studies recorded an overall of 658 species belonging to 60,100 individuals with the *Diadema setosum* (sea urchin; n=8423; 14.01%) has been documented as the most dominant species, followed by *Acanthomysis quadrispinosa* (shrimp; n=7290; 12.13%) and Amphipoda (crustacean; n=5676; 9.44%). The least dominant species was represented by *Namalycastis rhodochorde* (Nypa worm; n= 1; 0.002%), *Indothais rufotincta* (Murex snail; n= 3; 0.001%) and *Schistomeringos* sp. (marine worm; n=4; 0.01%). Approximately 50% of the species from the whole studies have a composition of less than 5% (n= 29,916) (Figure 7).

The *Diadema setosum* (Figure 8) which was abundantly documented in Teluk Tekek, Pulau Tioman, Pahang (n= 8371 individuals) implies that a higher abundance of algae was present in the study site (Kee et al., 2005). As the sea urchins play an important role in the benthic ecology of coastal ecosystems, particularly in barren grounds and coral reefs, the algal coverage and biomass will increase following the removal of the sea urchins. The sea urchins which practise grazing feeding habit was shown to effectively enhance the scleractinian coral recruitment and growth by grazing on algae that compete with coral. However, too high densities of the black-spined sea urchin can cause serious damage to the scleractinian coral as they will graze on the living coral as well (Do et al., 2020).

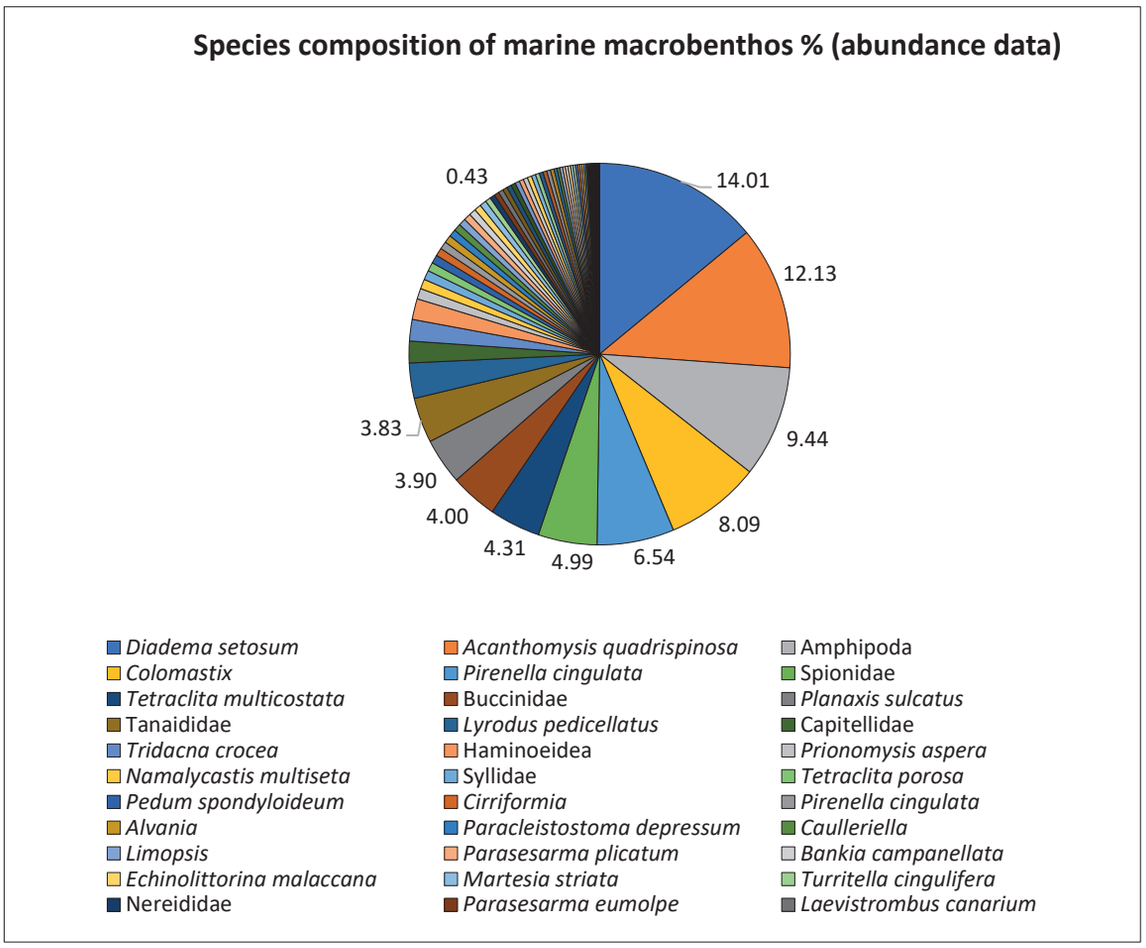


Figure 7: Composition of marine invertebrate (abundance data) from Malaysian water, obtained from 36 references

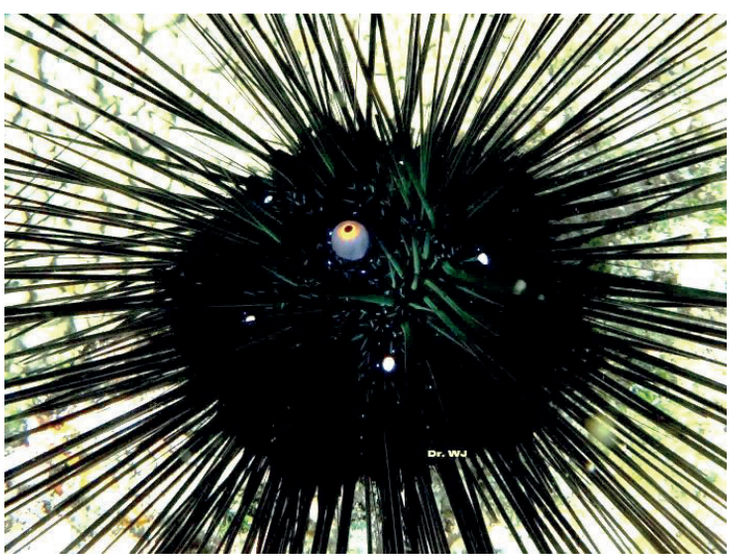


Figure 8: *Diadema setosum* (long black-spined sea urchin) is a sea urchin species commonly found in Malaysia. (Photo source: Worms, 2022a)

As the second highest dominant macrofauna recorded, the *Acanthomysis quadrispinosa* (Figure 9) has been found mainly in Pulau Tinggi, Johor, with a total of 7290 individuals collected from monthly sampling of one and half year period (Tan and Azman, 2018). The high frequency of sampling activity, as compared with the other studies might be the main contributors to the higher abundance of species recorded from the study. It is highlighted that the duration and frequency of sampling can affect the occurrence and distribution of the biota. For temporal aspect, there are many dimensions to consider prior conducting the sampling, such as deciding the most suitable time of collecting the samples, the sampling duration of how long it is conducted and the sampling frequency of how often the samples are taken within a given period (Bernal & Simcock 20126). All these factors eventually will affect the samples collection, with a higher abundance of organisms often corresponds with longer sampling duration and high sampling frequency.

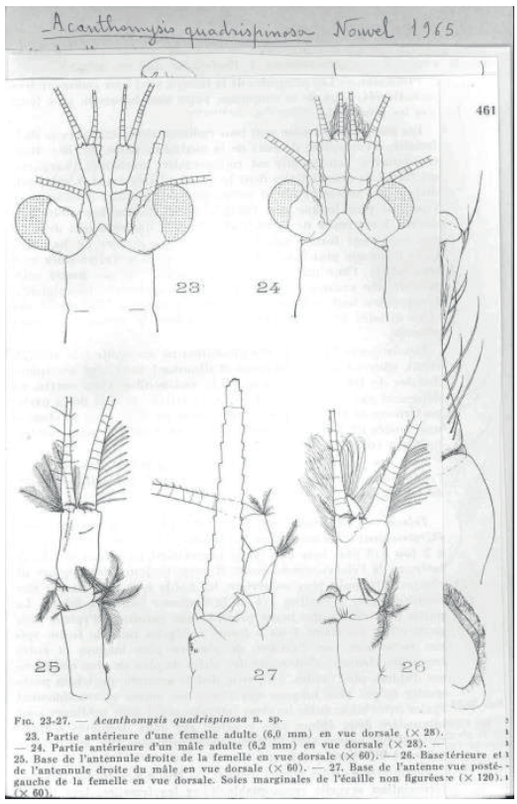


Figure 9. *Acanthomysis quadrispinosa* is a Mysid shrimp. This photo was scanned from a French ecologist, H. Nouvel's personal notes (Photo source: Worms, 2022b).

In terms of a higher taxa classification, from the 36 studies of a complete abundance data, Phylum Arthropoda recorded the highest percentage of abundance (n=25338; 43.22%), followed by Mollusca (n=17416; 29.70%) and Echinodermata (n= 8423; 14.37%) (Figure 10A). The least composition was represented by Annelida (n= 7452; 12.71%). More specific, marine invertebrates from Class Malacostraca revealed the highest composition (n=24756; 41.93%), followed by Class Gastropoda (n= 12283; 20.80%) and Class Echinoidea (n= 8423; 14.27%) (Figure 10B). The least composition of marine invertebrates was documented by Class Cephalopoda (n= 52; 0.09%), with the other Classes of Copepoda (n=128; 0.22%), Thecostraca (n=455;0.77%), Ophiuroidea (n=220; 0.37%), and Asteroidea (n=192; 0.33%) recorded less than 1% of composition individually.

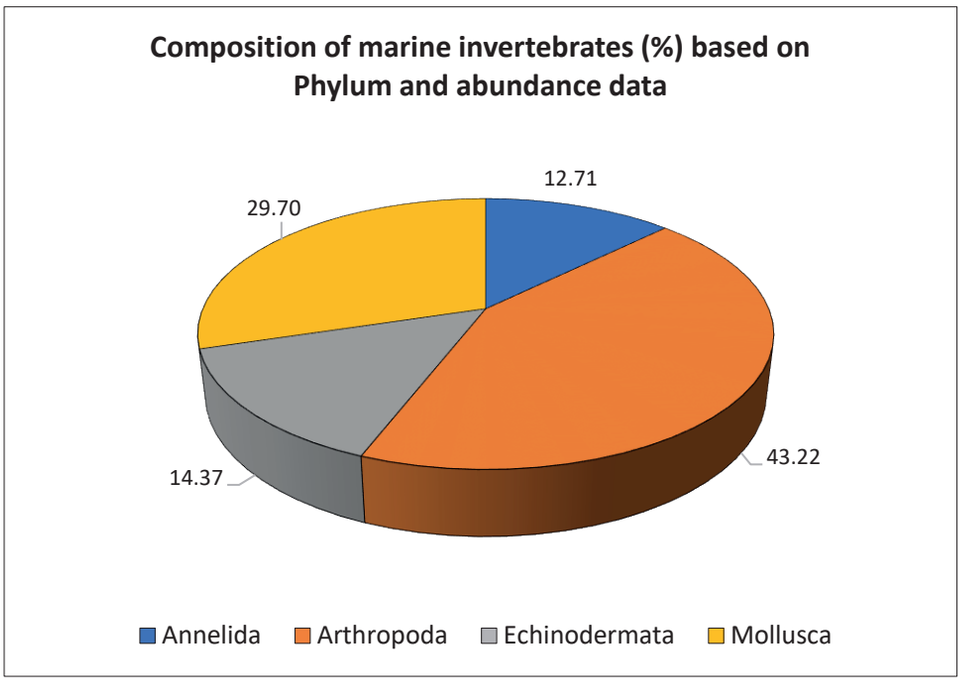


Figure 10A: Composition of marine invertebrates (%), collected from Malaysian water, based on Phylum and abundance data.

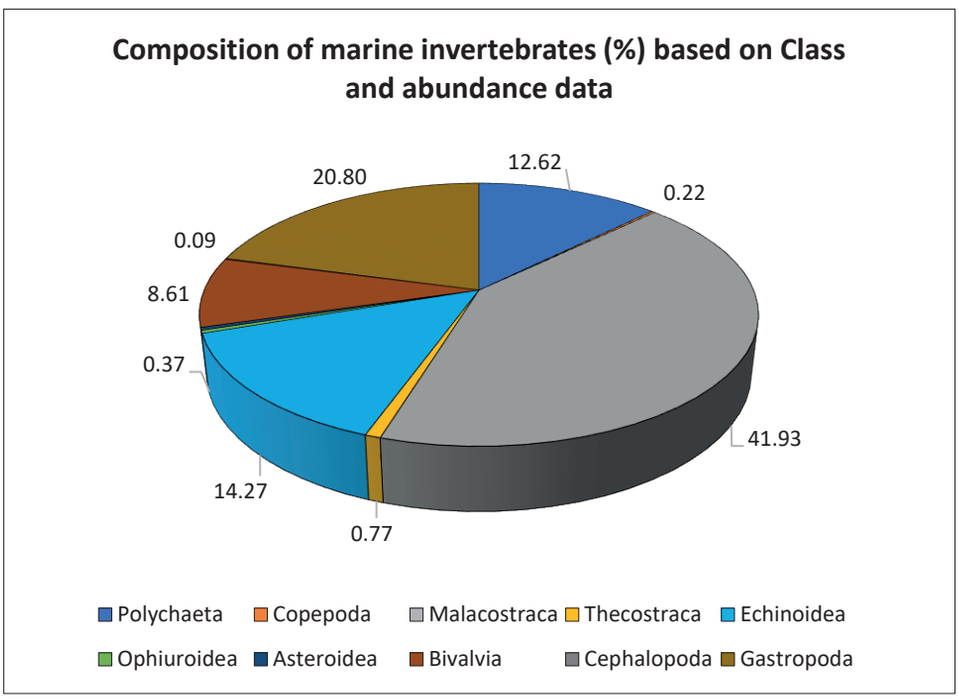


Figure 10B: Composition of marine invertebrates (%), collected from Malaysian water, based on Class and abundance data.

As previously discussed, one of the gaps in previously published studies on marine invertebrates in Malaysia is the discrepancy in terms of level of organism's classification. Some studies identified the invertebrates to the species level, while some identified to a higher level such as family and even phylum. Therefore, for the recording purpose of this project, a complete list of taxa is provided according to the states in Malaysia with the inclusion of the East Coast of Peninsular Malaysia where studies were conducted in a big spatial scale (Table 3a and 3b). The taxa in this sense refers to the taxonomic classification without discriminating what level the classification is. For instance, there are classification of family level while there is also classification of species level

Table 3a. A complete list of organisms (according to different taxonomic levels) recorded in Malaysia.

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Annelida														
Abarenicola sp.1	+											+		
Abarenicola sp.2												+		
Acromegalomma sp.												+		
Aglaophamus sp.	+											+	+	
Aglaurides fulgida					+									
Amaeana sp.	+											+		
Ampharete sp.1	+											+		
Ampharete sp.2												+		
Ampharete sp.3												+		
Ampharete sp.4												+		
Ampharetidae					+									+
Amphicorina sp.1												+		
Amphicorina sp.2	+													
Amphiglena sp.	+											+		
Amphinomidae					+									+
Ancistrosyllis	+						+					+		
Anguillosyllis sp.												+		
Antinoe sp.	+											+		
Aonidella sp.	+											+		
Aonides sp.	+													
Aphelochaeta sp. 1	+											+		
Aphelochaeta sp. 2	+											+		
Aphrodita	+											+		
Aphrodita aculeata										+				
Aphroditidae														+
Arabella iricolor					+									
Arabella sp. 1	+											+		
Archannelida						+								

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Arenicola cristata	+													
Arenicola sp.										+			+	
Arenicola sp. 1												+		
Arenicola sp. 2												+		
Armandia sp. 1										+		+	+	
Armandia sp. 2	+											+		
Armandia sp. 3												+		
Armandia sp. 4	+											+		
Artocama sp.		+												
Aspidosiphon					+									
Augeneria sp.														
Autolytus sp.		+												
Axiothella	+				+									
Bhawania sp.	+											+		
Boccardia sp.												+		
Brada sp.												+		
Branchiomaldane sp.	+											+		
Branchiomma sp.												+		
Branchiosyllis sp.	+											+		
Brania sp.												+		
Brianchiomma nigromaculata					+									
Cabira sp.	+													
Capitella sp.		+										+		
Capitella capitata		+												
Capitellidae						+	+			+	+	+	+	+
Caulleriella sp. 1							+							
Caulleriella sp. 2												+		
Ceratonereis sp.	+											+		
Chaetopteridae							+							

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Chaetopterus	+									+				
Chaetozone sp.												+		
Chloeia sp.												+	+	
Chone sp. 1	+											+		
Chone sp. 2	+											+		
Chrysopetalum sp.												+		
Cirratullidae 1							+				+	+	+	
Cirratullidae 2					+					+				+
Cirratulus sp. 1					+									
Cirratulus sp. 2	+											+		
Cirratulus sp. 3	+											+		
Cirratulus sp. 4	+											+		
Cirriformia sp. 1		+					+							
Cirriformia sp. 2	+											+		
Cirriformia sp. 3												+		
Cirriformia sp. 4	+											+		
Cossura sp.	+						+					+	+	
Cossuridae					+		+					+		+
Dasybranchus sp. 1	+											+		
Dasybranchus sp. 2												+		
Dendronereides sp.												+		
Dendronereis												+		
Diopatra cuprea					+									
Diopatra neapolitana					+									
Diopatra sp. 1	+											+		
Diopatra sp. 2												+		
Diplocirrus sp.	+											+		
Dipolydora sp. 1												+		
Dipolydora sp. 2												+		

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Dodecaceria sp. 1		+												
Dodecaceria sp. 2												+		
Dodecaceria sp. 3												+		
Dorveillidae										+				
Dorvillea sp.	+	+										+		
Drieschia sp.	+													
Drilonereis sp.	+											+		
Erinaceusyllis	+											+		
Eteone	+	+			+							+		
Euchone	+											+		
Euclymene annandalei														
Euclymene	+											+		
Euclymene	+											+		
Euclymene												+		
Euclymene												+		
Euclymene	+											+		
Eulalia		+												
Eunice	+						+			+	+	+	+	
Eunicidae										+		+		+
Eupanthalis												+		
Euphione	+													
Eurythoe	+						+					+		
Eusyllis	+													
Euthalenessa digitata														
Exogone	+				+							+		
Fabricinuda												+		
Ficopomatus uschakovi												+		
Filograna												+		
Flabelligera	+											+		
Flabelligeridae					+									+

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Gastrolepidia												+		
Gattyana												+		
Glycera alba														
Glycera		+			+		+			+		+	+	
Glycera	+				+							+		
Glycera					+									
Glycera tesselata														
Glyceridae					+		+			+				+
Glycinde												+		
Glyphanostomum	+											+		
Goniada		+					+					+		
Goniadidae					+		+			+	+	+	+	+
Goniadopsis maskallensis					+									
Gravierella												+		
Grubeulepis												+		
Haplosyllis	+											+		
Harmothoe	+				+									
Hemipodia		+												
Hesionidae					+		+			+		+	+	+
Heteromastus												+		
Heteromastus												+		
Hipponoe												+		
Hololepidella												+		
Hyalinoecia	+													
Hydroides												+		
Hydroides												+		
Hypsicomus												+		
Iospilus												+		
Isolda	+											+		
Jasmineira	+											+		

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Kirkegaardia	+											+		
Krohnia	+													
Lacydoniidae														+
Laetmonice												+		
Lanassa	+											+		
Lanice socialis					+									
Laonice	+											+		
Leiochone	+											+		
Leiochrides												+		
Leitoscoloplos												+		
Leitoscoloplos	+											+		
Leitoscoloplos												+		
Leocrates												+		
Leodice												+		
Loimia												+		
Loimia verrucosa														
Lopadorrhynchus	+											+		
Lumbricillus							+							
Lumbrineridae					+		+			+				+
Lumbrineris	+									+	+	+	+	
Gesaneris malaysiae														
Lumbrineridae					+		+			+				+
Lysidice	+									+	+	+	+	
Lysilla												+		
Lysilla												+		
Macroclymene												+		
Macroclymene	+											+		
Magelona		+										+	+	
Magelona	+													
Magelona												+		

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Magelona	+											+		
Magelonidae					+					+				+
Malacoceros	+											+		
Maldane	+											+		
Maldanella					+							+		
Maldanella												+		
Maldanella	+											+		
Maldanidae							+			+	+	+	+	+
Malmgrenia												+		
Marphysa macintoshi					+									
Marphysa moribidii							+							
Marphysa												+	+	
Marphysa												+		
Mediomastus							+					+		
Melinna	+											+		
Melinnopsides	+											+		
Mesochaetopterus selangora							+							
Mesochaetopterus												+		
Micronephthys	+						+				+	+		
Micronereides					+							+		
Myrianida sp.					+	+	+							
Mystides sp.												+		
Nainereis kalkudaensis												+		
Naineris sp. 1	+									+				
Naineris sp. 2														
Namalycastis abiuma					+									
Namalycastis rhodochorde														
Namalycastis sp. 1												+		

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Namalycastis sp. 2				+										
Neanthes sp.				+										
Neanthes glandicincta														
Neoleanira sp.	+				+								+	
Nephtyidae														
Nephtys sp.	+	+		+										
Micronephthys sphaerocirrata		+				+								
Nereididae												+		
Nereiphylla sp.							+	+						
Nereis sp.	+													
Nicomache sp. 1							+							
Nicomache sp. 2					+		+			+				
Nicomache sp. 3												+		
Nicon sp.		+											+	
Ninoe sp.	+													
Nothria sp.	+									+				
Notocirrus sp.	+													
Notomastus sp.												+		
Notomastus lineatus		+					+							
Notomastus sp. 1												+		
Notomastus sp. 2					+		+							
Notomastus sp. 3	+											+		
Notomastus sp. 4	+				+									
Notomastus sp. 5	+													
Novafabricia sp.												+		
Nudisyllis sp.	+												+	
Oenone sp.					+					+				
Olgalepidonotus kumari						+								
Onuphidae												+		

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Onuphis sp.	+													+
Ophelia sp.	+			+			+			+				
Opheliidae								+		+				
Ophelina sp.		+					+	+		+				
Opisthosyllis sp.	+						+			+				
Orbinia sp.							+	+						
Orbiniidae												+		
Owenia fusiformis												+		
Oxydromus sp.	+						+							
Paleanotus sp.	+						+					+	+	
Palola sp.	+													
Paradiopatra sp.	+													
Paralacydonia sp.	+													
Paralacydoniidae														
Paralepidonotus sp.												+		
Paraonidae					+		+							
Paraprionospio pinnata														
Paraprionospio sp.	+				+					+				
Parasabella sp.														
Parasclerocheilus branchiatus												+		
Pareurythoe sp.														
Pectinaria sp.	+													
Pectinariidae										+			+	
Pelagobia longicirrata					+									
Pelagobia sp.					+	+								
Perinereis maindroni		+												
Perinereis nuntia							+					+	+	
Perinereis sp.					+									
Petaloproctus sp.					+									

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Phalacrophorus sp.					+					+				
Golfingiidae														
Phascolosomatidae												+		
Pherusa sp. 1	+											+		
Pherusa sp. 2												+		
Pherusa sp. 3														+
Pherusa sp. 4											+			
Phyllochaetopterus sp.	+											+		
Phyllocomus sp.	+						+							
Phyllodoce sp.	+													
Phyllodocidae												+		
Phylo sp.	+				+		+			+				+
Pilargidae		+										+		
Pionosyllis sp.	+													
Piromis sp. 1	+				+		+			+	+	+	+	+
Piromis sp. 2												+		
Piromis sp. 3	+				+							+	+	
Pista sp. 1												+		
Pista sp. 2	+											+	+	
Pista sp. 3	+			+									+	
Pista sp. 4	+											+		
Pista sp. 5	+											+		
Platynereis sp.	+											+		
Podarkeopsis sp.	+	+		+										
Poecilochaetidae														
Poecilochaetus serpens				+										
Poecilochaetus sp. 1														
Poecilochaetus sp. 2	+			+										
Poecilochaetus sp. 3				+										

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Polycirrus sp. 1														
Polycirrus sp. 2	+													
Polyophthalmus sp. 1													+	
Polyophthalmus sp. 2													+	
Pontodora sp.	+											+		
Pontogenia sp.														
Potamilla sp. 1	+											+		
Potamilla sp. 2												+		
Potomilla leptochaeta												+		
Praxillella sp.												+		
Prionospio cirrobranchiata					+									
Prionospio malmgreni					+									
Prionospio pinnata					+									
Prionospio sexoculata					+									
Prionospio sp. 1		+					+					+	+	
Prionospio sp. 2	+											+		
Prionospio sp. 3	+											+		
Prionospio sp. 4	+											+		
Prionospio sp. 5	+											+		
Prionospio sp. 6	+											+		
Proceraea sp.												+		
Proscoloplos sp.												+		
Prosphaerosyllis sp.	+											+		
Protocirrineris sp.												+		
Protodorvillea sp. 1	+											+		
Protomystides sp.	+											+		
Psamathe sp.	+											+		
Pseudofabricola sp. 1												+		
Pseudofabricola sp. 2	+											+		

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Pseudonereis sp.												+		
Pseudopotamilla sp.												+		
Pulliella sp.							+							
Pygospio sp.												+		
Rhodine sp.												+		
Sabella sp.	+											+		
Sabellariidae							+							
Sabellidae	+				+					+		+	+	+
Saccocirridae		+												
Saccocirrus sp.	+													
Scalibregmatidae					+								+	+
Schistomeringos sp.	+											+		
Schroederella sp. 1	+											+		
Schroederella sp. 2												+		
Scolaricia sp. 1	+											+		
Scolaricia sp. 2												+		
Scolelepis sp. 1					+									
Scolelepis sp. 2	+											+		
Scolelepis sp. 3												+		
Scolelepis sp. 4												+		
Scolelepis sp. 5	+											+		
Scoloplella sp.							+							
Scolopolos sp.					+									
Scolopolos chevalieri					+									
Scyphoproctus sp. 1	+											+		
Scyphoproctus sp. 2												+		
Serpulidae												+		
Sigalion sp.	+				+							+		
Sigalionidae					+					+		+	+	+

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Sigambra	+						+					+		
Sige sp.					+							+		
Sipuncula sp.														
Sipunculidae		+												+
Sipunculus sp.					+									
Sipunculus nudus					+									
Sphaerodoridae										+				
Sphaerodoropsis sp.	+													
Sphaerodorum sp.	+											+		
Sphaerosyllis sp.		+										+		
Spio sp. 1												+		
Spio sp. 2	+											+		
Spiochaetopterus sp.												+		
Spionidae					+		+			+				+
Spiophanes sp. 1		+												
Spiophanes sp. 2	+													
Spiophanes sp. 3												+		
Spirorbis sp.					+									
Sternaspidae					+									+
Sternaspis scutata	+													
Sternaspis sp. 1												+		
Sternaspis sp. 2												+		
Sthenelais sp.	+											+		
Sthenelanella sp.							+							
Streblosoma sp. 1												+		
Streblosoma sp. 2	+											+		
Streblosoma sp. 3												+		
Subadyte sp.	+											+		
Syllidae	+				+		+			+	+	+	+	+

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Syllidia sp.							+							
Syllis sp.	+				+							+		
Terebella sp.												+		
Terebellidae					+	+	+			+	+		+	+
Terebellides sp. 1										+	+	+		
Terebellides sp. 2	+											+		
Terebellides sp. 3	+											+		
Thalenessa djiboutiensis					+									
Tharyx sp. 1												+		
Tharyx sp. 2												+		
Thelepus sp.	+											+		
Travisia sp.	+													
Trichobranchidae										+			+	+
Trichobranchus sp. 1												+		
Trichobranchus sp. 2	+											+		
Trypanosyllis sp.	+													
Tubificoides sp.		+												
Typosyllis sp.												+	+	
Unanereis sp.	+											+		
Vanadis sp.												+		
Websterinereis sp.	+											+		
Arthropoda														
Acanthomysis longispina										+				
Acanthomysis platycauda										+				
Acanthomysis quadrispinosa										+				
Alcockpenaeopsis hungerfordii														

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Alpheus sp.	+	+					+				+	+	+	
Alpheus euphrosyne														
Amphicteis sp.1	+											+		
Amphicteis sp.2												+		
Amphipoda							+				+	+	+	+
Anchialina dentata										+				
Anisomysis aikawai										+				
Anomura sp.							+				+			
Anthuridae														+
Apseudes					+									
Apseudidae														
Aratus pisonii	+													
Ashtoret lunaris										+				
Austruca triangularis					+									
Baetidae												+		
Balanus	+				+		+							
Balanus amphitrite					+									
Barantolla		+					+							
Baruna trigranulum					+									
Beanium batavicum		+												
Bodotria sp. 1					+									
Bodotria sp. 2					+									
Bodotridae														+
Brachyura														+
Caenidae												+		
Caligus sp. 1												+		
Caligus sp. 2												+		
Caligus sp. 3												+		
Callianassa spp.										+	+	+	+	

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Calliannassidae														+
Carcinoscorpius rotundicauda											+	+	+	
Caridae														+
Carinoma		+												
Charybdis affinis										+	+			
Charybdis anisodon											+			
Charybdis feriata										+	+			
Charybdis japonica											+			
Charybdis truncata										+				
Chironomidae												+		
Chthamalus sp.					+									
Chthamalus malayensis	+	+			+									
Cirolanidae														+
Cirripedia												+		
Clibanarius longitarsus		+										+		
Clibanarius striolatus	+	+												
Clistocoeloma merguiense		+		+			+	+		+		+		
Coenobita lila					+									
Colomastix		+												
Corduliidae												+		
Corixidae												+		
Corophiidae					+									
Corycaeus					+									
Cumacea							+							
Cumella sp.		+												
Dardanus	+													
Decapoda												+		
Diogenes sp		+			+									

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Diogenidae							+							
Doclea sp.										+				
Doclea armata										+				
Dotilla sp.												+		
Dytiscidae												+		
Episesarma mederi					+									
Episesarma palawanense										+				
Episesarma singaporense	+											+		
Episesarma				+			+							
Episesarma versicolor		+			+					+				
Erythrops minutus										+				
Euraphia					+									
Microeuraphia withersi					+									
Eurydice					+									
Excirolana														
Excirolana hirsuticauda							+							
Fasciarma fasciatum				+			+							
Galene bispinosa										+				
Gammaropsis					+									
Gammarus														
Gerridae												+		
Gomphidae												+		
Goniopsis cruentata	+													
Haberma												+		
Haplostylus bengalensis										+				
Harpacticus		+			+									
Harpiosquilla											+			
Harpiosquilla harpax	+													
Hemigrapsus												+		

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Heteropanope glabra												+		
Thecostraca												+		
Hydrophilidae												+		
Ilyograpsus nodulosus												+		
Ilyogynnis microcheirum					+									
Ilyoplax lingulata		+												
Ilyoplax punctata		+												
Isopoda							+					+	+	
Labuanium politum												+		
Leptochela												+	+	
Lernanthropus												+		
Libellulidae												+		
Lipiniella							+							
Luciferidae							+							
Lycomysis spinicauda										+				
Macrobrachium equidens							+							
Macrobrachium naso											+			
Macrobrachium rosenbergii											+			
Macrobrachium							+							
Macrophthalmus abbreviatus	+													
Macrophthalmus brevis	+													
Macrophthalmus												+		
Majidae	+													
Ashtoret lunaris										+	+			
Matuta planipes					+								+	
Melanella					+									
Metapenaeopsis stridulans							+							

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Metapenaeus affinis							+				+			
Metapenaeus brevicornis							+			+	+			
Metapenaeus ensis	+						+							
Metapenaeus lysianassa							+				+			
Metapenaeus ensis								+			+			
Metapenaeus														
Metapenaeopsis stridulans							+							
Metaplax distincta								+						
Metaplax crenulata				+			+							
Metaplax elegans	+	+		+	+		+	+		+		+		
Metaplax	+													
Metopograpsus frontalis					+							+		
Metopograpsus latifrons		+		+			+	+				+		
Metopograpsus oceanicus								+		+				
Metopograpsus quadridentatus								+						
Garthiope spinipes							+							
Mierspenaeopsis sculptilis														
Miyakella nepa											+			
Moguai aloutos		+												
Monoculodes sp.												+		
Monoporeia sp.														
Myra fugax				+										
Mysida														
Nannastacidae				+								+		
Nanosesarma andersonii					+									
Nanosesarma batavicum								+						
Nanosesarma edamense												+		
Nanosesarma minutum												+		

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Nanosesarma nunongi					+		+							
Nanosesarma pontianacense														
Nanosesarma sp. 1					+									
Nanosesarma sp. 2					+									
Neodorippe sp.												+		
Neosarmatium smithi												+		
Neosarmatium spinicarpus		+										+		
Neosarmatium sp.												+		
Notonectidae												+		
Ocypode ceratophthalmus					+							+		
Ocypode cordimana					+									
Ocypodidae							+							
Oedicerotidae														
Oratosquilla sp.												+	+	
Ostracoda												+	+	
Paguridae							+							
Paguroidea					+									
Pagurus sp.												+		
Palaemon styliferus														
Panulirus versicolor												+	+	
Paracleistostoma depressum								+						
Paracleistostoma sp. 1													+	
Paracleistostoma sp. 2														
Paragnathia sp.					+									
Parapenaeopsis coromandelica														

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Parapenaeopsis gracillina												+		
Mierspenaeopsis hardwickii							+			+		+	+	+
Alcockpenaeopsis hungerfordii												+		
Kishinouyepenaeopsis maxillipedo												+		
Mierspenaeopsis sculptilis												+		
Parasesarma batavianum														+
Leptarma lenzii		+											+	
Parasesarma eumolpe														
Parasesarma indiarum							+							
Parasesarma lanchesteri					+									
Leptarma lenzii		+			+									
Parasesarma longicristatum					+									
Parasesarma melissa							+							
Parasesarma onychophorum					+									
Parasesarma plicatum							+							
Parasesarma rutilimanum		+			+									
Pasiphaeidae					+									+
Penaeidae												+		
Penaeus indicus														
Penaeus merguiensis	+													
Penaeus monodon														
Penaeus penicillatus										+				
Perioculodes pallidus												+		
Perisesarma sp.		+			+		+			+		+		+
Parasesarma eumolpe		+										+		

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Parasesarma indiarum		+					+							
Parasesarma messa		+										+		
Parasesarma onychophorum		+												
Parasesarma plicatum												+		
Parasesarma semperi		+												
Philyra globus					+									
Philyra sp.												+		
Platyischnopus sp.														
Porcellanella triloba													+	
Eodemus hastatoides												+		
Portunus pelagicus												+		
Pseudanchialina inermis										+				
Rhopalophthalmus longipes										+				
Rhopalophthalmus longipes														
Sarmatium germaini							+	+						
Scina sp.							+							
Scopimera inflata													+	
Scylla sp.	+	+				+	+				+	+	+	
Scylla serrata	+					+	+					+	+	
Selatium brockii							+	+		+				
Sergestes sp.											+			
Sesarmidae												+		
Sesarmine sp. 1		+												
Sesarmine sp. 2		+												
Sesarmine sp. 3		+												
Sesarmoides borneensis		+												
Sesarmoides kraussi							+							

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Siriella media										+				
Siriella vulgaris										+				
Sphaeroma sp.					+									
Sphaeroma terebrans							+							
Sphaeroma triste						+	+							
Stenopus hispidus	+													
Stomatopoda							+						+	+
Synchelidium sp.					+									
Tachypleus gigas	+									+			+	
Tanaidae							+							+
Tanais sp.							+							
Tetraclita sp.	+				+									
Tetraclita multicostata	+													
Tetraclita porosa	+													
Thalamita crenata											+			
Thalassionidae													+	+
Thenus orientalis											+			
Thysanoessa sp.							+							
Trachypenaeus fulvis							+							
Trachypenaeus sp.													+	
Tubuca paradussumieri					+									
Tubuca rosea					+									
Uca annulipes												+		
Uca coarctata	+													
Uca forcipata		+												
Uca parplexa												+		
Uca rosea	+	+												
Uca sp. 1		+					+						+	
Uca sp. 2														

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Uca vocans	+											+		
Upogebia spp.											+	+	+	
Varuna litterata												+		
Xenophthalmus pinnotheroides							+							
Cnidaria														
Actinaria					+									
Anthozoa											+			
Entacmaea quadricolor													+	
Heteractis aurora													+	
Radianthus crispa													+	
Radianthus magnifica													+	
Merona cornucopiae							+							
Pachycerianthus sp.	+						+			+				
Pennatuloidea												+		
Pteroides sp.										+				
Stichodactyla sp.	+													
Stichodactyla gigantea					+									
Stichodactyla mertensii													+	
Echinodermata														
Acanthaster planci	+												+	
Actinocucumis longipedes					+									
Actinodendron sp. 1													+	
Actinodendron sp. 2													+	
Actinodendron sp. 3													+	
Actinopyga lecanora	+													
Amphioplus sp.					+									+
Amphipholis gracillima							+							

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Amphiuridae														
Archasterty picus														
Astropecten vappa		+			+						+			+
Bohadschia argus	+													
Bohadschia marmorata	+	+						+					+	
Choriaster granulatus	+	+												
Clypeaster					+									
Colochirus quadrangularis				+										
Culcita novaeguineae	+												+	
Diadema	+													
Diadema setosum					+									
Echinaster callosus	+													
Echinodiscus bisperforatus					+									
Echinodiscus truncatus					+									
Echinothrix calamaris													+	
Fromia	+													
Fromia monilis													+	
Goniodiscaster scaber										+				+
Holothuria (Metriatyla) martensii					+									+
Holothuria (Halodeima) atra	+	+		+		+		+		+		+	+	
Holothuria (Halodeima) edulis	+	+											+	+
Holothuria (Microthele) fuscogilva	+													
Holothuria leucospilota	+	+		+	+	+		+		+		+	+	
Holothuria (Lessonothuria) pardalis				+					+					

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Holothuria (Metriatyla) scabra	+			+						+				
Laganum fudsiyama										+				
Linckia	+													
Linckia multifora	+													
Luidia hardwicki					+									
Luidia maculata										+				
Macrophiothrix speciosa					+									
Mellita													+	
Molpadia sp.														
Opheodesoma sp.	+													
Ophiactis sp.												+		
Ophiactis carnea												+		
Ophiactis fuscolineata												+		
Ophiactis savignyi												+		
Ophiocoma sp.												+		
Ophiothela venusta					+									
Ophiothrix spinosissima												+		
Ophiuroidea		+										+		
Parasalenia gratiosa												+		
Pearsonothuria graeffei	+				+									
Phyrella thyonoides												+		
Phyllophorus sp.							+							
Protoreaster nodosus										+				
Salmacis sp.							+							
Salmacis dussumieri											+			
Stellaster childreni										+				
Stichopus chloronotus				+		+				+		+	+	
Stichopus herrmanni				+										

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Stichopus horrens				+		+				+		+		
Stichopus ocellatus	+			+									+	
Stichopus variegatus													+	
Stichopus vastus												+	+	
Stolus buccalis					+									+
Synaptula lamperti													+	
Thelenota ananas	+	+											+	
Thelenota anax	+													
Thyonidium sp.							+							
Foraminifera														
Asterorotalia pulchella							+							
Globorotalia sp.							+							
Pseudorotalia schroeteriana	+													
Mollusca														
Abra alba	+													
Acteocina sp.												+		
Acteon sp.					+							+		
Aeneator comptus		+												
Agaronia gibbosa		+												
Alvania sp.												+		
Americoliva sayana							+	+						
Amphioxus												+	+	
Anadara		+										+		
Anadara nodifera							+							
Anadara antiquata		+										+	+	
Anadara globosa							+							

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Anadara granosa		+											+	
Anadara gubernaculum														
Anadara indica		+												
Anadara kagoshimensis		+												
Anadara notabilis							+			+				
Angaria delphinus	+													
Apaturris												+		
Arca boucardi														
Architectonica sp.		+												
Arcuatula arcuatula							+							
Assiminea beddomeana		+												
Assiminea philippinica		+												
Assiminea microsculpta		+												
Assiminea brevicula	+			+										
Assiminea grayana		+												
Assiminea ovata		+												
Assiminea sp.												+		
Assiminea woodmasoniana		+												
Astralium calcar										+				
Atlanta												+		
Atrina pectinata					+									
Atrina vexillum					+									
Atys sp.												+		
Auriculastra cf. *subula*		+												
Azorinus coarctatus		+												
Bactronophorus thoracites	+						+							
Bankia campanellata						+								
Bankia gracilis	+					+	+							

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Bankia rochi						+	+							
Barbatia fusca							+							
Barbatia sp.														
Barleeia												+		
Bathytormus radiatus		+												
Batillaria sordida												+		
Batillaria sp.		+										+		
Batillaria zonalis		+										+		
Bithynia sp.		+												
Bivetiella cancellata										+				
Brachidontes pharaonis												+		
Brachiodontes sp.		+												
Brookula sp.												+		
Bursa sp.	+													
Cadulus sp.					+									
Calayptraeidae sp.					+									
Calliostoma ligatum										+				
Calliostoma pulchrum									+					
Callista erycina		+												
Calyptraea												+		
Canarium urceus	+	+												
Cancellaria reticulata								+						
Cantharus sp.	+													
Cardiidae		+										+		
Cassidula aurisfelis	+			+										
Cassidula labrella		+												
Cassidula mustelina		+												
Cassidula nucleus	+			+										
Cassidula sp.1	+	+										+		

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Cassidula sp.2	+											+		
Cassis cornuta		+												
Cellana sp.	+				+									
Cellana enneagona												+		
Cellana radiata	+											+		
Cellana rota	+													
Cellana testudinaria	+													
Cerastoderma edule							+	+	+	+				
Cerithidea quadrata		+												
Cerithidea alata		+												
Cerithidea cf. largillierti		+												
Cerithidea cingulata		+				+							+	
Cerithidea obtusa				+								+	+	
Cerithidea quoyii	+	+												
Cerithidea rhizophorarum		+					+							
Cerithidea sp. 1		+		+										
Cerithidea sp. 2										+				
Cerithidea sp. 3										+				
Cerithidea sp. 4												+		
Cerithideopsilla cingulata	+											+		
Cerithiopsis												+		
Cerithium	+				+		+					+		
Cerithium atratum		+												
Cerithium coralium		+			+									
Cerithium litteratum		+											+	
Cerithium zonatum	+													
Chama sp.	+													
Chicoreus brunneus		+												
Chicoreus capucinus	+	+										+		

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Chlamys							+							
Chromodoris lochi	+													
Chromodoris quadricolor	+													
Chromodoris reticulata													+	
Chrysallida												+		
Cingulina sp.												+		
Circe sp.													+	
Circulus												+		
Clathrodillia jeffreysii										+				
Clithon faba		+										+		
Clithon oualaniense	+	+										+		
Clithon oualaniense												+	+	
Clithon pulchellum												+		
Clithon retropictus		+												
Clithon sp.1												+		
Clithon sp. 2												+		
Clypeomorus		+												
Clypeomorus batillariaeformis	+			+										
Clypeomorus concisus		+												
Codakia orbicularis													+	
Codakia tigerina							+							
Coelotrochus												+		
Columbellidae					+									
Conus	+													
Conus magus	+													
Conus praecellens		+												
Conus vexillum		+												
Conus virgo													+	

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Coralliophilla neritoidea													+	
Corbicula fluminea												+		
Corbula sp.					+									
Corbulidae							+							
Crassostrea iredalei		+										+		
Crassostrea sp.	+											+		
Crassostrea virginiea		+												
Crepidula					+									
Crepidula sp.					+									
Crossostra							+							
Ctenoides philippinarum		+												
Cylichnidae					+		+							
Cylindrotis cf. *quadrasi*		+												
Cymatium tigrinum		+												
Cymbiola nobilis										+				
Cypraea europaea							+			+				
Cypraea miliaris										+				
Cypraea sp.1													+	
Cypraea tigris	+													
Cypraecassis testiculus														
Cyrenidae							+							
Dallocardia muricata									+					
Dentaliidae					+									
Dentalium octangulatum					+									
Dentalium sp.					+									
Dicyathifer mannii							+							
Dinocardium robustum							+	+	+	+				
Donacidae							+							
Donax sp.							+					+	+	

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Donax cuneatus													+	
Donax faba		+									+			
Donax trunculus							+	+	+	+				
Donax variabilis													+	
Dosinia anus												+		
Dosinia exilium												+		
Dostia cornucopia		+												
Dostia sp.												+		
Dostia violacea		+												
Doxander vittatus		+												
Drupella margariticola	+													
Drupella rugosa													+	
Echinolittorina												+		
Echinolittorina malaccana												+		
Echinolittorina millegrana	+													
Echinolittorina vidua												+		
Ellobium aurisjudae		+										+		
Ellobium aurismidae		+										+		
Enigmonia aenigmatica		+										+		
Epitonium	+											+		
Ergaea walshi							+							
Naria miliaris		+												
Ficadusta pulchella		+												
Ethaliella					+									
Euchelus atratus	+													
Eucithara marginelloides		+												
Eulima												+		
Eulimella												+		
Euplica scripta										+				

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Euplica scripta	+													
Eurytellina lineata		+												
Fasciolaria							+							
Faunus ater												+		
Faunus ater												+		
Ficus filosa		+												
Filifusus filamentosus		+												
Filopaludina sumatrensis												+		
Flabellina							+							
Fulgoraria hamillei		+												
Fusinus colus		+												
Fusinus salisburyi		+												
Gafrarium divaricatum					+									
Gafrarium pectinatum		+												
Gafrarium tumidum												+		
Gari	+													
Geloina expansa		+												
Geloina expansa						+								
Gemmula speciosa		+												
Gyraulus												+		
Gyrineum natator		+												
Morula spinosa													+	
Haminoea natalensis		+												
Harpa articularis		+												
Homalopoma					+									
Hyotissa hyotis													+	
Indothais javanica														
Indothais lacera		+												
Indothais malayensis		+												

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Indothais rufotincta		+										+		
Iravadia quadrasi		+												
Isognomon ephippium		+										+		
Isognomon perna	+													
Laemodonta punctatostriata		+												
Laemodonta punctigera		+												
Laemodonta	+	+		+										
Laevistrombus canarium		+					+							
Laevistrombus turturella		+												
Lambis	+													
Terestrombus fragilis							+							
Lambis lambis													+	
Laternula anatina										+				
Fusolatirus formosior										+				
Latirus										+				
Latirus										+				
Lepidolucina venusta		+												
Leporicypraea mappa		+												
Lymnaea		+												
Limopsis														
Liotinaria peronii	+													
Lithopoma phoebium										+				
Lithopoma tectum										+				
Littoraria angulifera	+													
Littoraria articulata	+													
Littoraria carinifera	+	+		+										
Littoraria intermedia		+										+		
Littoraria sp.		+		+	+							+		

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Littoraria strigata												+		
Littoraria undulata	+											+		
Littoraria vespacea		+												
Littoraria coccinea							+							
Littoraria zebra		+											+	
Littorina littorea							+							
Littoraria melanostoma						+								
Nodilittorina pyramidalis		+												
Littoraria scabra		+		+									+	
Littoraria undulata				+									+	
Littorinidae												+		
Loligo											+			
Uroteuthis chinensis										+				
Uroteuthis (Photololigo) duvaucelii											+			
Lopha		+												
Lopha cristagalli													+	
Lophiotoma acuta		+												
Loripes												+		
Loripes orbiculatus												+		
Lottiidae	+													
Lunella cinerea	+			+										
Lutraria												+		
Lymnaea														
Lyrodus pedicellatus						+	+							
Macoma					+									
Macrocallista nimbosa									+					
Mactra							+					+		
Mactra glauca							+	+	+	+				

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Mactra luzonica							+							
Standella pellucida							+							
Mactridae							+							
Malleus albus													+	
Mancinella echinata													+	
Marcia hiantina		+												
Marcia japonica											+	+		
Marcia recens												+		
Marcia sp.	+											+		
Marginellidae					+									
Neodilatilabrum										+				
Neodilatilabrum marginatum														
Martesia striata						+	+							
Megastomia					+									
Melampus		+												
Melanoides tuberculata												+		
Melo melo		+								+				
Meretrix casta		+												
Meretrix lusoria		+												
Meretrix lyrata		+												
Meretrix meretrix					+							+		
Meretrix	+												+	
Mimachlamys crassicostata							+	+		+				
Minolia ceraunia														
Mitra	+	+												
Strigatella decurtata	+													
Mitridae					+									
Modiolatus flavidus					+							+		+

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Modiolatus nitidus				+										
Modiolus sp.							+			+		+	+	
Moerchia sp.							+							
Monetaria annulus	+						+							
Monodonta australis		+					+							
Monodonta labio	+	+					+			+				
Monodonta canalifera							+							
Monodonta labio							+			+				
Morula sp.														
Tenguella granulata		+										+		
Neothais marginatra												+		
Tenguella musiva	+												+	
Morula striata					+									
Murex aduncospinosus		+						+		+				
Murex concinnus		+												
Murex ternispina		+		+	+		+	+		+				
Murex trapa				+										
Myadora sp.							+							
Myadora striata														
Myosotella myosotis		+			+									
Mytilidae				+										
Mytilus sp.				+			+							
Nassariidae							+	+		+				
Nassarius sp.														
Nassarius albescens		+					+							
Nassarius castus		+										+		
Nassarius foveolatus		+												
Nassarius globosus		+												
Nassarius jacksonianus														

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Nassarius kraussianus		+												
Nassarius livescens		+												
Nassarius niger		+										+		
Nassarius olivaceus		+												
Nassarius pullus		+			+							+		
Nassarius reeveanus		+												
Nassarius sp.														
Nassarius stolatus		+												
Nassarius glans					+					+		+		
Nassarius venustus														
Natica sp.													+	
Paratectonatica tigrina							+							+
Naticarius onca												+		
Paratectonatica tigrina														
Naticarius stercusmuscarum		+					+				+			
Neripteron violaceum		+					+				+			
Nerita sp.		+					+				+			
Nerita balteata		+					+							
Nerita albicilla	+	+					+							
Nerita balteata	+													
Nerita chamaeleon	+	+							+					
Nerita balteata		+										+		
Nerita litterata					+									
Nerita maxima														
Nerita planospira	+	+										+		
Nerita plicata		+										+		
Nerita polita														
Nerita histrio	+													

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Nerita tassellata		+										+		
Nerita undata		+												
Neripteron cornucopia	+													
Neritina sp. 1		+										+		
Neritina sp. 2												+		
Neripteron violaceum	+													
Neverita sp.							+							
Nodilittorina sp.	+						+							
Nodilittorina biangulata												+		
Echinolittorina millegrana		+										+		
Nodilittorina pyramidalis	+											+		
Echinolittorina pascua												+		
Noetia ponderosa													+	
Nucula sp.										+				
Nuculanidae							+							
Nuculidae												+		
Oliva sp.														
Oliva sayana													+	
Oliva sericea											+			
Oliva tremulina		+												
Olivella sp.													+	
Peronia verruculata		+											+	
Onoba sp.												+		
Optediceros breviculum		+										+		+
Orania gaskelli		+			+		+					+		
Orania sp.	+				+					+				
Orinella sp.							+							
Ostrea edulis					+									
Ostrea lurida		+			+									

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Ostrea sp.														
Otopleura auriscati		+												+
Oxyloma patentissimum		+										+		
Paphia sp.					+					+	+	+	+	
Onchidina sp.														
Parvanachis obesa		+										+		
Parvicardium sp.		+										+		
Patella sp. 1	+	+												
Patella sp. 2	+				+									
Patelloida saccharina	+													
Patelloida saccharinoides	+											+		
Patelloida sp.												+		
Peasiella roepstorffiana	+											+		
Pedum sp.	+										+			
Pedum spondlyloidum												+		
Peristernia nassatula		+										+		
Phalium glaucum		+			+						+			
Phidiana sp. 1													+	
Pholas orientalis												+		
Phos sp.					+									
Phrontis polygonata		=										+		
Phyllidiella zeylanica					+									
Phyllidia sp.	+			+										
Phyllidia coelestis							+			+				+
Phyllidia elegans												+		
Phyllonotus margaritensis														
Pictocolumbella ocellata	+				+									
Pila scutata							+				+	+	+	
Pilsbryoconcha exilis												+		

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Pinctada margaritifera	+											+		
Pirenella cingulata		+												
Pirenella conica		+												
Pirenella microptera		+			+									
Pitar citrinus					+									
Pitar sp.													+	
Placamen isabellina		+										+		
Placuna placenta												+		
Planaxis sp.												+		
Planaxis sulcatus	+	+										+		
Platyvindex sp.	+										+	+		+
Pleuroploca trapezium														
Polinices aurantius		+								+				
Polinices hepaticus		+										+		
Mammilla mammata												+		
Polinices mammilla					+							+		
Geloina expansa	+									+				
Polymesoda sp.	+									+				
Potamocorbula fasciata												+		
Prionomysis aspera										+				
Pteria penguin													+	
Pugilina morio		+												
Pugilina tupiniquim		+												
Pyramidella sp.												+		
Pyramidellidae							+							
Pyrene obscura		+												
Pyrene ocellata		+												
Pyrene testudinaria	+													
Pyrene versicolor										+				

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Pyrgulina sp.												+		
Pythia sp.	+													
Ranularia caudata		+												
Rapana venosa		+												
Reishia bitubercularis	+											+		
Rentusidae					+									
Reticutriton pfeifferianus		+												
Retusa					+							+		
Rhinoclavis kochi		+												
Rhinoclavis sp.													+	
Ringicula sp.					+							+		
Ringicula propinquans					+									
Risbecia tryoni													+	
Rissoina inca		+												
Rissooidea					+									
Rochia nilotica														
Ruditapes decussatus														
Saccostrea cuccullata	+				+							+		
Saccostrea scyphophilla	+													
Saccostrea sp.													+	
Sacella bellula					+									
Scaliola sp.												+		
Scaphander lignarius							+							
Scapharca cornea												+		
Scaphopoda												+		
Semele purpurascens									+					
Semelidae							+							
Semicassis bisulcata										+				
Semicassis glabrata		+												

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Semicassis granulata		+												
Semiricinula fusca												+		
Semiricinula sp.	+													
Semiricinula sp.	+													
Semisulcospira libertina		+												
Sepia aculeata											+			
Sepia inermis											+			
Sepia sp.										+				
Septifer sp.		+												
Sermyla sp.												+		
Siliqua sp.												+		
Sinonovacula constricta		+												
Siphonaria atra	+											+		
Siphonaria guamensis												+		
Siphonaria hispida												+		
Siphonaria javanica	+													
Siphonaria laciniosa	+													
Siphonaria sp.												+		
Siphonaria sp. 1	+				+									
Siphonaria sp. 2	+													
Solen sp.1					+								+	
Solen sp.2												+		
Solenidae							+							
Solenocera subnuda							+							
Solenosteira cancellaria		+												
Sphaerassiminea miniata				+										
Sphenia sp.		+												
Spiralinella sp.												+		
Spisula raveneli							+							

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Spisula solida							+	+	+	+				
Spondylus nicobaricus													+	
Spondylus tenebrosus													+	
Stellaria solaris		+												
Stenothyra polita						+								
Stigmaulax elenae		+												
Stosicia sp.												+		
Strombus canarium		+								+				
Strombus gibberulus		+												
Strombus haemostoma		+												
Strombus marginatus							+			+				
Strombus quadrata		+												
Strombus sp.										+				
Strombus sp. 1													+	
Strombus urceus										+				
Strombus vittatus										+				
Supplanaxis niger	+													
Syncera brevicula						+								
Syrnola adamsi		+												
Tanea lineata										+				
Tapes belcheri											+			
Tectus pyramis										+				
Tegillarca granosa							+							
Teinostoma												+		
Telescopium telescopium		+				+						+		
Tellina albenia							+							
Tellina foliacea							+							
Tellina sp. 1		+					+					+	+	
Tellina sp. 2												+		

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Tellina sp. 3												+		
Tellina staurella							+					+		
Tellina tenuis							+							
Tellina virgata													+	
Tellinidae							+							
Tenguella granulata	+													
Tenguella marginalba												+		
Tenguella musiva												+		
Terebra sp.	+									+		+		
Terebra maculata													+	
Terebralia palustris		+												
Terebralia sulcata				+										
Teredinidae sp.		+												
Teredo bartschi						+								
Teredo furcifera						+								
Teredo mindanensis							+							
Teredothyra sp.						+	+							
Thais carinifera					+									
Thais jubilaea										+				
Thais kieneri		+												
Thais musira		+												
Thais sp.	+									+		+	+	
Thais tuberosa		+		+										
Thiara sp.		+												
Tibia fusus		+												
Timoclea sp.														
Tivela sp.					+									
Tonna sp.	+													
Tonna galea		+												

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Tonna tessellata		+												
Tornidae							+							
Trabecula sp.												+		
Trachycardium sp.	+													
Trachycardium muricatum									+					
Tridacna sp.	+													
Tridacna crocea													+	
Tridacna maxima													+	
Tridacna squamosa													+	
Trisidos semitorta					+									
Tritia cuvierii		+												
Trivia monacha							+							+
Trochidae					+									
Trochochaetidae										+				
Trochus sp.	+													
Trochus histrio										+				
Trochus maculatus	+									+				
Trochus niloticus										+				
Trochus stellatus										+				
Turbo sp.	+													
Turbo intercostalis	+													
Turbo petholatus													+	
Turricula jurana					+									
Turris sp.					+									
Turritella sp.					+	+	+			+		+		
Turritella cingulifera														
Turritella terebra		+												
Umbonium costatum		+												
Umbonium elegans		+												

Taxa	Sabah	Sarawak	Perlis	Kedah	Penang	Perak	Selangor	Malacca	Negri Sembilan	Johore	Kelantan	Terengganu	Pahang	East Coast (P. Malaysia)
Umbonium eloiseae		+												
Umbonium moniliferum		+												
Umbonium sp.													+	
Umbonium suturale		+												
Umbonium thomasi		+												
Umbonium vestiarium		+			+								+	
Urosalpinx cinerea							+		+	+				
Vaceuchelus sp.					+									
Veneridae		+			+									
Veremolpa sp.					+									
Vitta virginea		+												
Vitta zebra		+												
Vittina coromandeliana		+												
Viviparous georgianus		+												
Viviparous sp.		+												
Volegalea cochlidium		+												
Volema myristica		+												
Volva volva		+												
Volvulella sp.												+		
Xenostrobus sp.	+													
Yoldia sp.													+	
Zafra sp.					+									
Nematoda														
Anotomastus sp.												+		
Marylynnia gerlachi												+		
Cephalothrix sp.		+			+									
Theristus pertenuis	+													
Trissonchulus bulbius		+												

+ denotes presence taxa

Table 3b. Summary of Table 3a – number of taxa by according to different Phylum of marine invertebrates recorded in Malaysia.

Phylum	Number of Taxa
Annelida	399
Athropoda	257
Cnidaria	13
Echinodermata	69
Foraminifera	3
Mollusca	609
Nematoda	5

4.5.2 Overall density of marine invertebrates

From 14 references of marine invertebrate studies in Malaysia (based on density data), a total of 42 species has been recorded from those studies with *Daptonema hirsutum* (roundworm; 28.3%) recorded the highest percentage of density, followed by Nematoda (roundworm; 24.02%), *Sphaerolaimus macrocirculus* (roundworm; 22.81%), Harpaticoida (copepod; 12.17%) and *Spilophorella candida* (nematoda; 10.97%). While, the rest of a total of 36 species (written as others) has documented a percentage of less than 1%, individually (Figure 11).

The *Daptonema hirsutum* (roundworm or nematode) which was found in Teluk Awar, Sarawak has strong characteristics of occurring in large numbers, practise sedentary lifestyle, shorter reproductive cycle, and intimate association with sediments (lack of planktonic or aerial life cycle) (Chen et al., 2012). Besides due to the hydrodynamic forces, which might lead to a greater sediment mixing, hence increases oxygenation on sandy and muddy areas, the highest density of those organisms was probably due to the abundant food sources coming from the influx of freshwater (associated with nutrients) (Shabdin & Othman, 2008). The nutrient from the water together with total organic matter (TOM) inside the sediment were also identified as one of the components that affected the distribution pattern of marine nematode in Teluk Awar, Sarawak. As the free-living species are very selective in the food they ingest, the presence of large amounts of particular food at a locality would favour the colonization of species.

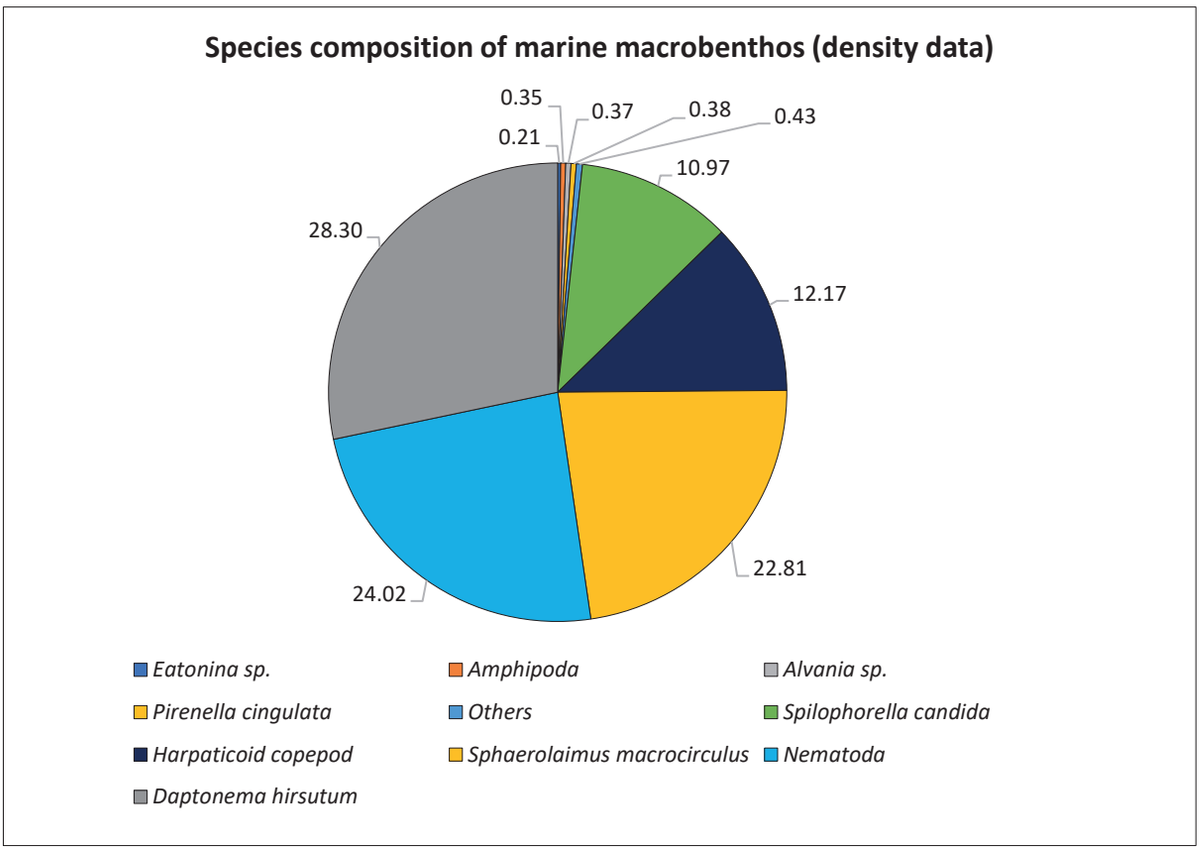


Figure 11: Composition of marine invertebrate (density data) from Malaysian water, obtained from 14 references

In terms of a higher taxa classification, invertebrates from Phylum Nematoda recorded the highest percentage of density (86%) from the 14 studies, followed by Arthropoda (12.63%), Mollusca (0.82%) and Annelida (0.45%) (Figure 12A). The least composition of invertebrate in terms of density percentage was represented by Echinodermata and Ochrophyta, which less than 0.001%. As for Class level, invertebrate from Class Chromadorea recorded the highest taxa found (86.10%), followed by Nematoda (24.02%) and Copepoda (12.63%) (Figure 12B). In a study by Madin et al. (2021) in Kota Kinabalu, Sabah, very few algae of Phylum Ochrophyta and sessile invertebrates were found on the upper intertidal shore of the selected sampling sites. The low abundance of those organisms is mainly contributed by the human visitation which have caused the disturbance to the algae cover and sessile inverts that act as ecosystem buffers for gastropods. In Sampadi Island, Sarawak, the high benthic algae composition has been detected together with the molluscs of *Littorina pyramidales*. The benthic algae which are attached on the surface of sediment and rocks possibly become one of the food sources for the gastropods, which grazed on the macroalgae (Long et al., 2014).

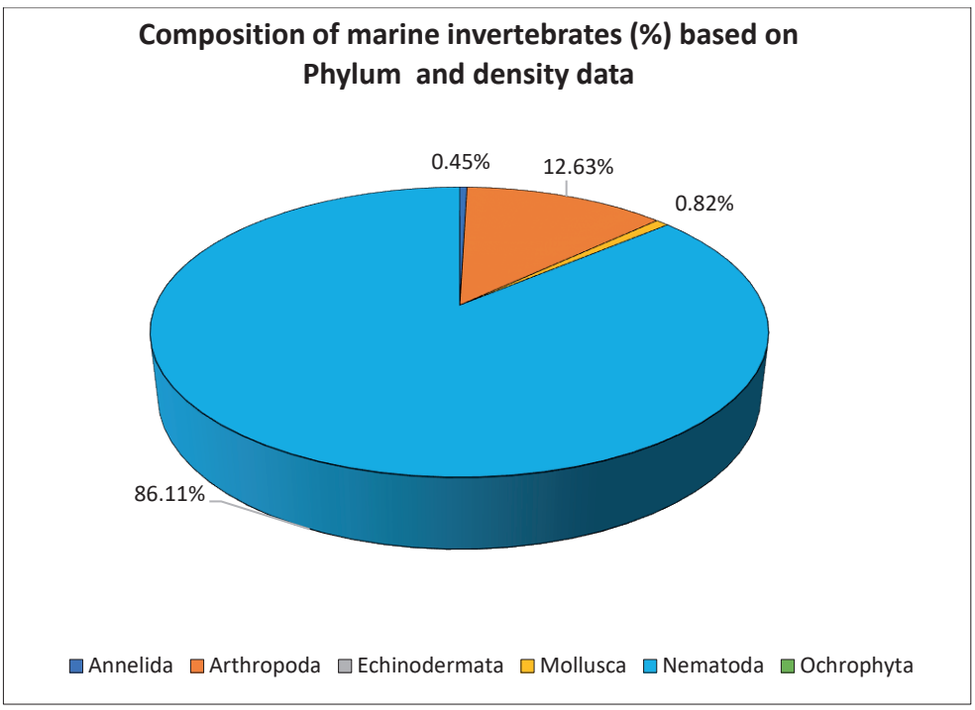


Figure 12A: Composition of marine invertebrates (%), collected from Malaysian water, based on Phylum and density data

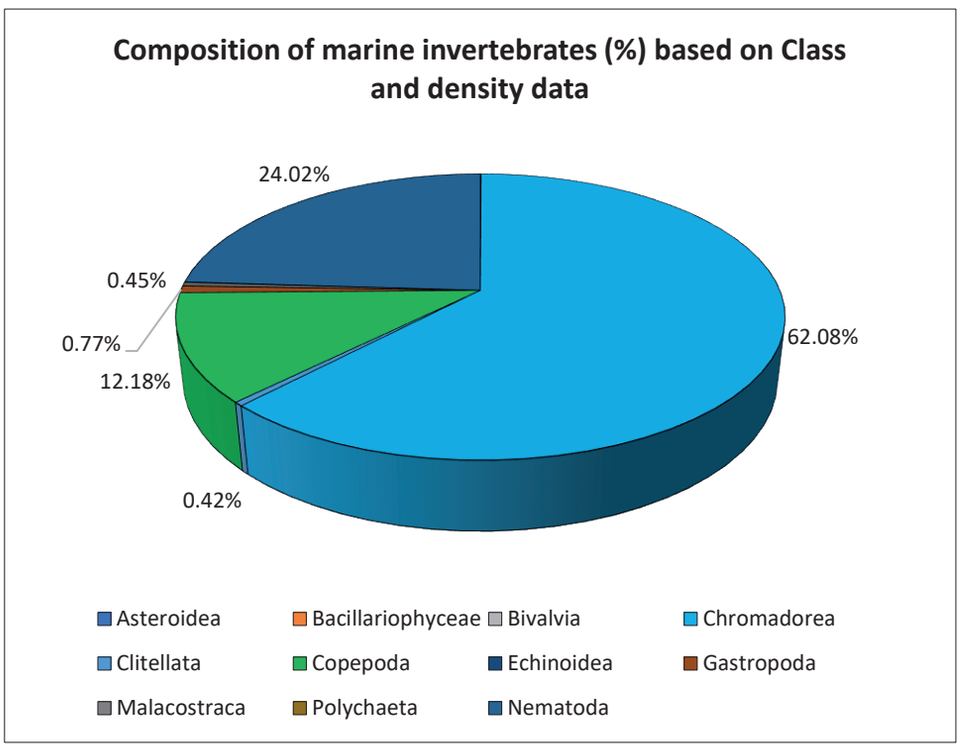


Figure 12B: Composition of marine invertebrates (%), collected from Malaysian water, based on Class and abundance data

4.5.3 Percentage abundance of marine invertebrate

From 18 references of marine invertebrate studies in Malaysia (based on percentage abundance data), a total of 42 species has been recorded from those studies with Spionidae (marine worm; 7.92%) recorded the highest percentage of abundance, followed by Nereididae (marine worm; 6.88%) and *Parapenaeopsis sculptilis* (rainbow shrimp; 5.73%). A summation of 39 species has documented a percentage of less than 5%, individually (Figure 13).

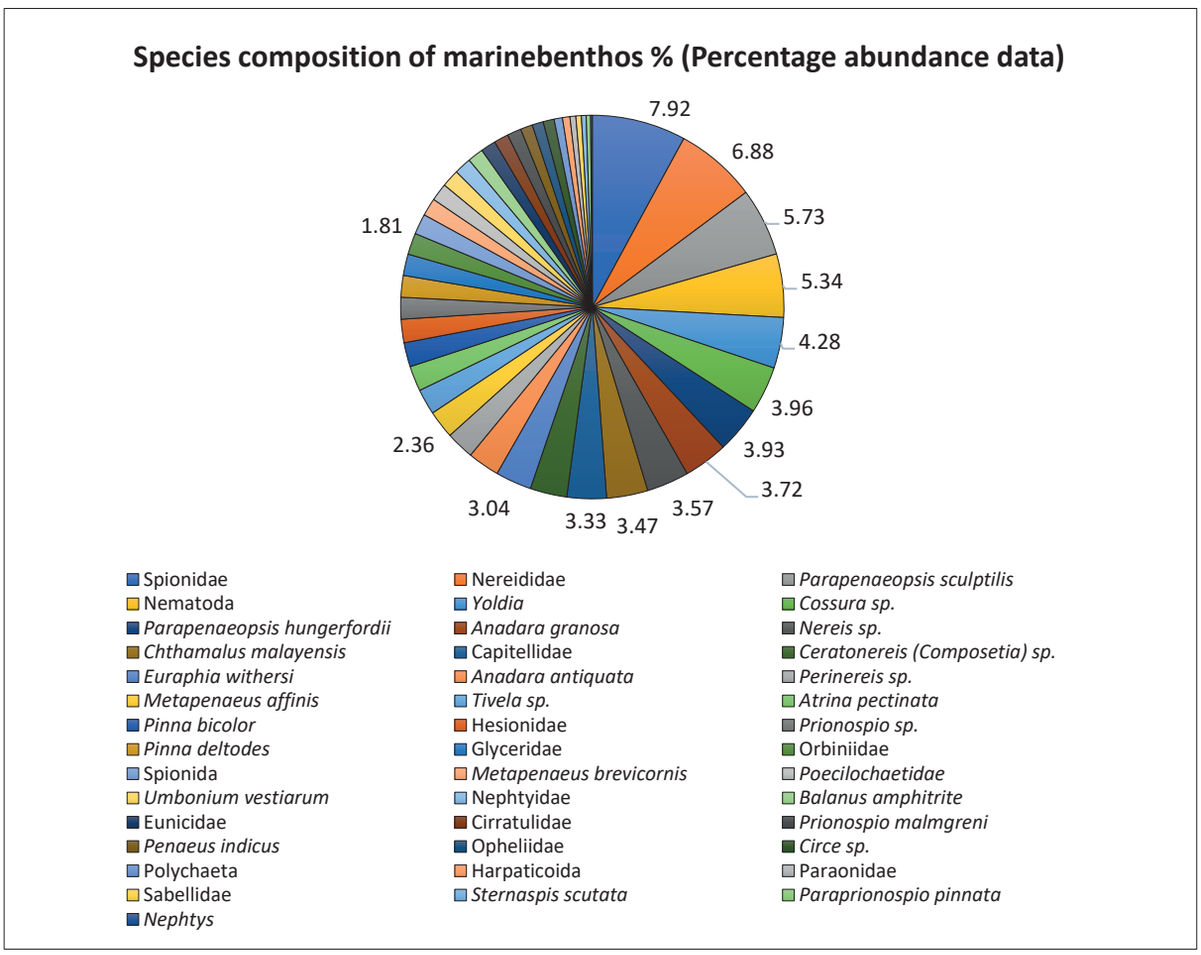


Figure 13: Composition of marine benthos (percentage abundance data) from Malaysian water, obtained from 18 references

The Spionidae of marine worms was collected from 43 sampling stations located at offshore areas of Pekan-Dungun, Kuala Terengganu and Kudat - Balambangan Island (Rosli et al., 2016). The high occurrence of the polychaetes is highlighted to be contributed by the higher number of sampling stations, which covered three large areas of southern South China Sea. The South China Sea is known to harbour a vast array of biodiversity in which the species richness and abundance are higher as compared to the neighbouring seas. In relation to the Spionidae itself, this family of polychaetes is one of the largest and most diverse taxa of polychaetous annelids, which contributed to a major component in marine and estuarine benthic communities all over the world. The

spionids are widely distributed, ranges from deep-sea to freshwaters (Abe et al., 2019). This group is well known to inhabit various substrates such as bottom sediment, sand or mud deposits in crevices of stones, rocks, shells and byssus and to associate with other invertebrates. In addition to the ability of exploiting wide range of habitats, the spionids also practise a great plasticity feeding method and possess diverse reproduction and developmental modes, which play an important role in the evolutionary success of the family.

In terms of a higher taxa classification, marine invertebrates of Phylum Annelida recorded the highest percentage (51.04%) of abundance from the 18 studies, followed by Arthropoda (22.38%) and Mollusca (21.24%) (Figure 14A). The least composition of marine invertebrates was represented by Nematoda (5.34%). More details, marine invertebrates from Class Polychaeta recorded the highest taxa found (51.04%), followed by Malacostraca (22.38%) and Bivalvia (19.76%) (Figure 14B).

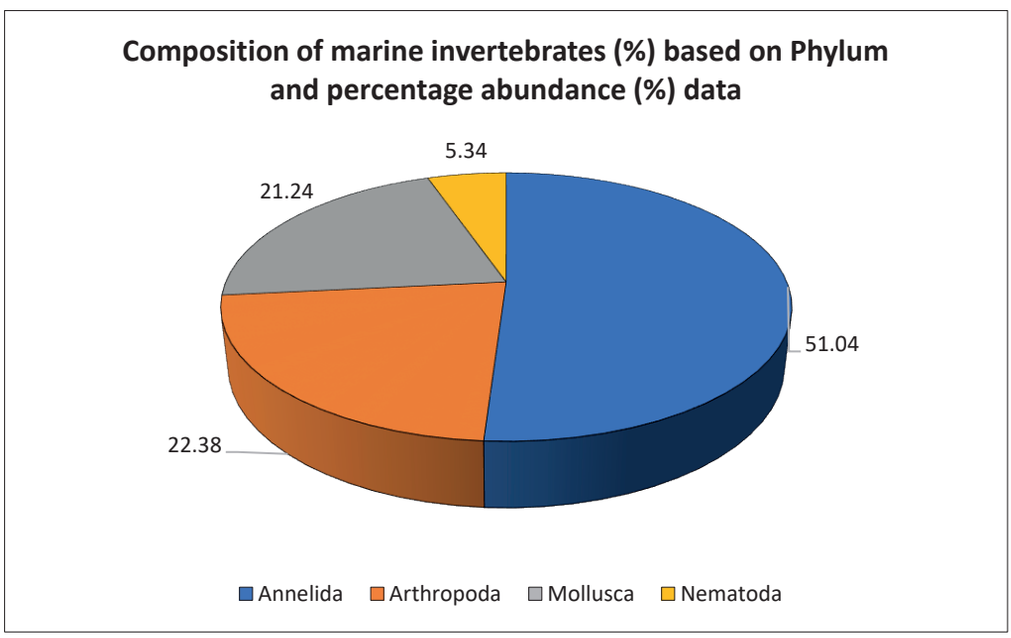


Figure 14A: Composition of marine invertebrates (%), collected from Malaysian water, based on Phylum and percentage abundance (%) data

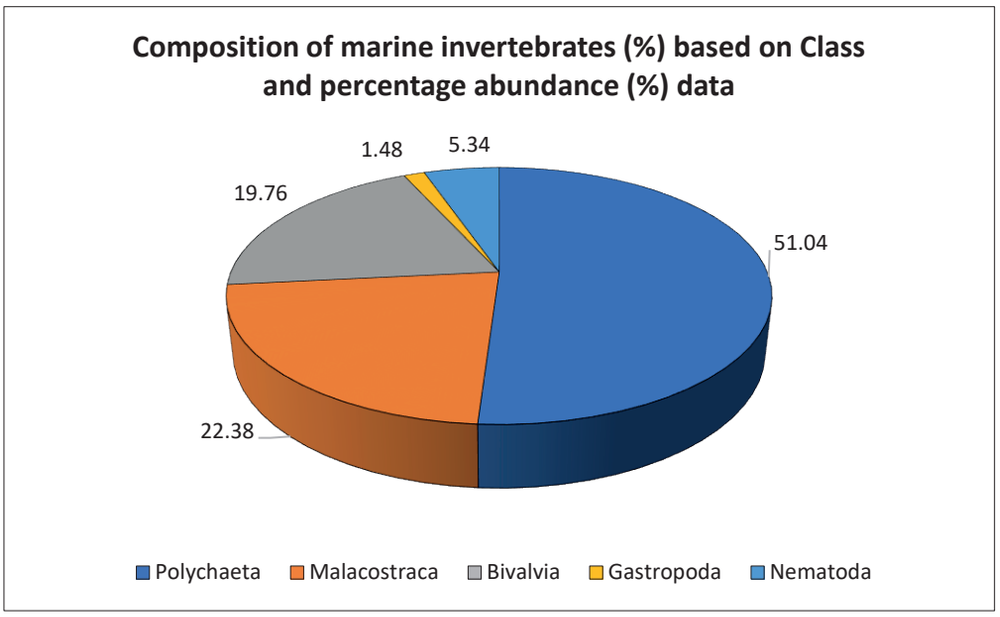


Figure 14B: Composition of marine invertebrates (%), collected from Malaysian water, based on Class and percentage abundance (%) data

4.6 The IUCN Red List of macroinvertebrate species

According to IUCN Red List or Red Data, species has been classified into three major groups of Extinct, Threatened and Lower Risk, with further nine groups have been formed in details (Figure 15) - Not Evaluated (NE), Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Extinct in the Wild (EW) and Extinct (EX). The classifications have been set through the criteria such as rate of decline, population size, area of geographic distribution and degree of population as well as the distribution fragmentation (Dublin, 2019). The brief description of each category is shown as below:

1) Data Deficient (DD) - there is insufficient information available to adequately apply the criteria, such as taxonomic uncertainty, lack of key biological information, or inability to adequately quantify the impact of known threats.
2) Endangered (EN) - treated for species which have been categorized as very likely to become extinct in their known native ranges in the near future.
3) Least Concern (LC) - there are no known threats to a species, or quantification of known threats for a species does not come close to meeting any of the threatened category threshold.
4) Vulnerable (VU) - refers to the species that is facing a high risk of extinction in the wild.
5) Near Threatened (NT) - the criteria are not qualified for Critically Endangered, Endangered or Vulnerable now, but is approximately close to qualify the Threatened category in the near future.
6) Not Evaluated (NE) - the species basically has not yet been evaluated against the criteria.
7) Critically Endangered (CR) - species that is extremely high risk of extinction in the wild
8) Extinct in the wild (EW) - known only to survive in captivity, or as a naturalized population outside its historic range
9) Extinct (EX) – assigned to species for which there is no reasonable doubt that the last individual has died.

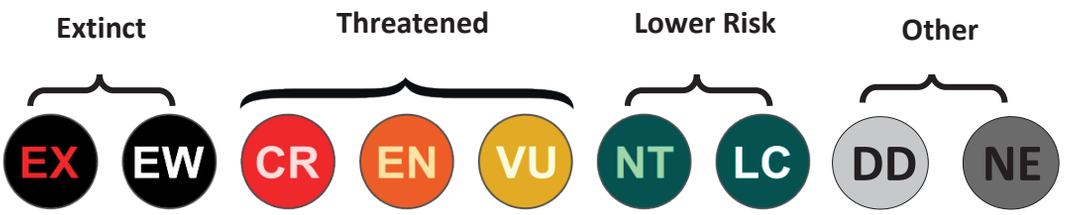


Figure 15: The conservation status by International Union for Conservation of Nature (IUCN)

From this study, a total of 23 species has been successfully assessed for the IUCN Red List (Table 4), with the rest of the other species are not even recorded in the Red List. Five species have been listed as "data deficient (DD)" with most of them come from the horseshoe crabs and sea cucumbers, one species of *Holothuria scabra* (golden sandfish) classified as "endangered (EN)", six species of gastropods and sea cucumbers as "Least Concern (LC)", three species of giant clams as "Lower Risk" and two species of sea cucumbers - *Holothuria fuscogilva* and *Stichopus herrmanni* as "vulnerable (VU)". While six genera (*i.e. Alpheus, Cassidula, Gammarus, Littoria, Loligo, Tridacna*) are listed as "depend on species" category, with a few information provided on the categories of full scientific name under the same genus.

Table 4: Species assessed for the IUCN Red List of macroinvertebrate species

	Scientific Name	Common name	IUCN Status
1	*Carcinoscorpius rotundicauda*	Round-tailed horseshoe crab	Data Deficient
2	*Stichopus horrens*	Black sea cucumber	Data Deficient
3	*Stichopus ocellatus*	Yellow sea cucumber	Data Deficient
4	*Tachypleus gigas*	Indo-Pacific horseshoe crab	Data Deficient
5	*Thelenota anax*	Amber fish	Data Deficient
6	*Alpheus sp.*	Snapping shrimps	Depends on species. *Alpheus cyanoteles* = Endangered
7	*Cassidula sp.*	Salt marsh snails	Depends on species. *Cassidula aurisfelis* = Least Concern; *Cassidula labrella* = Least Concern; *Cassidula multiplicate* = Least Concern *Cassidula crassiuscula* = Least Concern
8	*Gammarus sp.*	Gammarid amphipod	Depends on species. *Gammarus acherondytes* = Endangered *Gammarus hyalelloides* = Vulnerable *Gammarus desperatus* = Critically Endangered *Gammarus bousfieldi* = Vulnerable *Gammarus pecos* = Vulnerable

9	*Littoraria sp.*	Mangrove periwinkle	Depends on species. *Littoraria undulata* = Least Concern *Littoraria flammea* = extinct *Littoraria angulifera* = Least Concern
10	*Loligo sp.*	Long-finned squid	Depends on species. *Loligo forbesii* = Least concern *Loligo vulgaris* = Data deficient *Loligo reynaudii* = Least Concern
11	*Tridacna sp.*	Giant clam	Depends on species. *Tridacna gigas* =Vulnerable *Tridacna rosewateri* = Vulnerable
12	*Holothuria scabra*	Sandfish (sea cucumber)	Endangered
13	*Holothuria (Lessonothuria) pardalis*	Mottled light brown-grey and white sea cucumber	Least Concern
14	*Holothuria leucospilota*	Black sea cucumber or black tarzan	Least Concern
15	*Stenothyra polita*	Snails	Least Concern
16	*Stichopus chloronotus*	Greenfish sea cucumber	Least Concern
17	*Stichopus vastus*	Zebrafish	Least Concern
18	*Telescopium telescopium*	Telescope snail	Least Concern
19	*Tridacna maxima*	Small giant clam	Lower Risk/conservation dependent
20	*Tridacna squamosa*	Fluted giant clam	Lower Risk/conservation dependent
21	*Tridacna crocea*	Saffron-coloured clam	Lower Risk/least concern
22	*Holothuria fuscogilva*	White teatfish or white-teeth	Vulnerable
23	*Stichopus herrmanni*	Herrmann's sea cucumber	Vulnerable

The Golden sandfish of *Holothuria scabra* falls onto the Endangered (EN) category as this species is commercially exploited as food delicacies (bêche-de-mer) - boiled, dried and smoked flesh of sea cucumbers to make soups (Hamel et al., 2013). Most of the bêche-de-mer originated from the southwestern Pacific, where the dozen species of the genera *Holothuria, Stichopus and Thelonota* can be found in coral reefs area. By at least 30% overexploiting as food delicacies, the sea cucumber populations are estimated to have declined by more than 90% in at least 50% of its range (e.g. in East Africa, Madagascar, India, Vietnam, Papua New Guinea, Solomon Islands). In Vanuatu, this species may also be overexploited as the fishery industry has been closed. As the species population had already declined and overexploited since the 1960s, it is thus estimated to have experienced of at least 50% declines over the past 30–50 years, therefore, listed as Endangered (EN). If the species exploitation was significantly decreased, this species may recover relatively quick due to its reproductive capacity.

The sea cucumbers of *Holothuria fuscogilva* (white teatfish) and *Stichopus herrmanni* (Herrmann's sea cucumber) are among the many invertebrate species that are poached in tropical Indo-Pacific region since more than a thousand year (Jummy et al., 2012). Their exploitation has risen for the last 25 years and is approaching the international markets due to its highest value species and greatest demand. Their high commercial value and ease of capture as well as their vulnerability have contributed to a high exploitation activity and therefore cause the depletion of stocks in many coastal areas. The white teatfish itself are particularly vulnerable to overfishing due to their life history traits of low mobility, density dependent reproduction and external fertilization, as well as presumed slow growth, and late sexual maturity.

In short, for marine kind, the marine scientists have set a target of assessing the global conservation status of 20,000 marine species, with now, more than 14,000 have been represented in the IUCN Red List (IUCN, 2022). Most of the accomplished taxonomic groups include all the worlds' known marine mammals, sea turtles, sharks and rays, sea snake, corals, mangroves, seagrasses, tunas and billfish, and numerous fish families. However, for marine invertebrate species of five different Phyla (Porifera, Cnidaria, Mollusca, Crustacea and Echinodermata), over 30% of the species are considered as Data Deficient (DD) by the IUCN Red List. For Phylum Mollusca, approximately 85,000 to 100,000 species have been identified, with up to 200,000 extant species may exists (Polidoro et al., 2011).

In conclusion, for the marine realm, the record of the list is still poorly covered, comprising less than 15% of the species accessed. The IUCN has identified priority taxonomic groups of marine fish, vertebrates, corals, plants (mangrove and seagrass), macroalgae (seaweeds) and selected invertebrate families of crustaceans, echinoderms and molluscs. It is highlighted that once the priority groups can be fully assessed, the number of marine species on the IUCN Red List will be increased more than six-fold.

5.0 GAP ANALYSIS

Some limitations or study gaps have been discovered while working on data accession for the marine ecosystem and biodiversity in Malaysia's water (i.e. focused on marine invertebrate studies). First off, there is no international consensus on data processing and findings for research on the ecology of marine invertebrates. As an instance, some research used the sighting frequency while others give the data on overall abundance in percentage form. Next, difference in unit of measurement is another limitation; for example, some studies assess density as "total number of individuals/cm^2" rather than "total number of individuals/m^2".

The next gap in studies been encountered is the unstandardized terms of level of taxonomy and focus groups. Most of the published studies identified the organisms up to the Family and Class level only as the detail identification might be the limitation factor for the studies, especially when covering a major aspect of benthos as overall, instead of one or two focus groups. It is understandable that the higher classification was conducted in order to minimize the errors of the identification. Credit should be given to

the authors who successfully identify the marine organisms up to the genus or species level as the data is very useful as references for other studies.

In addition to that, due to the author's use of the higher and moderate identification levels of marine invertebrates (phylum and genera level), the study also has this restriction, making it difficult to fully evaluate the status of the marine invertebrate species on the IUCN Red List of Threatened Species in Malaysia's waters. Next, some studies are limited because the author did not provide details of study location (coordinates) which could possibly make the compilation of data slight inaccurate. It is also found that Malaysia has quite a number of marine invertebrate's paper checklist. Unfortunately, the checklist documents are discarded from this study because it does not include the fundamental ecological indices by details (or at least the overall invertebrate's abundance per station).

Since there are limitations and additional marine invertebrate studies in this region that have not been covered up, this constraint means that these entire set of data in this study does not represent the actual data in Malaysia's water. Therefore, more research needs to be conducted in this region, especially in southwest and northwest of Peninsular Malaysia, specifically in Perlis, Kedah, Perak, Negeri Sembilan, Melaka and Kelantan, to identify the true status of marine invertebrates in Malaysia's water overall. Lack of studies on marine invertebrates in habitats such as mudflat, lagoon and rocky shore area, as compared to the other habitats also has been notified from this project. By having the data from the less covered habitats, the potential of finding more new species and in the meantime, increasing the data from Malaysian water would be very beneficial for nation's record.

Finally, a scarcity of seasonal variation in data also has been highlighted. It is acknowledged that the seasonal data requires high commitment and efforts by the scientists. However, the seasonality is a critically important aspect of environmental variability as it will strongly shape all aspects of life of the organisms, living in a highly seasonal environment. The contributions in driving the seasonal pattern also may help the scientists in understanding the kinds of evolutionary adaptations at a global scale. The data then will be very useful as a prediction tool for future seasonal studies, especially at the environments with a rapid change.

6.0 DISCUSSION AND RECOMMENDATION

The present project has revealed the baseline information of the macroinvertebrate community in Malaysia, covering different habitats and ecosystems. In brief, an increasing trend of macroinvertebrate studies in Malaysia has been documented since year 2000 until 2021, with the patterns fairly fluctuate over times. The year 2014 recorded the highest number of publications, covering several states of Selangor, Johor, Sarawak and Kedah. Terengganu state has recorded the highest percentage of marine invertebrate studies, followed by Johor and Selangor. Bidong Island and Setiu Wetlands, Terengganu have contributed much data for the macroinvertebrate studies, as those locations have been gazetted as research stations for Universiti Malaysia Terengganu.

The most well-known locations for research regarding the seagrass ecosystem are in Merambong and Tanjung Adang shoals, Johor as these sites are heavily threatened by the urban developments around such as the shipping port, industrial and agriculture activities. Above all the ecosystem and habitats covered, the coastal water around Malaysia recorded the highest percentage of marine invertebrate studies, followed by mangrove and intertidal as well as subtidal areas.

6.1 Marine Protected Area (MPAs)

According to Malaysian Nature Society (2013), Marine Protected Areas (MPA's) are defined as the area of coastal and seawater that spatially limited with different regulation and legislation with the purpose of managing, conserving and preserving the marine biodiversity and natural resources (Edgar et al., 2007). In Malaysia specifically, the enforcement of MPA's is strictly gazetted under Federal Act and State Enactment/Ordinance. On 14th June 2006, the establishment of a new department responsible for managing and administering the National Marine Protected Areas, especially the Marine Parks of Malaysia has been approved by the Cabinet Meeting that was known as Department of Marine Park Malaysia (Department of Fisheries Malaysia, 2022). In 2019, this the merging of Department of Marine Park Malaysia has seen this department absorbed into the Department of Fisheries Malaysia, Ministry of Agriculture & Food Industries (later, in 2022 is known as Ministry of Agriculture and Food Security). Function and role in gazetting and managing the Marine Park is under purview of the Department of Fisheries Malaysia.

The MPA's in Malaysia consists of four different kinds of areas, namely the marine park, fisheries prohibited area, wildlife reserve and turtle sanctuary, with up to date, a total of 42 islands have been gazetted as Marine Park around Malaysia's water (Maslim et al., n.d) (Appendix 2).

6.1.1 Proposing the potential areas for MPAs

From these collected data on marine invertebrate studies, few areas are chosen to be proposed as Marine Protected Areas (MPAs). Setiu Wetlands, Merchang, Punang Sari, Merambong Shoal, Tanjung Adang Shoal and Pulau Gazumbo are suggested as MPAs by taking into account the species richness in an area and the degree to which the area is vulnerable to threats.

Setiu Wetlands is located in Setiu, Terengganu, which have distinctive habitats with a high diversity of flora and fauna. Consequently, the region has enormous potential to emerge as one of Terengganu's premier ecotourism hotspots (Aziz et al., 2020). However, Setiu Wetlands has also been renowned for its superior aquaculture since 1990s up till the present. The lagoon, where fish cage culture activity is focused, and its rapid and intense expansion is anticipated to pose a serious danger to the ecosystem processes and functions that support the provision of many other ecosystem service outputs in Setiu (Alipiah et al., 2020).

While Merchang is a town located in Marang, Terengganu is recognized to have the agriculture and fisheries (including oyster cultivation) as their main economic activities. Despite being significant for traditional fishing and small-scale tourism, this estuary habitat is understudied. Up to date, only one ecological study, on the fish communities in the seagrass bed in 2005 (Aziz et al., 2006), and a study on microbenthic

communities in 2018 (Hussin & Ab Lah, 2020) are known to have been done in this lagoon.

Punang-Sari estuary is in Lawas and is well acknowledged as the single largest seagrass bed in Malaysia (240 ha). The seagrass ecosystem of Lawas, according to Johan et al. (2020), is home to a rich and diverse set of fish communities, including juvenile and adult stages, signalling a significant commercial fisheries resource habitat. Al-Asif et al. (2020) also supports that the bio-assemblage in seagrass ecosystem was shown to be abundant, which may be helpful for future ecological research.

Merambong and Tanjung Adang Shoal are located in the west side of Johor Straits. Effects on microbenthic organisms were anticipated due to the growth in human population and the rapid development along the straits (such as port expansion, industrial development, and agricultural development). Shi et al. (2014) hypothesised that the presence of Capitellidae, Spionidae, Cirratulidae, and Nereididae in these regions would be a sign that Merambong and Tanjung Adang Shoal are under pressure as a result of environmental pollution brought on by human activities. These regions are acknowledged as being crucial to Malaysia's economy, but unfortunately, they are situated in a very productive coastal environment.

The man-made island of Pulau Gazumbo in Penang is well-known for its extensive seagrass bed. Additionally, these seagrass beds are proven to aid local fishermen economically, promote tourism, and serve as important educational resources for kids (Chee at al., 2017). However, the possible environmental effects of Penang's rapid population expansion, mega-urban development, land reclamation, and breadth of artificial shorelines have been noted by Chee et al. (2017).

From all of these brief summaries of the proposed MPAs region, it is clear that in addition to having a vast diversity of marine organisms, these places have played a key role in the development of our economy and society. However, with the inevitable globalisation of coastal development, there are numerous opportunities to attempt a delicate balance between development and conservation. These opportunities should be taken advantage in both current and future projects in order to protect treasured coastal ecosystems for future generations. Therefore, it is crucial to note that these six areas (i.e., Setiu Wetlands, Merchang, Punang-Sari, Merambong Shoal, Tanjung Adang Shoal and Pulau Gazumbo) need attention to be classified as Marine Protected Areas.

6.2 Recommendation

A few recommendations are proposed in relation to this project. On top of all, it is suggested that in the future, the Department of Fishery and other stakeholders may organize a holistic survey which covers all types of macrobenthos in all types of habitats. For locations with highly vulnerable to human impact (e.g. Merambong and Tanjung Adang Shoal, Setiu Wetlands and Pulau Gazumbo), more studies need to be done in that particular area. The higher data or studies related to the marine invertebrates in threatened areas are then maintained, so that people and authorities will concern, notice and give a better attention to that situation. In addition, since the environment will keep changing overtime, and the fact is that, we never know when is it the fragile

ecosystems are going to reach their equilibrium states, hence, the best option would be to keep monitoring those areas.

A large-scale study, covering a wider geographical areas around Malaysian water also would be a great effort to do. Meanwhile for the less covered sites or habitats such as in mudflat, lagoon and rocky shore areas, it is suggested to start exploring those areas, to find possible new species, hence, update and increase the new record in Malaysia. In highly productive and complex ecosystems such in in coral reef area and deeper water locations, the priority should be given on collecting the real samples using either core, grab sampler or hand scope of known volume, rather than the image and videos, during the sampling. By doing so, the precise and more accurate data of the tiny macrobenthos will be obtained and the validity of the species can be checked thoroughly.

In relation to the large-scale study, previously this type of study was mainly conducted by foreign researchers which had collaborated with the local scientists. In the future, it is suggested that the large-scale studies are fully conducted by the local scientists, in order to give more exposure to the earlier or young scientists mainly. By doing so, the purity and the originality of the data will be more precise, and unquestionable as well as the marine samples surely will become the national's treasure for future references. The new knowledge gained and shared by the local scientists then can be an inspiration to the younger local generation to continue the same or a better legacy later.

Regarding the data and information sharing through publications, which is already practised right now by the researchers, it is then further suggested to have a special research group or association focusing on the marine invertebrate studies. This group which will gather the young scientists or students of high interest to the marine invertebrates, together with the experts of the field are expected to share, exchange and circulate the knowledge that they have. By doing so, lots of benefits will be gained together such as found better ways of doing researches in terms of the standardising the data collection, data analysis and manuscript preparation of specific filed, build a community and learning culture, retain knowledge and expertise in the organization, and open up many opportunities for early carrier scientists. The strong engagement and networks among the young and senior researchers are highly encouraged to ensure the sustainability of the knowledge among the Malaysians.

In parallel to having the research interest group, one thing to be highlighted is that the financial aid or sponsorship from many parties, in order to carry out more comprehensive researches, particularly on the marine invertebrate studies. By having a stable financial status, it is then possible to cover a wider geographical area in a short period of time to collect the data. The enormous data within a similar period of time then should be able to represent the current status of the study, as the data obtained will be more relevant since the comparisons can be made directly between each other.

REFERENCES

Abdullah, S. (1993). Coastal developments in Malaysia – Scope, issues and challenges.

Abe, H., Takeuchi, T., Taru, M., Sato-Okoshi, W., & Okoshi, K. (2019). Habitat availability determines distribution patterns of spionid polychaetes (Annelida: Spionidae) around Tokyo Bay. *Marine Biodiversity Records*, *12*(1), 1-12.

Al-Asif, A., Hamli, H., Kamal, A. H. M., Idris, M. H., Gerusu, G. J., Ismail, J. B., & Karim, N. U. (2020). Benthic macrofaunal assemblage in seagrass-mangrove complex and adjacent ecosystems of Punang-Sari Estuary, Lawas, Sarawak, Malaysia. Biodiversitas Journal of Biological Diversity, 21(10).

Alipiah, R. M., Ismail, F., Mansor, N., & Abd, A. (2020). The Potential of Ecotourism Management Scenario for Sustainable Setiu Wetlands Ecosystems: An Integrated Ecosystem Approach. Journal of Sustainability Science and Management, 15(1), 15-25.

Anker, A., & De Grave, S. (2012). Description of Alpheus cedrici sp. n., a strikingly coloured snapping shrimp (Crustacea, Decapoda, Alpheidae) from Ascension Island, central Atlantic Ocean. *ZooKeys*, (183), 1.

Araujo-Leyva, O. S. M. A. R., Rodríguez-Villanueva, L. V., & Macías-Zamora, J. V. (2020). Biodiversity of polychaetous annelids in Bahía de Todos Santos, Baja California México. *Zoosymposia*, *19*, 51-71.

Aziz, A. A., Ismail, F., Saat, S. A., Alipiah, R. M., & Mansor, N. (2020). The potential of ecotourism management scenario for sustainable Setiu Wetlands ecosystems: an integrated ecosystem approach. Journal of Sustainability Science and Management (Malaysia).

Aziz, A., Bujang, J. S., Zakaria, M. H., Suryana, Y., & Ghaffar, M. A. (2006). Fish communities from seagrass bed of Merchang Lagoon, Terengganu, Peninsular Malaysia. Coastal Marine Science, 30(1), 268-275.

Barbier, E. B. (2017). Marine ecosystem services. *Current Biology*, *27*(11), R507-R510.

Bernal, P., & Simcock, A. (2016). Marine scientific research. *The First Global Integrated Marine Assessment: World Ocean Assessment I*, 18.

Capa, M., Kupriyanova, E., Nogueira, J. M. D. M., Bick, A., & Tovar-Hernández, M. A. (2021). Fanworms: Yesterday, today and tomorrow. *Diversity,* 13(3), 130.

Chee, S. Y., Othman, A. G., Sim, Y. K., Adam, A. N. M., & Firth, L. B. (2017). Land reclamation and artificial islands: Walking the tightrope between development and conservation. Global ecology and conservation, 12, 80-95.

Chen, C. A., Long, S. M., & Rosli, N. M. (2012). An ecological study of free-living marine nematodes in Teluk Awar, Sarawak, Malaysia. *Borneo Journal of Resource Science and Technology*, *2*(1), 1-10.

Cochrane, S. K., Andersen, J. H., Berg, T., Blanchet, H., Borja, A., Carstensen, J., ... & Renaud, P. E. (2016). What is marine biodiversity? Towards common concepts and their implications for assessing biodiversity status. *Frontiers in Marine Science*, *3*, 248.

Do Hung Dang, V., Fong, C. L., Shiu, J. H., & Nozawa, Y. (2020). Grazing effects of sea urchin Diadema savignyi on algal abundance and coral recruitment processes. *Scientific reports*, *10*(1), 1-9.

Dublin, H. (2019). IUCN Red List of Threatened Species. Encyclopaedia Britannica. https://www.britannica.com/topic/IUCN-Red-List-of-Threatened-Species

Edgar, G. J., Russ, G. R., & Babcock, R. C. (2007). Marine protected areas. *Marine ecology*, *27*, 533-555.

Gray, J.G., Elliott, M. (2009). Ecology of marine sediments. 2nd Ed. Oxford University Press, 256p.

Guerra-Vargas, L. A., Gillis, L. G., & Mancera-Pineda, J. E. (2020). Stronger together: do coral reefs enhance seagrass meadows "blue carbon" potential? *Frontiers in Marine Science*, 628.

Haegerbaeumer, A., Mueller, M-T., Fueser, H., Traunspurger, W. (2019). Impacts of Micro- and Nano-Sized Plastic Particles on Benthic Invertebrates: A Literature Review and Gap Analysis. *Front. Environ. Sci*. 7:17. doi: 10.3389/fenvs.2019.00017

Hamel, J. F., Mercier, A., Conand, C., Purcell, S., Toral-Granda, T. G., & Gamboa, R. (2013). Holothuria scabra. The IUCN Red List of Threatened Species 2013: e. T180257A1606648.

Hussin, W. M. R. W., & Ab Lah, R. (2020). Community structure and taxonomic diversity of macrobenthic communities in Merchang lagoon, Malaysia. Aquaculture, Aquarium, Conservation & Legislation, 13(6), 3593-3604.

IUCN (International Union for Conservation of Nature). (2022).

Japar Sidik B, Muta Harah Z, Arshad A. Seagrass resources and their declining in Malaysia. MIMA Bull. 2007;14(2):36–42.

Jimmy, R. A., Pickering, T. D., & Hair, C. A. (2012). Overview of sea cucumber aquaculture and stocking research in the Western Pacific region. *Asia-Pacific Tropical Sea Cucumber Aquaculture. ACIAR Proceedings*, *136*, 12-21.

Johan, I., Hena, M. A., Idris, M. H., Amin, S. M. N., Denil, N. A., Kumar, U., & Karim, N. U. (2020). Species composition and diversity of fishes from the seagrass habitat of Lawas, Sarawak, Malaysia. Journal of Environmental Biology, 41, 1382-1389.

Kee Alfian, A. A., Wong, W. S., Badrul, H., & Affendi, Y. A. (2005, March). Macroinvertebrate diversity of Kg. Tekek, Pulau Tioman Marine Park. In *Proceedings of the Second Regional Symposium on Environment and Natural Resources* (Vol. 2, pp. 79-84).

KETSA (Kementerian Tenaga dan Sumber Asli), 2006. Biodiversity in Malaysia. Retrieved from: https://www.ketsa.gov.my/PustakaMedia/Penerbitan/Biodiversity%20in%20Malaysia.pdf

Long, S. M., Abdullah, A. A. F. A., & Ab Rahim, S. A. (2014). Marine gastropod and bivalves of Sampadi Island, Lundu, Sarawak. In *Monograph Aquatic Science Colloquium* (pp. 75-87).

Long, S. M., & Ross, O. H. (2008). Horizontal distribution of intertidal nematode from Sabah, Malaysia. Journal of Tropical Biology & Conservation (JTBC).

Madin, J., Maran, B. A. V., & Ho, S. M. (2021). Gastropods in the Intertidal Shore of Kota Kinabalu, Sabah (Malaysian Borneo). *Borneo Journal of Resource Science and Technology*, *11*(1), 9-23.

Maslim, A. R., Mohd Noh, M. Z., Mohd Alizanah, Z., Zulkifli, N. A. A., Mohs Salbi, N. A. & Ahmad Zairil, F. N. (n.d). Marine Protected area. Marine Coastal and Delta Sustainability for Malaysia.

Nakao, S., Nomura, H. & Satar, M. K. A. (1989). Macrobenthos and sedimentary environments in a Malaysian intertidal mudflat of the cockle bed.

Polidoro, B. A., Elfes, C. T., Sanciangco, J. C., Pippard, H., & Carpenter, K. E. (2011). Conservation status of marine biodiversity in Oceania: an analysis of marine species on the IUCN Red List of Threatened Species. *Journal of Marine Biology*, *2011*.

Purchon, R. D. and D.E.A. Purchon. (1981). The marine shelled mollusca of west Malaysia and Singapore. Part 1. General introduction and an account of the collecting stations. Journal of Molluscan Studies, 47(3): 290–312

QGis. (2022) QGis: a free and open source geographic information system. Dekstop version. https://www.qgis.org/en/site/.

Rabaoui, L., Abdulqader, E., Maneja, R., Joydas, T. V. (2019). Marine invertebrates. In: Al-Abdulkader, K., Loughland, R.A., Qurban, M.A. (eds.) Ecosystems and Biodiversity of the Arabian Gulf - Saudi Arabian Waters: 50 years of Marine Research (pp.365-385). Saudi Aramco and King Fahd University of Petroleum and Minerals.

Rosli, N. S., Yahya, N., Arifin, I., & Bachok, Z. (2016). Diversity of Polychaeta (Annelida) in the continental shelf of southern South China Sea. *Middle-East Journal of Scientific Research*, *24*(6), 2086-2092.

Salim, J. M., Lee, G. E., Salam, M. R., Shahimi, S., Pesiu, E., Jani, J. M., ... & Nikong, D. (2020). A checklist of vascular plants and uses of some species for livelihood-making in Setiu Wetlands, Terengganu, Malaysia. *PhytoKeys*, *160*, 7.

Shabdin, M.L. & Othman, B.H.R. (2008). Horizontal distribution of intertidal nematode from Sabah, Malaysia. Journal of Tropical Biology and Conservation, 4(1): 39-53.

Shi, G. W., Ghaffar, M. A., Ali, M. M., & Cob, Z. C. (2014). The Polychaeta (Annelida) communities of the Merambong and Tanjung Adang Shoals, Malaysia, and its relationship with the environmental variables. *Malayan Nat J*, *66*(1), 2.

Young, S. S., Yang, H. N., Huang, D. J., Liu, S. M., Huang, Y. H., Chiang, C. T., & Liu, J. W. (2014). Using benthic macroinvertebrate and fish communities as bioindicators of the Tanshui River Basin around the greater Taipei area—multivariate analysis of spatial variation related to levels of water pollution. *International journal of environmental research and public health*, *11*(7), 7116-7143.

Sasekumar, A. 1974. Distribution of macrofauna on a Malayan mangrove shore. Journal of Animal Ecology, 43, 1: 51–69.

Tan, H. S., & Rahim, A. A. (2018). Diversity of coastal mysids from Pulau Tinggi, Sultan Iskandar Marine Park, Malaysia. *Nauplius*, *26*.

The Star. (2006). Pulau Bidong gazetted as recreational island. https://www.thestar.com.my/news/community/2006/12/29/pulau-bidong-gazetted-as-recreational-island. Access on 01.08.2022

Vinithkumar, N. V., Sathish, T., Das, A. K., Sivaperuman, C., Raghunathan, C., Dharani, G., ... & Sujathkumar, N. V. (2008). Marine ecosystems of Andaman and Nicobar Islands–species abundance and distribution. In *Biodiversity and climate change adaptation in tropical islands* (pp. 217-256). Academic Press.

WORMS (2022a). World Register of Marine Specie. *Diadema setosum.* https://www.marinespecies.org/aphia.php?p=taxdetails&id=213372. Access on: 27.09.2022

WORMS (2022a). World Register of Marine Specie. *Acanthomysis quadrispinosa.* https://www.marinespecies.org/aphia.php?p=image&tid=214810&pic=95464. Access on: 27.09.2022

Appendix 1 - Photos of marine invertebrates (Malaysian records) listed in IUCN Red List

Carcinoscorpius rotundicauda (Data Deficient)

Alpheus (Depends on species)

- *Alpheus cyanoteles* = Endangered under criteria B1ab (iii,v) +2ab(iii,v)

Cassida (Depends on species)

- *Cassidula aurisfelis* = Least Concern
- *Cassidula labrella* = Least Concern
- *Cassidula multiplicate* = Least Concern
- *Cassidula crassiuscula* = Least Concern

Gammarus (Depends on species)

- *Gammarus acherondytes* = Endangered under criteria B1ab(ii)+2ab(ii)
- *Gammarus hyalelloides* = Vulnerable under criteria D2
- *Gammarus desperatus* = Critically Endangered under criteria B1+2c
- *Gammarus bousfieldi* = Vulnerable under criteria D2
- *Gammarus pecos* = Vulnerable under criteria D2

Holothuria (Lessonothuria) pardalis (Least Concern)

Holothuria leucospilota (Least Concern)

Holothuria scabra (Endangered)

Tridacna (Depend on species)

- Depends on species.
- *Tridacna gigas* = Vulnerable
- *Tridacna rosewateri* = Vulnerable

Littoraria (Depends on species)

- *Littoraria undulata* = Least Concern
- *Littoraria flammea* = extinct
- *Littoraria angulifera* = Least Concern

Loligo (Depends on species)

- *Loligo forbesii* = Least concern
- *Loligo vulgaris* = Data deficient
- *Loligo reynaudii* = Least Concern

Holothuria fuscogilva (Vulnerable)

Holothuria scabra (Endangered)

Holothuria (Lessonothuria) pardalis (Least Concern)

Stichopus vastus (Least Concern)

Stenothyra polita (Least Concern)

Stichopus chloronotus (Least Concern)

Telescopium telescopium (Least Concern)

Tridacna maxima (Lower Risk)

Tridacna squamosa (Lower Risk)

Tridacna crocea (Lower Risk)

Stichopus herrmanni (Vulnerable)

Appendix 2 (List of Marine Protected Area – Marine park, fisheries prohibited area, wildlife reserve and turtle sanctuary.

	Marine park	Fisheries prohibited area	Wildlife reserve	Turtle sanctuary	Protected Area fo Sea Cucumber
1	Pulau Tioman	Pulau Selang Besar	Samunsam	Pulau Penyu	Pulau Singa Besar
2	Pulau Sembilang	Pulau Talang-Talang Besar	Pulau Tukang Ara-Banun	Pulau Sipadan	
3	Pulau Sri Buat	Pulau Talang-Talang Kecil	Kulamba	Pulau Layang Layang	
4	Pulau Tinggi	Rantau Abang	Lankayan	Semporna	
5	Pulau Sibu	Tanjung Tuan	Kuala Pahang	Rantau Abang	
6	Pulau Besar	Tanjung Tuan 1	Pulau Empat		
7	Pulau Pemanggil	Tanjung Tuan 2			
8	Pulau Aur	Pulau Besar			
9	Pulau Hujung				
10	Pulau Rawa				
11	Pulau Tengah				
12	Pulau Harimau				
13	Pulau Mensirip				
14	Pulau Yu Besar				
15	Pulau Yu Kecik				
16	Pulau Tenggol				
17	Pulau Nyireh				
18	Pulau Perhentian Besar				
19	Pulau Perhentian Kecil				
20	Pulau Susu Dara				
21	Pulau Lang Tengah				
22	Pulau Redang				
23	Pulau Ekor Tebu				
24	Pulau Lima				
25	Pulau Kapas				

26 Pulau Pinang
27 Pulau Jahat
28 Pulau Chebeh
29 Pulau Labas
30 Pulau Sepoi
31 Pulau Tokong Bahara
32 Pulau Sembilang
33 Pulau Tulai
34 Pulau Kaca
35 Pulau Segantang
36 Pulau Payar
37 Pulau Lembu
38 Pulau Rusukan Besar
39 Pulau Rasukan Kecil
40 Pulau Kuraman
41 Taman Tun Mustapha

Appendix 3 – List of references used for macroinvertebrate studies

Abdulla, A. A., Hadi, H., Abu Hena, M. K., Mohd Hanafi, I., Geoffery, J. G., J. I. & Muyassar, H. A. (2021). Bivalves (Mollusca: Bivalvia) in Malaysian Borneo: status and threats. *Journal of Threatened Taxa*. 13(11): 19553–19565.

Abu Hena, M. K. Hishamuddin, O. & Misri, K. (2006). Benthic faunal composition of *Penaeus monodon Fabricius* culture pond in West Coast of Peninsular Malaysia. *Pakistan Journal of Marine Science*, *15*(2), 179–184. https://doi.org/10.3923/jbs.2004.631.636

Ahmad, O., Fang, T. P. & Yahya, K. (2011). Distribution of intertidal organisms in the shores of Teluk Aling, Pulau Pinang, Malaysia. *Pub. Seto Mar. Bio. Lab*, *41*, 51–61.

Aina, N., Binti, S., & Bachelor, R. (2014). *Community Structure of Macrobenthos in Maludam River, Betong, Sarawak*. Thesis of Bachelor Science with Honours. Universiti Malaysia Sarawak.

Al-Asif, A., Hamli, H., Kamal, A. H. M., Idris, M. H., Gerusu, G. J., Ismail, J. Bin, & Karim, N. U. (2020). Benthic macrofaunal assemblage in Seagrass-Mangrove complex and adjacent ecosystems of Punang-Sari Estuary, Lawas, Sarawak, Malaysia. *Biodiversitas*, *21*(10), 4606–4615. https://doi.org/10.13057/biodiv/d211019

Andria, F. A., & Rahmaningsih, S. (2018). Jurnal ilmiah perikanan dan kelautan. *Jurnal Ilmiah Perikanan Dan Kelautan*, *10* (2), 95–105.

Around, P. (1998). Distribution and abundance of benthic polychaetes around artificial reefs. *IFR Journal*, *IV* (1), 51–56.

Ashton, E. C., Macintosh, D. J., & Hogarth, P. J. (2003). A baseline study of the diversity and community ecology of crab and molluscan macrofauna in the Sematan mangrove forest, Sarawak, Malaysia. *Journal of Tropical Ecology*, *19*(2), 127–142. https://doi.org/10.1017/S0266467403003158

Azizil, A., Bin, F., & Abdullah, A. (2011). *Molluscs community in Batang Kayan estuary, Lundu, Sarawak*. Bachelor of Science with Honours. Universiti Malaysia Sarawak.

Bachok, Z., Shahida Rosli, N., Yahya, N., & Arifin, I. (2016). Diversity of Polychaeta (Annelida) in the Continental Shelf of Southern South China Sea. *Middle-East Journal of Scientific Research*, *24*(6), 2086–2092. https://doi.org/10.5829/idosi.mejsr.2016.24.06.23650

Baharuddin, N., Basir, N. H. M., & Zainuddin, S. N. H. (2019). Tropical intertidal gastropods: Insights on diversity, abundance, distribution and shell morphometrics of Pulau Bidong, Malaysia. *AACL Bioflux*, *12*(4), 1375–1387.

Baharuddin, N., Basri, N. B., & Syawal, N. H. (2018). Marine gastropods (Gastropoda; mollusca) diversity and distribution on intertidal rocky shores of Terengganu, Peninsular Malaysia. *AACL Bioflux*, *11*(4), 1144–1154.

Baharuddin, N., & Zakaria, N. A. (2018). The biodiversity and conservation status of the marine gastropod (Mollusca; Gastropoda) in Pulau Bidong, Terengganu, Malaysia. *AACL Bioflux*, *11*(4), 988–1000.

Byrne, M. (2011). Impact of ocean warming and ocean acidification on marine invertebrate life history stages: Vulnerabilities and potential for persistence in a changing ocean. *In:* Gibson et al. Oceanography and Marine Biology: An Annual Review, 2011, 49, 1-42.

Chen, C. A. (2017). Sublittoral macrobenthos community structure of South-Western Sarawak Coastal Waters: A Case Study in Kuching Wetland National Park (KWNP) and Adjacent Area. *(Doctoral Thesis)*, *2017*, 236. Universiti Malaysia Sarawak.

Chen, C.-A., Mohd Long, S., & Rosli, N. M. (1970). An ecological study of free-living marine Nematodes in Teluk Awar, Sarawak, Malaysia. *Borneo Journal of Resource Science and Technology*, *2*(1), 1–10. https://doi.org/10.33736/bjrst.267.2012

Chiaje, D. (1995). Changes in the macrobenthos community of a sand flat after erosion. *Estuarine, Coastal and Shelf*, *40*, 21–33.

Chong, V. C., Sasekumar, A., Leh, M. U. C., & D'Cruz, R. (1990). The fish and prawn communities of a Malaysian coastal mangrove system, with comparisons to adjacent mud flats and

inshore waters. *Estuarine, Coastal and Shelf Science*, *31*(5), 703–722. https://doi.org/10.1016/0272-7714(90)90021-I

Chong, V. C., Jaziman, A. R., Mohamad Yazid, Z., Rizman-Idid, M., Muhammad Ali, S.H., & Natin, P. (2010). Diversity and abundance of fish and invertebrates of Semerak Estuary and adjacent inshore waters, Kelantan. *Malaysian Journal of Science*, *29*(SP), 95–110. https://doi.org/10.22452/mjs.vol29nosp.11

Choo, S. Y. F. (2005). Diversity and distribution of bivalve and gastropod species in mangrove area at Asajaya Laut, Samarahan Sarawak. Thesis of Bachelor of Science with Honours. Universiti Malaysia Sarawak.

Cob, Z. C., Arshad, A., Bujang, J. S., Bakar, Y., Simon, K. D., & Mazlan, A. G. (2012). Habitat preference and usage of *Strombus canarium* Linnaeus, 1758 (Gastropoda: Strombidae) in Malaysian seagrass beds. *Italian Journal of Zoology*, *79*(3), 459–467. https://doi.org/10.1080/11250003.2012.670273

Cob, Z., Samat, A., Muda, W., & Mazlan, A. (2012). Preliminary checklist of marine invertebrate fauna within the intertidal of Teluk Penyabong and Teluk Gorek, Mersing, Johor, Malaysia. *Journal of Tropical Marine Ecosystem*, *1*, 1–14.

Eka, F., Subekti, S., Megan, B., Toh, K. B., Ian, M. & Ruchira, S. (2007). Marine invertebrate diversity along a reef gradient at Tunku Abdul Rahman Marine Park. *Biodiversity of Borneo Harvard Field Course.*

Convention on Biological Diversity. (2009). 4th National Report to the Convention on Biological Diversity. In *Quality*. www.nre.gov.my

Fagbenro, O., Adeparusi, E., & Jimoh, W. (1816). Fisheries and aquatic science. *Journal of Fisheries and Aquatic Science*, *8*(1), 80–86.

Fuseya, R., Tsuchiya, K., Man, A., & Rahim, M. A. (2020). *Tegillarca granosa (Bivalvia: Arcidae)*. *55*(12), 47–55.

Gholizadeh, M. (2015). Macrobenthic community and its relations with environmental factors in coastal waters of Penang National Park, Malaysia. Thesis of Doctor of Philosophy.

Gholizadeh, M., Yahya, K., Talib, A., & Ahmad, O. (2012). Distribution of macrobenthic Polychaete families in relation to environmental parameters in North West Penang, Malaysia. *Journal of Environmental and Ecological Engineering*, *6*(12), 756–761.

Gholizadeh, M., Yahya, K., Talib, A., & Ahmad, O. (2012). Effects of environmental factors on polychaete assemblage in Penang National Park, Malaysia. *World Academy of Science, Engineering and Technology*, *6*(12), 752–755.

Hadi, R., Mohd Zamani, Z. N., Saidin, M. S. & Denis, S. (n.d.). The first prawn resource assessement of Lawas district of Sarawak, Federal territory Labuan and Sabah coastal waters (8th january - 23rd may 2015).

Hamli, H., & Asif, A. Al. (2021). Trends of bivalve (Bivalvia) research in East Malaysia: a systematic review. *Asian-Australasian Journal of Bioscience and Biotechnology*, *6*(2), 50–59. https://doi.org/10.3329/aajbb.v6i2.56140

Harith, M. N., Md Desa, M. H. I., & Ilias, Z. (2018). *Holothuria leucospilota* population in Satang Besar Island, Sarawak, Malaysia. *International Journal of Zoology*, *2018*. https://doi.org/10.1155/2018/8047029

Nurul Hayati, H. N., Talib, A., Ahmad, O. & Yahya, K. (2013). The distribution and zonation of barnacles around intertidal shores of Penang Island. *1*, 139–143.

Hookham, B., Shau-hwai, A. T., Dayrat, B., & Hintz, W. (2014). A baseline measure of tree and gastropod biodiversity in replanted and natural mangrove stands in Malaysia: Langkawi Island and Sungai Merbok. *Tropical Life Science Research*. *25*(1), 1–12.

Ibrahim, N. F., Ibrahim, Y. S., & Sato, M. (2019). New record of an estuarine polychaete, *Neanthes glandicincta* (Annelida, Nereididae) on the eastern coast of peninsular Malaysia. *ZooKeys*, *2019*(831), 81–94. https://doi.org/10.3897/zookeys.831.28588

Ibrahim, N. E., Omar, W. B. W., & Mohamad, F. (2018). Population density and size of blood cockle, *Anadara cornea* in Setiu Wetlands, Terengganu during Northeast monsoon season. *Journal of Sustainability Science and Management*, *13*(Special Issue 5), 113–124.

Ibrahim, S., Mohd, W., Wan, R., Kassim, Z., Joni, Z. M., Zakaria, M. Z., & Hajisamae, S. (2006). Seasonal Abundance of benthic communities in coral Areas of Karah Island, Terengganu, Malaysia. *Turkish Journal of Fisheries and Aquatic Sciences*, *6*(2), 129–136.

Idris, I. & Arshad, A. (2013). Checklist of polychaetous annelids in Malaysia with redescription of two commercially exploited species. *Asian Journal of Animal and Veterinary Advances*, *8*(3), 409–436.

Idris, I., Glasby, C., & Arshad, A. (2012). Nereididae (Annelida: Polychaeta) used as baitworms in Peninsular Malaysia. *Universiti Malaysia Terengganu Postgraduate Conference*, *July*, 239–250.

Idris, I. (2015). Diversity, biological and ecological aspects of marine baitworms, with an emphasize on a polychaete *Marphysa moribidii* (Idris, Hutchings, Arshad 2014) from Morib mangrove area, Malaysia. Thesis of Degree of Doctor of Philosophy. Universiti Putra Malaysia.

Idris, I., Hutchings, P., & Arshad, A. (2014). Description of a new species of *Marphysa Quatrefages*, 1865 (Polychaeta: Eunicidae) from the west coast of Peninsular Malaysia and comparisons with species from Marphysa Group A from the Indo-West Pacific and Indian Ocean. *Memoirs of Museum Victoria*, *71*(December), 109–121. https://doi.org/10.24199/j.mmv.2014.71.11

Ilias, Z. (2015). *Holothuria scraba* (sandfish) habitat dan distribution in Peninsular Malaysia. *Malaysian Fisheries Journal. 14: 21–28.*

Ismail, M. S., Khoo, M. L., Masazurah, A. R., Dzulfikkar, B. M, & Hadzley, H. (2017). Checklist and distribution of jellyfish in the coastal waters of Peninsular Malaysia. *Malaysian Fisheries Journal*, *16*(4), 9–18.

Izwandy, I., Aileen T. S. H., Zulfigar, Y. & Mahadi, M. (2005). The biodiversity of topshells in Pulau Pemanggil, Johor, Malaysia. *Jurnal Biosains*, *16*(2), 97–2005.

Izzah Farzana Mohd Rafi, N., Maisarah, I., Rahim, F., Ahmad, R., Sanusi, M., Arif Iskandar Abdul Wahab, M., & Ngadi, E. (2020). Diversity of sea shore invertebrates at West Coast Peninsular Malaysia. *Insan Junior Researcher Conference*, 42–47.

Jie, E. J. (2018). *Cyclic development and community structure of the intertidal polychaete reefs in the Jeram mudflat, Peninsular Malaysia*. http://studentsrepo.um.edu.my/11511/1/Samsuddin.pdf

John, B. A., Jalaland, K. C. A., & Kamaruzzaman, B. Y. (2013). Macrobenthic diversity in horseshoe crab nesting ground- Balok station, Pahang, Malaysia. *Oriental Journal of Chemistry*, *29*(4), 1311–1318. https://doi.org/10.13005/ojc/290406

Kamaruzzaman, A. binti A. (2015). *The gastropod and bivalve of Bruit Island, Sarawak* (Vol. 13, Issue 3).

Kasihmuddin, M. S. M., & Cob, Z. C. (2021). Ecological roles of benthic community in seafloor northwards of Pulau Indah, Klang, Malaysia. *Pertanika Journal of Science and Technology*, *29*(2), 1267–1288. https://doi.org/10.47836/pjst.29.2.31

Kasihmuddin, M. S. M., & Cob, Z. C. (2021). Distribution of benthic macroinvertebrates in seafloor northward of Pulau Indah, Klang. *Pertanika Journal of Science and Technology*, *29*(1), 641–662. https://doi.org/10.47836/pjst.29.1.34

Kassim, Z., Ahmad, Z., & Ismail, N. (2018). Diversity of bivalves in mangrove forest, Tok Bali Kelantan, Malaysia. *Science Heritage Journal*, *2*(2), 04–09. https://doi.org/10.26480/gws.02.2018.04.09

Kassim, Z., Kasmarudin, K., Huda, N., Ishak, A., Radzi, R. M., Erni, N., Hadnan, A., & Yunus, K. (2011). Biodiversity of selected marine arthropoda in Malaysia. *Malaysias Marine Biodiversity Inventory and Current Status*, *January*, 99–108.

Kee Alfian, A. A., Wong, W. S., Badrul, H., & Affendi, Y. A. (2005). Macroinvertebrate diversity of Kg. Tekek, Pulau Tioman Marine Park. *Proceedings of Second Regional Symposium and Natural Resources, Vol:2*, *March*, 79–84.

Kumar, R. S. (2003). A checklist of polychaete species some mangroves of Asia. *Zoos' Print Journal*, *18*(2), 1017–1020.

Laura, R., Phaik, E., L., Rosli, R. & Guancula, P. (2020). Diversity and habitat segregation of mangrove grapsoid crabs along the west coast of the Malay Peninsula. *Marine and Freshwater Research*, *71*(8), 984–995. https://doi.org/10.1071/MF19147

Long, S. M. (2010). Macrofauna of Rajang River, Sarawak, Malaysian Borneo. *Journal of Tropical Biology and Conservation*, *7*(1), 11–30.

Long, S. M., Azizil, A., Abg, F., Atiqah, S., & Rahim, A. (2014). Marine Gastropod and Bivalves of Sampadi Island, Lundu, Sarawak. *Monograph Aquatic Science Colloquium*, *September*, 75–87.

Long, S. M., & Ross, O. H. (2008). Horizontal distribution of intertidal nematode from Sabah, Malaysia. *Journal of Tropical Biology and Conservation*, *4*(1), 39–53.

Madin, J., Suet, M. Ho., & Maran, B. A. V. (2021). Gastropods in the intertidal shore of Kota Kinabalu, Sabah (Malaysian Borneo). *Borneo Journal of Resource Science and Technology*, *11*(1), 9–23. https://doi.org/10.33736/bjrst.3371.2021

Manjaji-Matsumoto., B. M., Saleh, E., Waheed, Z., Muahmmad Ali, S. H., & Madin, J. (2017). Marine profiling of coastal and marine resources management. In *Final report: Marine profiling of Marudu Bay, Sabah*.

Mohamamad, A., & Jalal, K. C. A. (2018). Macrobenthic diversity and community composition in the Pahang Estuary, Malaysia. *Journal of Coastal Research*, *82*(4), 206–211. https://doi.org/10.2112/SI82-030.1

Mohamed, Z. & Muhammad Nawaz, R. (2015). Assessing the fauna diversity of Marudu Bay mangrove forest, Sabah, Malaysia, for future conservation. *Diversity*, *7*(2), 137–148. https://doi.org/10.3390/d7020137

Mohd Hanafi, I. (2001). Kepelbagaian dan taburan spesies makrobentos di kawasan terumbu karang dan rumput laut di Pulau Babi Besar, Johor, Malaysia. Thesis of Master of Science. Universiti Putra Malaysia.

Mohd Ismailuddin, S. A., Mohd Abdullah, M., Ibrahim, Y. S., & Idris, I. (2021). Benthic community diversity at marine archaeological site, Pulau Bidong, South China Sea. *Universiti Malaysia Terengganu Journal of Undergraduate Research*, *3*(3), 93–106. https://doi.org/10.46754/umtjur.2021.07.011

Mohd Long, S., Taufek, M., & Mohd Salleh, N. M. (2014). Macrofauna community structure on seagrass meadows of Sampadi. *Monograph Aquatic Science Colloquium*, *October*, 62–74.

Muda, W. L. W., Samat, A., Cob, Z. C., & Ghaffar, M. A. (2010). Checklist of marine epibenthic invertebrate species from Mersing, Johor. *Penyelidikan Pantai Timur Johor: Mersing Warisan Terpelihara*, *21*(1961), 203–212.

Muda, W. W., Ghaffar, M. A., Omar, R., Cob, Z. C., & Samat, A. (2004). Spatial Distribution Pattern of Macrobenthos in East Johor Straits. *Earth Observation Centre (EOC), UKM.* Ekosistem Marin Malaysia. Penyelidikan Pantai Timur Johor Darul Takzim. 23–30.

Muhamad Darif, N. A., Abdul Samad, N. S., Salleh, S., Mohammad, M., Ahmad Nordin, N. A., Mohamed Javeed, A. M., Jonik, M. G. G., & Mohd Zainudin, M. H. (2016). The abundance and spatial distribution of soft sediment communities in Tanjung Bungah, Malaysia: A preliminary study. *Tropical Life Sciences Research*, *27*, 71–77. https://doi.org/10.21315/tlsr2016.27.3.10

Mustaffa, A., Ahmad, O., Vongpanich, V., & Talib, A. (2013). Benthic mollusc assemblages in subtidal coastal waters of Penang National Park, Malaysia. *Proceedings of the 3rd Annual International Conference Syiah Kuala University (AIC Unsyiah) in Conjunction with the 2nd International Conference on Multidisciplinary Research (ICMR)*, 144–150.

Nakao, S., Nomura, H., & Satar, M. K. A. (1989). Macrobenthos and sedimentary environments in a Malaysian intertidal mudflat of the cockle bed. *Bulletin - Hokkaido University, Faculty of Fisheries*, *40*(4), 203–213.

Nishi, E. (1999). Redescription of *Mesochaetopterus selangolus* (Polychaeta: Chaetopteridae), based on type specimens and recently collected material from Morib Beach, Malaysia. *Pacific Science*, *53*(1), 24–36.

Noor Shahida, R., Nurulafifah, Y., Izwandy, I. & Zainudin, B. (2019). Settlement rate of fouling serpulid *Ficopomatus cf. uschakovi* Pillai, 1960 on artificial structure at Setiu Wetlands, Terengganu, Malaysia. *Malaysian Journal of Analytical Sciences*, *23*(6), 1067–1076.

Noor Shahida, R., Nurulafifah, Y., Izwandy, I. & Zainudin, B. (2018). Polychaetous annelid community structure in relation to soft bottom sediment characteristics in continental shelf of the southern south China Sea. *Journal of Sustainability Science and Management*, *26*(2), 107–110.

PETRONAS. (n.d.). *Environmental sensitivity index for Pahang 2010*.

Piamthipmanus, M. (1985). Temporal changes in the abundance of macrobenthos in the south china sea, area I: Gulf of Thailand and east coast of Peninsular Malaysia. 1990, 285–293. Department of Fishery.

Piamthipmanus, M. (1997). Temporal changes in the abundance of macrobenthos in the south china sea, *Area II*: Sarawak, Brunei and Sabah survey area and sampling stations. 323–337.

Pinn, W. S., Fang, A. N. P., Razalli, N. M., Nilamani, N., Peng, T. C., Yasin, Z., Tan, S. W., & Fujita, T. (2014). New records of sea stars (Echinodermata Asteroidea) from Malaysia with notes on their association with seagrass beds. *Biodiversity Journal*, *5*(4), 453–458.

Ponnusami, J., & AZIZ, F. (2017). Supplementary materials: checklist of Molluscs (Gastropoda and Bivalvia) of Malaysia Exclusive Economic Zone (EEZ) in Sarawak Waters. *Borneo Journal of Resource Science and Technology*, *7*(2), 111–117. https://doi.org/10.33736/bjrst.598.2017

Port, W. (2014). Diversity and distribution of benthic invertebrates. *International Journal of Environmental, Ecological, Geological and Mining Engineering*, *8*(7), 458–461.

Ransangan, J., & Soon, T. K. (2018). Occurrence and distribution of marsh clam, *Polymesoda* spp. in Marudu Bay, Sabah, Malaysia. *Open Journal of Marine Science*, *08*(02), 314–322. https://doi.org/10.4236/ojms.2018.82017

Rosle, S., & Ibrahim, S. (2017). Habitat preferences of shrimp (*Penaeus monodon*) in Kelantan Delta, Malaysia. *International Journal of Fisheries and Aquatic Studies*, *5*(6), 326–330. www.fisheriesjournal.com

Saleh, E., Kiat, Y. T., Geng, C. N., & Masidi, A. M. (2020). Inventory of marine fauna on reef balls structures of Selingan Island, Sandakan, Sabah, Malaysia. *Journal of Tropical Biology and Conservation*, *17*, 203–216.

Sanapi, N. (2012). *Community structure of the macrobenthos in Tanjung Bajong, Sebuyau, Sarawak*. Thesis of Bachelor of Science with Honours. Universiti Malaysia Sarawak.

Sasekumar, A. (1974). Distribution of macrofauna on a Malayan mangrove shore. *British Ecological Society*, *43*(1), 51–69.

Saupi, M, Mushidi, H., Zainuddin, I. & Daud, A. (2010). Assessment of species composition and abundance of selected marine invertebrates in Pulau Layang Layang, Malaysia 1/ 2/ 3/ 2. *Malaysian Fisheries Journal*, *9*(5), 46–56.

Shafie, B. B., Man, A., Ali, N. F., & Rahim, A. A. (2021). Macrobenthos diversity along the exclusive economic zone of east coast peninsular Malaysia. *Journal of Environmental Biology*, *42*(3), 817–823. https://doi.org/10.22438/JEB/42/3(SI)/JEB-13

Shi, G. W., Ghaffar, M. A., Ali, M. M., & Cob, Z. C. (2014). The Polychaeta (Annelida) communities of the Merambong and Tanjung Adang Shoals, Malaysia, and its relationship with the environmental variables. *Malayan Nature Journal*, *66*(1–2), 168–183.

Sing, H. R., & Sasekumar, A. (1994). Distribution and abundance of marine wood borers on the west coast of Peninsular Malaysia. *Hydrobiologia*, *285*(1–3), 111–121. https://doi.org/10.1007/BF00005659

Siti-Balkhis, A. B., Yaman, I. C., Siti-Hasmah, I., Khalil, M. Z., Muhammad-Shukri, M. Y., Zulfigar, Y., & Aileen-Tan, S. H. (2014). A survey of the marine intertidal macrogastropoda in the northern straits of Malacca. *ASM Science Journal*, *8*(2), 159–164.

Mohd Hanafi, I. (2009). Biology and distribution of pen shell (Bivalvia: Pinnidae) in selected areas of Peninsular Malaysia. Thesis of Doctor of Philosophy. Universiti Putra Malaysia.

Stiepani, J., Gillis, L. G., Chee, S. Y., Pfeiffer, M., & Nordhaus, I. (2021). Impacts of urbanization on mangrove forests and brachyuran crabs in Penang, Malaysia. *Regional Environmental Change*, *21*(3). https://doi.org/10.1007/s10113-021-01800-3

Su Yin, C., & Yee Kwang, S. (2016). Coastal macroinvertebrate study in Penang Island, Malaysia. *Tropical Life Sciences Research*, *27*, 39–44. https://doi.org/10.21315/tlsr2016.27.3.6

Table, P. (1981). the Marine Shelled Mollusca of West Malaysia and Singapore Part 3, Bivalvia. *Journal of Molluscan Studies*, 290–312. https://doi.org/10.1093/oxfordjournals.mollus.a065575

Tan, A. (2020). Survey on the diversity of benthic macrofauna in seagrass bed, Middle Bank, Penang, Straits of Malacca. 650969.

Tan, E. et al (2022). A review of plastic and microplastic pollution towards the Malaysian marine environment. IOP Conf. Ser.: Earth Environ. Sci. 1013 012012

Tan, H. S., & Rahim, A. A. (2018). Diversity of coastal mysids from Pulau Tinggi, Sultan Iskandar Marine Park, Malaysia. *Nauplius*, *26*(0), 1–12. https://doi.org/10.1590/2358-2936e2018037

Teh, C., Nithiyaa, N., Amelia Ng, P., Woo, S., Norhanis, M., Zulfigar, Y., & Aileen Tan, S. (2014). The diversity of the marine macrogastropods on the seagrass meadows in Merambong Shoal, Johore. *The Malayan Nature Journal*, *66*(1&2), 132–138.

Teoh, V. Y. J., & Woo, S. P. (2021). The diversity of echinoderms in the seagrass meadows of Penang Island, Malaysia. *IOP Conference Series: Earth and Environmental Science*, *711*(1). https://doi.org/10.1088/1755-1315/711/1/012012

Wan Hussin, W. M. R., & Lah, R. A. (2020). Community structure and taxonomic diversity of macrobenthic communities in Merchang Lagoon, Malaysia. *AACL Bioflux*, *13*(6), 3593–3604.

Wan Shi, G., Di Min, L., Ghaffar, M. A., Md Ali, M., & Cob, Z. C. (2014). Macrobenthos composition, distribution and abundance within Sungai Pulai estuary, Johor, Malaysia. *AIP Conference Proceedings*, *1614*(September), 591–596. https://doi.org/10.1063/1.4895269

Wong, N. L. W. S. & Arshad, A. (2011). A brief review on marine shelled Mollusca (Gastropoda and Bivalvia) record in Malaysia. *Journal of Fisheries and Aquatic Science*, *8*(1), 80–86.

Yahya, N., Idris, I., Rosli, N. S., & Bachok, Z. (2018). Population dynamics of mangrove clam, *Geloina expansa* (Mousson, 1849) (Mollusca, Bivalvia) in a Malaysian mangrove system of South China Sea. *Journal of Sustainability Science and Management*, *13*(5), 203–216.

Yap, C. K., Ismail, A. R., Ismail, A., & Tan, S. G. (2003). Species diversity of macrobenthic invertebrates in the Semenyih River, Selangor, Peninsular Malaysia. *Pertanika*, *26*(2), 139–146.

Yap, T. K., Gallagher, J. B., Saleh, E., & Admodisastro, V. A. (2018). The occurrence of boring bivalve (Genus: *Zachsia*), in a tropical seagrass meadow in Gaya Island (Sabah, Malaysia) and its possible ecological implications. *Borneo Journal of Marine Science and Aquaculture (BJoMSA)*, *2*(12), 48–53. https://doi.org/10.51200/bjomsa.v2i0.1554

Zaidi, C. C., Aziz, A., Japar Sidik, B., & Mazlan, A. G. (2009). Species description and distribution of *Strombus* (Mollusca: Strombidae) in Johor Straits and its surrounding area. *Sains Malaysiana*, *38*(1), 39–46.

Zakirah, M. T., Shabdin, M. L., Khairul-Adha, A. R., & Fatimah-A'tirah, M. (2019). Distribution of intertidal flat macrobenthos in Buntal Bay, Sarawak, Borneo. *Songklanakarin Journal of Science and Technology*, *41*(5), 1048–1058. https://doi.org/10.14456/sjst-psu.2019.132

Zaleha, K., Farah Diyana, M. F., Amira Suhaili, R., & Amirudin, A. (2009). Benthic community of the Sungai Pulai seagrass bed, Malaysia. *Malaysian Journal of Science*, *28*(2), 143–159. https://doi.org/10.22452/mjs.vol28no2.4

Zaleha, K., Farah Diyana, M. F., Mohd Luthfi, O., Noorul Ain Falah, A., & Ahmad Wafi, A. (2011). Health status of recreational beaches in Iskandar development region, Johor, Malaysia. *Malaysian Journal of Analytical Sciences*, *15*(2), 184–190.

Zaleha, K., Nasiratul Shahida, M. N., Siang, H. Y., & Kamaruzzaman, B. Y. (2016). Trend of meiobenthos density and composition in Karah Island, South China Sea. *Sains Malaysiana*, *45*(7), 1019–1024.

Zauki, N. A. M., Satyanarayana, B., Fairuz-Fozi, N., Nelson, B. R., Martin, M. B., Akbar-John, B., & Chowdhury, A. J. K. (2019). Horseshoe crab bio-ecological data from Balok, East Coast Peninsular Malaysia. *Data in Brief*, *22*, 458–463. https://doi.org/10.1016/j.dib.2018.12.027

Zuha, R. M., Huong-wen, S., Disney, R. H. L., & Omar, B. (2017). Checklist of gastropods from the Exclusive Economic Zone (EEZ), Sarawak, Malaysia. *Tropical Life Sciences Research 28(1): 131–143. 28*(1), 131–143.

Appendix 4 – Excerpt of MS Excel spreadsheet of references classification

I17

	A	B	C	D	E	F	G	H
1	**Year**	**Ref. no**	**Area**	**Habitat**	**Type of study**	**No of species**	**Publication**	
2								
3	2010	**1**	Pulau Layang Layang, Kota Kinabalu,	Atoll	Marine inverts all phyla	37	Mohamad Saupi, I., Mushidi, H., Zainuddin, I. &	
4	2020	**2**	Punang-Sari, Lawas, Sarawak	Seagrass bed, mangrove	Onfaunal & Infaunal all	111	Abdulla Al-Asif, Hadi Hamli, Abu Hena Mustafa	
5	1995	**3**	Teluk Aling, Pinang	Sand flat	Macrobenthos all phyla	47	Bessie Ong & Sekaran Krishnan. 1995. Changes in	
6	2010	**4**	Tanjung Penyabong, Mersing, Johor	Soft bottom seabed	Marine inverts all phyla,	32	Wan Lotfi Wan Muda, Abdullah Samat, Zaidi Che	
7	2016	**5**	Coast of Penang	Coastal waters of	Benthic macroinverts all	56	Chee Su Yin & Sim Yee Kwang. 2016. Coastal	
8	2011	**6**	Teluk Aling, Pulau Pinang	Sandy & rocky shores	Intertidal organisms all	46 (sandy shore) & 13	Omar Ahmad, Tay Pei Fang & Khairun Yahya. 2011.	
9	2012	**7**	Teluk Ketapang & Pantai Acheh	Coastal water	Polychaeta	604 individuals of 23	Mohammad Gholizadeh, Khairun Yahya, Anita Talib	
10	1999	**8**	East coast of Peninsular Malaysia	Coastal water	Macrobenthos all phyla	33 families (pre-	Abdul Hamid Yasin & Solahuddin A. Razak. 1999.	
11	1974	**9**	Kapar Mangrove Forest Reserve,	Mangrove shore & estuary	Mangrove macrofauna	78	A. Sasekumar. 1974. Distribution of macrofauna on	
12	2014	**10**	West Port, Selangor	Mangrove island &	Macroinverts all phyla	33	Seyedeh Belin Tavakoly Sany, Majid Rezayi, Rosli	
13	2016	**11**	Offshore Pekan-Dungun, Kuala	Soft bottom of continental	Polychaeta	368	Noor Shahida Rosli, Nurulafifah Yahya, Irna Arifin,	
14	2020	**12**	Pengkalan Balak & Teluk Gong	Seashore	Molluscs (Bivalve and	51	Nur Izzah Farzana Mohd Rafi, Irdeena Maisarah,	
15	2021	**13**	Pulau Indah, Klang	Coastal water	Macrbenthos all phyla	37 taxa (848 individuals)	Mohd Sophian Mohd Kasihmuddin, Zaidi Che Cob.	
16	2020	**14**	Selingan Island, Sandakan, Sabah	Coastal area (Reef ball	Marine fauna all phyla	21 species	Ejria Saleh, Yap Tzuen Kiat, Chen Nuo Geng, Adam	
17	2018	**15**	Pahang estuary	Estuary	Macrobenthos all phyla	4	Azfar Mohamamad, K. C. A. Jalal. 2018.	
18	1989	**16**	Selangor river estuary	Estuary	Macrobenthos all phyla	56	Shigeru Nakao, Hirotaka Nomura, Mustafa Kamal	
19	2014	**17**	Sungai Pulai estuary (Merambong	Shoal	Macrobenthos all phyla	Dominated by	Guan Wan Shi, Lee Di Min, Mazlan Abd Ghaffar,	
20	2012	**18**	Teluk Penyabong & Teluk Gorek,	Intertidal areas of	Invertebrate fauna	62	Cob Z. C., Samat A., Muda W.M.L.W., Mazlan A. G.	
21	2018	**19**	Pulau Bidong, Terengganu	Coastal water	Gastropods	25	Nursalwa Baharuddin, Nur A. Zakaria. 2018. The	

Appendix 4 - Excerpt of MS Excel spreadsheet of references classification

J3

Ref.No	Area	LAT	LON	Habitat	Type of study	No of species	Publication	Methods	Remarks
3	Teluk Aling beach, Pinang	5.466667	100.183333	Sand flat	Macrobenthos all ph	47	Bessie Ong & Sekaran Krishnan. 1995. Changes in the macrobenthos community of a sand flat after erosion. Estuary, Coastal and Shelf Science.	Hand-held corer	macrobenthos composition ch vestiarum to a predominantly replaced numerically by the po bivalve Tivela sp. The recovery high densities 6 months later, beach. Lower total density wa February, which was characte always recorded during the ca
4	Tanjung Penyabong, Mersing, Johor	2.633333	103.733333	Soft bottom seabed	Marine inverts all phyla, mostly mega size	32	Wan Lotfi Wan Muda, Abdullah Samat, Zaidi Che Cob & Mazlan Abd Ghaffar. 2010. Checklist of marine epibenthic invertebrate species from Mersing, Johor. Penyelidikan Pantai Timur Johor: Mersing Warisan Terpelihara	Traw net by Class A trawler boat	Most of the sample considere was 1 x 1 inch. Almost half of species such as crabs (Portunu hungerfordi, P. sculptilis & Me Mersing coastal waters is a po
5	Coast of Penang (Queensbay)	5.332022	100.309172	Coastal waters of reclaimed areas, Adjacent to reclaimed areas, & less disturbed areas	Benthic macroinverts all phyla	56 from 47 families	Chee Su Yin & Sim Yee Kwang. 2016. Coastal macroinvertebrate study in Penang Island, Malaysia. Tropical Life Sciences Research.	Transect & coring method	Maxillopods and polychaetes Ischinocerithium rostratum, Sc found only in undisturbed sites Drive= 2 species (The lowest s diversity (3.0798) & Gurney Dr ricness and diversity were the and reclaimed areas, respectiv

Appendix 5 - Photos of some marine invertebrates found in Malaysia's water

Source: www.marinespecies.org

Anadara antiquata

Source: www.conchology.be

Assiminea sp.

Source: www.conchology.be

Cantharus sp.

Source: www.conchology.be

Astralium calcar

Source: www.conchology.be

Cassidula aurisfelis

Source: www.conchology.be

Optediceros breviculum

Source: www.conchology.be

Source: www.conchology.be

Source: www.conchology.be

Source: seaslugforum.net

Chromodoris lochi

Source: www.conchology.be

Trochus sp.

Source: www.conchology.be

Umbonium vestiarium

Source: www.conchology.be

Yoldia sp.

Source: https://www.crabdatabase.info

Goniopsis cruentata

Source: https://gilwizen.com

Metaplax elegans

Source: https://m.singapore.biodiversity

Parasesarma eumolpe

Source: bushguide101.com/backtonature

Tachypleus gigas

Source: www.aphotomarine.com/

Tetraclita sp.

Source: www.marinespecies.org/

Arenicola cristata

Source: wikipedia.org

Capitella capitata

Source: https://eol.org/

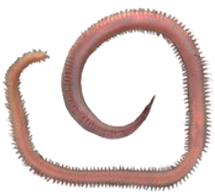
Caulleriella sp.

Source: https://www.flickr.com/photos/artour_a/8455620771

Chaetopterus sp.

Source: www.marinespecies.org

Cossura sp.



Source: https://invertebase.org

Glycera sp.

Source: www.pandubio.com

Lysidice sp.

Source: www.123rf.com

Acanthaster planci

Source: www.pinterest.com

Choriaster granulatus

Source: www.marinespecies.org

Echinodiscus bisperforatus

Source: https://echinoblog.blogspot.com/

Linckia sp.

Source: www.conchology.be

Telescopium telescopium

Source: Capa et al. (2021)

Sabellidae

Source: https://scialert.net

Pinna bicolor

Source: https://marinespecies.org

Mactra glauca

Source: www.conchology.be

Nassarius livenscens

Source: www.wildsingapore.com

Solenidae

Source: wikipedia.org

Donax tranculus

CHAPTER 3

MARINE ENDANGERED SPECIES

Saifullah Arifin Jaaman @ Sharman
Mohd Uzair Rusli
Nazuki Sulong
Muhammad Amirul Siddiq Abd Rashid
Muhammad Fadhli Mat Sobri
Chong Kai Syin
Syamsyahidah Samsol

1.0 MARINE MAMMALS

1.1 INTRODUCTION

Malaysian seas are especially significant because the continental shelf is highly nutrient-rich and can support a remarkable diversity of species (MOSTE, 1997; Oakley et al., 2000). Thirty-one species of marine mammals have been recorded to either reside in or transit the Southeast Asian seas (Perrin et al., 2005; Hines et al., 2015). However, the status of populations is largely unknown, particularly in Malaysian waters. Based on published and unpublished literature, a total of 28 species of marine mammals have been recorded in Malaysia (Bali et al., 2008; Hines et al., 2015; Jaaman et al., 2021; 2013; 2010; Jaaman, 2010; Jaaman and Bali, 2011; Jamal-Hisne et al., 2013 and Ponnampalam, 2012), consisting mainly of cetaceans and one sirenian species. Malaysia is separated into two distinct regions by the South China Sea, Peninsular Malaysia in the west and East Malaysia, which includes the states of Sarawak and Sabah.

Evidence suggests that three more cetaceans stray into or pass-through Malaysian waters, at least occasionally. This observation is based on species [dwarf sperm whale (*Kogia sima*), Blainville's beaked whale (*Mesoplodon densirostris*), and striped dolphin (*Stenella coeruleoalba*)] that have been positively identified in neighbouring countries – Brunei, Singapore, Thailand, Myanmar, Cambodia, Vietnam, Indonesia, and the Philippines. Threats from habitat loss and degradation, declining fisheries resources, encroachment of fisheries into restricted areas, and coastal developments are known to affect marine mammal populations in South East Asia (Marsh et al., 2002; Perrin et al., 2005), including in certain Malaysian waters (Jaaman et al., 2010).

1.2 OBJECTIVE

i. To record, document, and analyze marine mammal information/data resulting from previous studies in Malaysian waters to be translated into a comprehensive inventory report, including the production of geospatial maps of the distribution of marine mammals;
ii. To analyze information gaps and the need for further research on marine mammals to obtain additional information to ensure that they represent areas of interest to be protected more comprehensively; and
iii. To identify areas that have the potential to be protected as Marine Protected Areas (MPA) for marine mammals with the creation of marine ecological corridors.

1.3 MATERIALS AND METHODS

i. Desktop Study – Collection of data/information on marine mammal inventory based on previous studies and published and unpublished literature. The species list is prepared to indicate in which region each species is known to occur. These records comprised species that are known from stranding (including bycatch and hunting) records, live sightings, or both from UMT and other databases. The list of species and the region in which they are known to occur is presented in Tables and Figures.
ii. Data Analysis and Mapping - Spatial analysis to identify information gaps and marine mammal habitat areas that are important and desirable to be protected.
iii. Workshops and Publications – Focus group discussions (FGD), workshops on progress, and final reports have been conducted. Drafting a manuscript titled "Cetacean and Dugong in Malaysia: A national assessment of status, distribution and threat" and producing geospatial maps of species composition, distribution, and density of marine mammals in Malaysia.

1.4 RESULTS/DATA ANALYSIS

i. Desktop Study

Two hundred twenty-five materials consisting of 73 journal articles, 27 technical reports, 15 postgraduate theses, 19 books, 30 proceedings, 41 newspaper clips, and 20 social media postings were examined to have records of marine mammals in Malaysia. These materials are listed in MALAYSIAN MARINE MAMMAL REFERENCES (Refer to Google Drive/ECOLOGICAL CORRIDOR /FG3/MM Reference/ MALAYSIAN MARINE MAMMAL References Ver5). Materials on cetaceans in Malaysia are stored in [Google Drive/ECOLOGICAL CORRIDOR/FG3/MM Reference/Cetaceans], and for Dugong are stored in [Google Drive/ECOLOGICAL CORRIDOR/FG3/MM Reference/Dugong].

In addition to the published and unpublished materials, information from UMT and other marine mammal databases are used to develop a checklist of 27 cetaceans and one dugong species that have confirmed records of live sighting and stranding (including bycatch and hunting) according to regions (state/sea) in Malaysia. The states of Peninsular Malaysia recorded 17 cetacean species, and Sarawak and Sabah recorded 18 and 22 cetacean species, respectively. The Dugong has records from all regions of Malaysia.

The marine mammal species checklist is stored in [Google Drive/ECOLOGICAL CORRIDOR/FG3/MM database/MM checklist/Marine Mammals Species checklist OVERALL (VER 2.1)]. The UMT and other marine mammal databases are stored in [Google Drive/ECOLOGICAL CORRIDOR/FG3/MM database/MM excel data/INOS-UMT Marine Mammal Database 2.0] and [Google Drive/ECOLOGICAL CORRIDOR/FG3/MM database/MM excel data/Other Marine Mammal Database 2.0], respectively.

ii. Data Analysis and Mapping

All records in UMT and other marine mammal databases contain species, date, time, position (latitude/longitude/locality), and the number of individuals involved. This information is used to generate maps of species composition, distribution, and density of marine mammals in Malaysia based on the survey methodology and how the records are obtained (i.e., boat survey, aerial survey, stranding, public report, etc.).

Six marine mammal species (i.e., Dugong, false killer whale, Indo-Pacific bottlenose, Indo-Pacific humpback, Irrawaddy, and spinner dolphins) were recorded during UMT aerial surveys. Their maps are stored in [Google Drive/ECOLOGICAL CORRIDOR/FG3/MM database/MM map/Map (UMT data)/MAP UMT DATA - Aerial Survey].

Sixteen marine mammal species (i.e., dugong, Bryde's, common Minke, false killer, melon-headed, short-finned pilot and sperm whales, and common bottlenose, Indo-Pacific bottlenose, Fraser's, Indo-Pacific humpback, Irrawaddy, long-beaked common, pantropical spotted and spinner dolphins, and finless porpoise) were recorded during UMT boat surveys. Their maps are stored in [Google Drive/ECOLOGICAL CORRIDOR/FG3/MM database/MM map/Map (UMT data)/MAP UMT DATA - Boat Survey].

Two marine mammal species (i.e., dugong and humpback whale) were recorded during other aerial surveys, and their maps are stored in [Google Drive/ECOLOGICAL CORRIDOR/FG3/MM database/MM map/Map (additional data)/ MAP Other data (Aerial Survey)].

Thirteen marine mammal species (i.e., Dugong, Bryde's, false killer, melon-headed, pygmy killer and sperm whales, Indo-Pacific bottlenose, Fraser's, Indo-Pacific humpback, Irrawaddy, long-beaked common, pantropical spotted and spinner dolphins) were recorded during other boat surveys. Their maps are stored in [Google Drive/ECOLOGICAL CORRIDOR/FG3/MM database/MM map/Map (additional data)/ MAP Other data (Boat Survey)].

Twenty marine mammal species (i.e., Dugong, blue, Bryde's, fin, sei, Omura's, Cuvier's beaked, false killer, killer, melon-headed, short-finned pilot, pygmy sperm and sperm whales, and Indo-Pacific bottlenose, Indo-Pacific humpback, Irrawaddy, long-beaked common, rough-toothed and spinner dolphins, and finless porpoise) were recorded during UMT boat surveys. Their maps are stored in [Google Drive/ECOLOGICAL CORRIDOR/FG3/MM database/MM map/ Map (other data)/MAP Other data (Stranding].

iii. Workshops and Publications

No	Phase / Workshop	Date
i.	Proposal presentation workshop (online)	October 25, 2021
ii.	Submission of Proposal (online)	October 31, 2021
iii.	GIS training workshop (UMT)	February 08, 2022
iv.	FG coordination meeting (UMT)	April 12, 2022
v.	Project coordination discussion (UMT)	April 16, 2022
vi.	Progress presentation workshop (DOF Putrajaya)	June 21, 2022
vii.	Project coordination discussion (UMT)	July 25, 2022
viii.	Final presentation workshop (DOF Putrajaya)	September 01, 2022

Drafting a manuscript titled "Cetacean and Dugong in Malaysia: A national assessment of status, distribution, and threat."

Producing geospatial maps of species composition, distribution, and density of marine mammals in Malaysia.

1.5 GAP ANALYSIS

i. Species and Distribution

Recommendations to reduce our knowledge gap on species composition and distribution of marine mammals in Malaysian waters:

a) Determine species composition and distribution of marine mammals in areas that have never been surveyed. This includes large portions of the offshore waters in the South China Sea, Straits of Malacca, and Sulawesi Sea. Based on reports and sightings of large whales and many small cetacean species in the waters of Layang-Layang, Luconia, and Sipadan reefs and shoals and near the continental shelf break, species diversity in the proposed survey areas should be high. Surveys can be conducted using platforms of opportunities (e.g., Navy patrol vessels, petroleum companies' supply ships, or helicopters), which are not labor-intensive and relatively cheap. They may have a broad spatial and temporal coverage (Evans and Hammond, 2004). A joint program between neighboring countries could be initiated to survey cetaceans in Spratly waters.

b) Dedicated boat and aerial sighting surveys need to be conducted along the inshore waters, particularly in the large estuaries and bays of Peninsular Malaysia, Sabah, and Sarawak, to determine the current distribution and threats to the Irrawaddy and Indo-Pacific humpback dolphins, finless porpoise and Dugong that inhabit the areas close to shore and which are often intensively used by humans. These populations are exceptionally vulnerable to anthropogenic threats.

c) The Malaysian Marine Mammal Stranding Network to recover stranded and incidentally caught animals is urgently needed operational fully. It should be established in conjunction with a fisheries bycatch reporting/monitoring program, with technical support from marine mammal biologists and veterinarians. Carcasses can be used not only to determine the cause of death but also to contain critical information regarding the animals' biology and life history and the populations' status. Among others, data and various samples collected from the carcasses can be analyzed to determine age, reproductive biology, feeding habits, molecular genetics, histopathology, and chemical contaminants of marine mammals. Results are also essential to understand the levels of interactions between marine mammals and humans or their environment.

d) Using marine mammal posters and brochures, a nationwide program to gather opportunistic sightings and strandings from the Navy and Air Force patrol crafts, beach/island resort operators, and the public should be developed. Although this type of information only helps to create a species list and some rough measure of status and seasonal variation in abundance (Evans and Hammond, 2004), the program is an excellent platform to initiate interest and increase awareness of the public to participate in the conservation and research of marine mammals in Malaysia (Jaaman et al., 1999; Jaaman, 2004). Furthermore, it yields primary data

at a low cost and can help draw attention to geographical areas or seasons for cost-effective targeting using a more refined survey methodology (Evans and Hammond, 2004).

e) Management and local authorities should act promptly to establish a concerted and dedicated program to report and monitor incidental catches of marine mammals in fisheries, hunting, and illegal and destructive fishing practices. There are adequate laws and regulations to protect and conserve marine mammals and fisheries in Malaysia; therefore, the problem of poor enforcement needs to be resolved. Routine monitoring of at least fish markets and landing sites should be carried out, if not having observers to monitor fishing trips. Enforcing fisheries and wildlife regulations within a large area is often complex and costly; therefore, effort should be made to regularly patrol known "hot spot" areas where there are harmful interactions between marine mammals and humans (e.g., in Cowie Bay (Sabah), Bay of Brunei, Kinabatangan Estuary and Kudat, Sandakan, Lahad Datu, and Semporna waters). Those found to contravene regulations shall not only receive warnings but should be given significant fines or punishment. However, this has to be done cautiously since, in some countries, enforcement of laws prohibiting direct takes or landing of incidental catches of marine mammals has increased the difficulty in obtaining information on such takes (Perrin et al., 1996; 2005).

f) Research on incidental catches of marine mammals in fisheries and hunting must be developed and should be given top priority. It should look at more than just the magnitude and sustainability of the catches and estimate mortality for each species' population. However, it should also focus on the economics, tradition, culture, political, and sociological factors related to the marine mammals, people, and area involved. A multi-disciplinary approach should be used, which involves both natural and social scientists. Social scientists may, in particular, assist in developing improved interview survey techniques. The information gathered must be integrated to provide a comprehensive picture of marine mammal-human interactions and produce a sound management program for conservation. This research should run parallel with the public education campaign.

ii. Population Status

Recommendations to reduce our knowledge gap on the population status of marine mammals in Malaysian waters:

a) Quantitative data on density, absolute abundance, and population dynamics at the species level should be obtained. This is particularly important for the Irrawaddy and Indo-Pacific humpback dolphins, finless porpoises, and Dugongs that inhabit the waters close to shore and which are often intensively used by humans. Therefore, research combining line-transect and photo-identification surveys and genetic sampling is necessary. Monitoring and detecting trends in populations of the inshore species are significant to determine whether the

people are declining in a specific area. Absolute abundance is essential to estimate the Potential Biological Removal (PBR) or upper limit for a sustainable number of marine mammals that could be killed in fisheries bycatch or hunting.

b) The definition of the genetic identity of marine mammal species from Malaysian waters and the geographical range of these animals are among the critical aspects that need to be investigated. This is especially important to the Straits of Malacca, Sulu, and Celebes Seas populations, where many glasses of water belong to Indonesia and the Philippines. There have been assumptions that dugongs travel between the three countries in search of food (Jaaman et al., 2013) and the small population of Irrawaddy and Indo-Pacific humpback dolphins in Cowie Bay (Sabah), Bay of Brunei Bay and Matang, Perak could move in and out of Malaysian waters to the neighboring countries. This must be ascertained if joint conservation measures are undertaken between the neighboring countries. On a larger scale, the primary objective is to determine how discrete the various groups of the inshore species are along the coast. This information helps identify critical habitats.

c) To understand the population status and trend of Irrawaddy and Indo-Pacific humpback dolphins in the Bay of Brunei, Matang (Perak), and Cowie Bay (Sabah), long-term research is needed research team can continuously monitor the dolphins, monthly or seasonally. The bio-acoustic method can be applied to know about their underwater communication. The underwater drone can be used to know details of mating strategies, intra-specific interaction (e.g., adult and calf, male and female), and interspecific interactions when socializing with other dolphin species. Radio telemetry, satellite tracking, photo-identification, and DNA techniques can be applied to know details about their site fidelity, traveling routes, migration routes, and habitat preference. Diet, food resources stock, and feeding behavior need to be conducted.

d) Dugongs are believed to occur in small and fragmented populations within the Bay of Brunei and Sultan Iskandar Marine Park (Johor). The animal was reported as rarely seen, and the information on trends suggests that dugongs are declining in the areas. These areas are essential for dugongs to feed on the seagrass bed, dominated mainly by *Halophila* sp and *Halodule* sp, which are Dugong's preferred food. To empower a deeper understanding of the dugong population in the areas, the following would be beneficial for future research: 1) Extensive dugong monitoring surveys using advanced equipment and techniques such as bioacoustics, drones, and uncrewed aerial vehicle (UAV), satellite-tagging, stationary underwater video recording, etc.; 2) A detailed study of dugongs including genetics, behaviors, diets, their interaction with other species such as turtles, etc.; 3) A comprehensive study of seagrass communities including mapping, identification, nutrient content, community structure, etc.; and 4) A comprehensive trans-boundaries research and conservation program with a collaboration between Malaysian and its neighboring countries regarding Dugong and other endangered marine mammals.

iii. Habitat Status

Recommendations to reduce our knowledge gap on the habitat status of marine mammals in Malaysian waters:

a) Determine habitat use and identify critical habitats or "hot spots" for the Irrawaddy and Indo-Pacific humpback dolphins, finless porpoises, and Dugongs that inhabit the waters close to shore. This should be of high priority. There is a high probability that different marine mammal species occur nearby or use the same habitats. Moreover, the distribution and abundance of seagrass should be mapped, and seagrass diversity determined. Once these are identified, fixed stations (platforms) can be installed to further study or monitor marine mammals at a relatively low cost (Evans and Hammond, 2004) and without influencing their natural behavior (Ng and Leung, 2003)

b) Forest/land and environmental management and local authorities should also act promptly to ensure responsible logging and palm oil planting are practiced in upstream areas. This reduces sediment, logs, debris, insecticide, and fertilizer from polluting rivers, especially during the rainy season. Many fish and wildlife and their habitats and prey downstream or in inshore waters are threatened by pollution from river effluents. In addition, a significant effort should be made to clean up waters near coastal towns from litter and floating waste.

c) In Cowie Bay (Sabah), the Bay of Brunei and Matang, Perak, and other areas of intensive use by humans, the effects of boat traffic and acoustic disturbance on local marine mammal populations need to be studied in detail. These effects are believed to be detrimental to the social order and behavior of the animals and have been known to cause injury/death from propeller strikes (Ng and Leung, 2003). Research should focus on determining the magnitude and significance of these disturbances to the coastal populations and finding a strategy to minimize them. So far, there has been no control of boat speed or traffic implemented in East Malaysia waters except in harbors because of safety considerations.

d) The Malaysian government has to develop a national strategy to mitigate vessel-cetacean interactions as the species that all live in coastal or riverine areas are most affected by human activity. Although a recent study showed no mortality involving boat-strike of resident dolphins in Cowie Bay (Norhashim, 2011), it is still a concern of the possibility of such an event to occur in the future. The strategies should focus on public awareness, education, and improved protocols for reporting vessel-cetacean incidents or developing a national ship strike database and associated web-based questionnaire, based closely on established data collection questionnaires (e.g., International Whaling Commission). This will ensure that the data collected in Malaysia is compatible with the current international ship strike database. This database could also incorporate records of sightings, stranding, and population, including genetic and photographic data.

e) A large-scale public education campaign targeting fishermen and coastal communities should be launched to inform them of environmental and biodiversity conservation needs. They should be warned to stop taking protected species (e.g., Dugongs and cetaceans) and stop illegal and destructive fishing practices (e.g., dynamite fishing and trawling in restricted waters). They need to be informed of the current status of fisheries and the marine environment surrounding them, encouraged to conduct responsible fisheries and conserve the environment, and to learn the reasons and benefits of doing so. Moreover, local communities must be educated about compliance with conservation regulations as an alternative to enforcement and encourage their involvement in species monitoring.

f) Promote the conservation of marine mammals and their habitats by establishing marine protected areas (MPAs). Although no MPA is specifically shown to reduce threats to marine mammals, several MPAs have been established, with the primary objective of conserving coral reefs and turtles and allowing some traditional fishing and recreational fishing activities. These MPAs, such as the Sultan Iskandar Marine Park (Johor), Talang-Satang National Park (Sarawak), Tunku Abdul Rahman Park, and Semporna Islands Park (Sabah), indirectly protect coastal marine mammal species and their habitats, such as dugongs and seagrass beds. Thus, establishing more marine protected areas (MPAs) with integrated coastal zone management (ICZM) approach, at least in areas where marine mammals or their habitats are in serious conflict with humans, must be considered seriously. However, MPAs should be established with as much involvement of the local people as possible and designed with features to maximize their social and economic benefits (Oakley et al., 2000; Reeves et al., 2003). In this way, those affected by the MPA are more likely to comply with the regulations. The Bay of Brunei, Matang (Perak), Cowie Bay, Sandakan Bay, Beluran, and Kinabatangan Estuaries, are suitable areas to be established as the first MPA for marine mammals (i.e., Irrawaddy and Indo-Pacific humpback dolphins and finless porpoise). Parts of the Rajang (at Tanjung Manis) and Saribas (at Beladin) Rivers that are Irrawaddy dolphin's hot spots should also be considered for protected area (PA) status.

g) Live marine mammals could represent a valuable resource; therefore, they could be exploited and their conservation promoted through eco-tourism. In addition to the proposed MPAs, a carefully-planned, small-scale dolphin-watching industry may help to stimulate further interest in conservation and increase awareness, with a financial benefit accruing preferably to the entire local community. Small cetaceans, such as the Irrawaddy and Indo-Pacific humpback dolphins, appear to be locally common in several localities mentioned above. This condition is conducive to reliable sightings but also means that dolphins may be susceptible to disturbance, mainly from increased boat traffic. Therefore, such non-consumptive use of cetaceans can only be encouraged if it is preceded by appropriate feasibility studies and evaluation of the areas' carrying capacity. Minimal disturbance to the population can be assured, and the development of such an eco-tourism industry does not promote the degradation of the overall

environment. Prospective tour operators must be trained to understand dolphin behavior and responsible dolphin-watching guidelines and codes of conduct. One way of compensating for disturbance is to use the dolphin-watching industry to help accomplish research and management objectives (Reeves et al., 2003).

h) The study area should implement rules and regulations on controlling boat speed. Limiting the number of high-speed vessels as there have been injuries and deaths of dolphins from propeller strikes (Ng and Leung, 2003). Control and regulations procedures are critical, but many need to be clarified, and most that have been implemented to protect the area from trawlers, boats, and other fishing activities were impromptu. So far, there has been no control of boat speed or traffic implemented in East Malaysia waters except in harbors for safety concerns (Jaaman, 2010).

1.7 DISCUSSION

i. Species and Distribution

Marine mammal species found in Peninsular Malaysia are the sei, Bryde's, Omura's, pygmy sperm, ginko-toothed beaked, killer, short-finned pilot, false killer, pygmy killer and melon-headed whales, Irrawaddy, Indo-Pacific humpback, rough-toothed, Risso's, Indo-Pacific bottlenose, pantropical spotted, spinner, long-beaked common and Fraser's dolphins, finless porpoise and Dugong (21 species).

Marine mammal species found in Sabah are the blue, fin, Bryde's, sperm, pygmy sperm, Cuvier's beaked, killer, short-finned pilot, false killer, pygmy killer, and melon-headed whales, Irrawaddy, Indo-Pacific humpback, rough-toothed, Indo-Pacific bottlenose, pantropical spotted, spinner and Fraser's dolphins, finless porpoise and Dugong (20 species).

Marine mammal species found in Sarawak are the Bryde's, common minke, humpback, sperm, pygmy sperm, killer, short-finned pilot, false killer, pygmy killer and melon-headed whales, Irrawaddy, Indo-Pacific humpback, rough-toothed, Risso's, Indo-Pacific bottlenose, pantropical spotted, spinner and Fraser's dolphins, finless porpoise and Dugong (20 species).

The Irrawaddy and Indo-Pacific humpback dolphins and finless porpoise are the most common cetaceans found in the inshore waters of Peninsular Malaysia, Sabah, and Sarawak, especially in the large estuaries and bays. The pantropical spotted, spinner, and Indo-Pacific bottlenose dolphins are common cetaceans recorded in the open waters of Malaysia. There are numerous records of Bryde's whales, primarily tropical/subtropical species, considered the most common baleen whale in Malaysian waters. Dugongs are found primarily in the southern part of Peninsular Malaysia, in the waters surrounding the State of Johor. In East Malaysia, records of dugongs are received from the Bay of Brunei, Kota Kinabalu, Kudat, Sandakan, Lahad Datu, and Semporna.

ii. Population Status

The status of all cetacean species in Peninsular and East Malaysia is currently unknown due to a lack of scientific research effort and projects that are newly established and, therefore, still in the stages of primary data collection. Nevertheless, several populations of Irrawaddy and Indo-Pacific humpback dolphins and finless porpoises have been estimated.

Minton et al. (2013) estimated population numbers in Kuching Bay. The Irrawaddy dolphins achieved this by using mark-recapture techniques on photo-identified individuals and line transect surveys conducted between April 2010 and September 2011. Mark recapture methods yielded the best estimate of the Irrawaddy dolphin population in Kuching Bay of 233 dolphins (CV = 22.5%, 95% CI 151-360). Line-transect methods yielded an estimate for this species of 149 individuals (CV=28%, 95% confidence interval 87-255). Indo-Pacific finless porpoises were estimated to be 135 (CV= 31.3%; 95% CI 87-255) based on line-transect/DISTANCE methods.

Teoh et al. (2013) estimated a population of Irrawaddy dolphins that occurs in Cowie Bay, southwest of Sabah. Boat-based photo-identification surveys were conducted over 12 months, from October 2009 to September 2010. Photographs were first sorted according to the quality and physical appearance of Irrawaddy dolphins' dorsal fins. They were then assigned a unique code. A total of 27 Irrawaddy dolphins were identified, and all were adults. The data from this survey was used to estimate the population size via the mark-recapture method. CAPTURE within Program MARK 6.1 estimated the population size of Irrawaddy dolphins in Cowie Bay to be small (N=31, 95%CI=28 – 34; CV=0.06).

Zulkifli Poh et al. (2016) estimated the abundance of Indo-Pacific humpback dolphins in Kuching Bay. A total of 101 individuals of all levels of distinctiveness and photo quality were assigned catalog ID numbers based on the LDF side, and 87 individuals were cataloged based on the RDF side. Of these, 77.2 and 67.8% were cataloged during the first year. Based on the mark-recapture analysis of marked individuals, the abundance estimates were 44 (CV = 15.3%, 95% CI = 36 to 65) for the LDF photos and 37 (CV = 14.0%, 95% CI = 31 to 54) for the RDF photos. Estimates of the proportion of marked individuals within the population were 0.575 (CV = 14.5%) for LDFs and 0.386 (CV = 26.3%) for RDFs. Abundance estimates corrected for the proportions were 77 (CV = 20.9%, 95% CI = 51 to 115) and 96 (CV = 26.3%, 95% CI = 58 to 159), respectively. Therefore, the best estimate of humpback dolphins in the Kuching Bay using inverse CV-squared weighted mean was 84 (CV = 16.4%, 95% CI = 61 to 116).

Mahmud et al. (2018) estimated the abundance of Irrawaddy dolphins in the Malaysian waters of the Bay of Brunei. A total of 36 individuals (adults) of Irrawaddy dolphins were identified using dorsal fin photo match software (DARWIN) by undertaking 297.91 h of boat-based dedicated surveys (April 2013 – October 2015). By using the mark-recapture open-population parameterization, the estimated population size (adult) was 33 (95% CI = 28–39) with an apparent survival rate of 0.98 (0.89–0.99, SE = 0.01). Also, the recapture rate was 0.27 (0.14–0.45, SE = 0.07), and the estimated individual entry rate from super-population was 0.15 (0.10–0.22, SE = 0.03). The estimated total population size was 41 (95% CI = 36–49), including calves. The observed mean group size was 6 (SE = 0.66, range 1–18).

Rodríguez-Vargas et al. (2019) reported vessel-based observations on Irrawaddy dolphins were conducted in Penang waters throughout 2013, and mark-recapture analysis of the photo-identification data was used to estimate population size. Thirty individuals were identified from 28 unique left and 26 unique right dorsal fins. Closed and open models were used to estimate the population size of 32 ± 3 (SE) and 43 ± 12 (SE) individuals, respectively.

Kuit et al. (2021) provided the first abundance estimates of Indo-Pacific humpback dolphins, Irrawaddy dolphins, and Indo-Pacific finless porpoises in the inshore waters of Matang, Peninsular Malaysia. Estimates of abundance from four sampling strata totaled 763 Irrawaddy dolphins (CV = 13%, 95% confidence interval (CI) [588, 990]) and 600 Indo-Pacific finless porpoises (CV = 27%, 95% CI [354, 1,016]). The annual abundance estimates of Indo-Pacific humpback dolphins ranged between 171 (95% CI [148, 208]) in 2014–2015 and 81 (95% CI [67, 98]) in 2015–2016, likely due to the presence of offshore

individuals that moved in and out of the study area. The estuarine strata were inhabited by 68 (95% CI [63, 73]) Indo-Pacific humpback dolphins in 2013–2014 to 87 (95% CI [78, 97]) dolphins in 2014–2015.

The dugong population status in Peninsular and East Malaysia remains to be discovered, as estimations on population abundance have yet to date.

iii. Habitat Status

In Peninsular Malaysia, areas of already high human population and intensive coastal development (such as the south coast of Johor, Klang, and Penang), direct impacts from sedimentation and pollution, untreated waste disposal, and other human activities have severely degraded important marine habitats (e.g., seagrass beds, coral reefs, and mangroves) that many marine organisms are directly or indirectly dependent upon (Jaaman et al. 2013; Jamal-Hisne et al., 2013; Hines et al., 2015).

Many coastal areas that are currently under-developed have been earmarked for large-scale development within designated 'development regions,' including the coastlines of Kelantan, Terengganu, Pahang, and the district of Mersing in Johor that come under the East Coast Economic Region (ECER), and the shoreline of the Johor Straits which will be developed under the Iskandar Development Region (IDR). Planned projects within the ECER that could potentially affect marine mammal habitats along the east coast include constructing petrochemical and port facilities and the construction of integrated tourism hubs on the reclaimed coastline and artificial islands. These development projects could severely affect the ecology of marine mammals through habitat degradation and destruction due to land reclamation, dredging, deforestation of mangrove forests, coastal erosion, pollution (water and noise), and reduction of prey (Jaaman et al. 2013; Jamal-Hisne et al., 2013; Hines et al., 2015).

Similarly, under the IDR plans, dugong and dolphin habitats in the Johor Straits are at high risk of disappearing due to intense coastal development of heavy industrial hubs (biofuel and petrochemical), residential areas, ports, and marinas, all of which will involve land reclamation, dredging, pollution (water and noise) and clearing of vast tracts of mangrove forests. Elsewhere in Peninsular Malaysia, marine mammal habitats are threatened by pollution from siltation and sedimentation due to oil palm plantations near the coast and riverbanks, pollution from areas of high human habitation (e.g., Penang, Klang Valley), and pollution from oil spills (Jaaman et al. 2013; Jamal-Hisne et al., 2013; Hines et al., 2015).

In the last decade, many riparian areas of bays and rivers in Sabah have been converted into agricultural or urban areas, which has caused the degradation of marine mammal habitats from effluent discharges, increased nutrient and sedimentation load, and pollution (Jaaman 2008; 2010). The rapid development of Sandakan, Tawau, Tanjung Manis, and Muara Tebas into important ports and industrialized towns might affect the natural habitat and behavior of the Irrawaddy dolphin populations in the areas (Jaaman 2010). In addition, a causeway that runs across the Santubong River, which ultimately cuts flow to the ocean, and a barrage in Pending that limits the flow of the Sarawak River to the sea (through Muara Tebas) is a problem to the natural migration routes of inshore

cetaceans in and out of the Kuching river systems (Jaaman et al. 2013; Jamal-Hisne et al., 2013; Hines et al., 2015).

The seagrass meadow in Lawas, Sarawak, is believed to be the largest seagrass habitat in Malaysia. Most Dugong and marine turtle sightings during aerial surveys conducted in East Malaysia are off Lawas, indicating that Lawas is a vital feeding and nursery ground for the two protected animals. A proposal has been submitted under the 10th Malaysia Plan (2011-2015) to gazette the entire inshore waters of Lawas as a Marine Protected Area (MPA) to protect the seagrass habitat. This remains a proposal, and the seagrass habitat is still unprotected from any anthropogenic influences. During aerial surveys of the inshore waters of Sabah (Sipitang and Menumbuk), Labuan and Brunei were found to be murky compared to Lawas, Sarawak (Bali et al., 2008; Jaaman and Bali, 2011). This may be due to the high human population and intensive coastal development activities, which are evident along the coastline of these three areas. Direct impacts from sedimentation and pollution (from Sipitang and Labuan industrial areas), untreated waste disposal, and other human activities may have severely degraded seagrass beds in these areas, and which dugongs (and sea turtles) are directly dependent upon.

Appendix photo, maps, etc.

All databases, references, tables, maps, etc., on marine mammals in Malaysia, are stored in [Google Drive/ECOLOGICAL CORRIDOR/FG3/].

REFERENCES

Bali, J., Jaaman, S. A., Tisen, O. B., Landong, W. S., Zaini, M. K., Chin, W. Y., Bakir, K. and Saimin, S. 2008. Distribution and Aerial Sighting Rate of Marine Wildlife in Sarawak Waters. *Paper presented in the 7th IOC-WESTPAC International Scientific Symposium 2008, MOSTI-UMS-UNESCO, Magellan Sutera Harbour, Kota Kinabalu, 21-25 May 2008*. 21pp.

Evans, P. G. H. and P. S. Hammond. 2004. Monitoring cetaceans in European waters. *Mammal Review*, **34(1)**: 131-156.

Hines, E., Ponnampalam, L.S., Jamal Hisne, F.I., Whitty, TS., Jackson-Ricketts, J., Kuit, S.H. & Acebes, J.M. 2015. *Report of the Third Southeast Asian Marine Mammal Symposium - SEAMAM III*. UNEP/CMS Secretariat, Bonn, Germany. 643 pp.

Ilham, R. (2019, July 17). Paus pembunuh muncul di perairan Terengganu. *Harian Metro Online*. https://www.hmetro.com.my/mutakhir/2019/07/476570/paus-pembunuh-muncul-di-perairan-terengganu.

Jaaman, S. A., Ahmad-Kamil, E. I., Bali, J., Ibrahim, K., Jamal-Hisne, F. I., Mohd-Noor, N., Pilcher, N. J., Ponnampalam, L. S., Rajamani, L. and Syed Abdul Kadir, S. A. 2013. *Dugong dugon*: Status Review on Habitats, Threats and Conservation Initiatives in Malaysia. *Working paper of the Second Signatory State Meeting (SS2) of the Dugong MoU and the International GEF Workshop of the Dugong and Seagrass Conservation Project, Best Western Premier F1 Hotel, Manila, Philippines, 19-22 February 2013*.

Jaaman, S. A., Azizul, N., Chew, W. G., Mat Sobri, M. F., Mat Yaacob, M. A, Muda, A. M., Muhamad, H. M. and W. N. A. Wan Hassan. 2021. MARINE FLORA AND FAUNA SURVEY AT LUCONIA SHOALS NATIONAL PARK (LSNP), OFFSHORE SARAWAK (PART I: MEGAFAUNA SURVEY). A technical report submitted to Sarawak Shell Berhad (SSB) (Unpublished).

Jaaman, S. A., Bali, J. and Ponnampalam, L. 2010. Summary of Current Knowledge on Marine Mammals and Their Conservation Efforts in Malaysia. Paper presented in the National Museum of Nature and Science International Symposium 2010: Diversity of Marine Mammals – Along the Asian Coasts, Tokyo, Japan, 26-28 August 2010.

Jaaman, S.A. 2010. *Marine Mammals in East Malaysia: Distribution and Interactions with Fisheries*. VDM Verlag Dr. Muller Aktiengeselischaft & Co. KG. ISBN: 978—3-6639-22208-1. pp. 284.

Jaaman, S.A. and Bali, J. 2011. *Marine Mammals in Borneo*. In Malaysia's Marine Biodiversity: Inventory and Current Status (Kamarruddin, I., Mohamed, C. A. R., Rozaimi, M. J., Kee Alfian, B. A. A., Fitra, A. Z. and Lee, J. N., eds.), Department of. Marine Park Malaysia, Putrajaya. 47-70pp.

Jamal-His, F. I., Ponnampalam, L. S., Jaaman, S. A., Rajamani, L., Rodriguez, L. H. and Syed Abdul Kadir, S. A. 2013. National Reviews of Status, Research, Catch, Bycatch, Conservation and Legislation on Marine Mammals in Malaysia. *Working paper of the Third Southeast Asian Marine Mammal Symposium (SEAMAM III), Fave Hotel, Langkawi, Malaysia, 4 – 10 March 2013.*

Jeremy, H. (2012, January 12). Cute animal picture of the day: pygmy killer whale saved after stranding, MONGABAY. https://news.mongabay.com/2012/01/cute-animal-picture-of-the-day-pygmy-killer-whale-saved-after-stranding.

Kuit, S.H., Ponnampalam, L.S., Hammond, P.S., Chong, V.C., Then, A.Y.-H. 2021. Abundance estimates of three cetacean species in the coastal waters of Matang, Perak, Peninsular Malaysia. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 1–13. https://doi.org/10.1002/aqc.3699

Mahmud, A.I., Jaaman, S.A., Muda, A.M., Muhamad, H.M., Zhang, X. & Scapini, F. (2018). Population estimation, distribution and habitat preferences of Irrawaddy dolphins *Orcaella brevirostris* in the Brunei Bay, Malaysian waters. Wildlife Biology. DOI:10.2981/wlb.00383.

Marsh, H., Penrose, H., Eros, C. and J. Hugues (Compilers). 2002. Dugong – Status Reports and Action Plans For Countries and Territories. UNEP Early Warning and Assessment Report Series. UNEP/DEWA/RS.02-1. 162pp.

Ministry of Science, Technology and Environment Malaysia (MOSTE). 1997. Malaysia: Country Study on Biological Diversity – Assessment of Biological Diversity in Malaysia. Ministry of Science, Technology and Environment Malaysia, Kuala Lumpur. 186 pp.

Musa, I. (2019, July 26). Paus pilot sirip pendek pula muncul [METROTV]. Metro Online. https://www.hmetro.com.my/mutakhir/2019/07/479642/paus-pilot-sirip-pendek-pula-muncul-metrotv.

Ng, S. L. and S. Leung. 2003. Behavioral response of Indo-Pacific humpback dolphin (*Sousa chinensis*) to vessel traffic. *Marine Environmental Research*, 56: 555-567.

Norhashim, N. A. and Jaaman, S. A. 2011. Boat effects on the behavior of Indo-Pacific Humpback (*Sousa chinensis*) and Irrawaddy (*Orcaella brevirostris*) dolphins in Cowie Bay, Sabah, Malaysia. *Sains Malaysiana*, 40(12):1383–1392.

Norina, L., Norsharina, A., Nurnadiah, A. H., Sarol, K., Nurliyana, M. T., FAHMI, A. M., ... & Tamimi, M. A. A. (2017). First report of decompression sickness (DCS) in a sei whale (*Balaenoptera borealis*) in Southern Peninsular Malaysia. *Malaysian Journal of Veterinary Research*, 8(1), 57-64.

Oakley, S., Pilcher, N and E. Wood. 2000. Borneo. In: *Seas at the Millennium: An Environmental Evaluation, Vol.2: The Indian Ocean to The Pacific*. C. R. C. Sheppard (Ed.). Elsevier Science Ltd. Pages 361-379.

Perrin, W. F., Dolar, M. L. L. and M. N. R. Alava (eds.). 1996. Report of the Workshop on the Biology and Conservation of Small Cetaceans and Dugongs of Southeast Asia. UNEP(W)/EAS WG.1/2. Bangkok: UNEP. 101 pp.

Perrin, W.F., Reeves, R.R., Dolar, M.L.L., Jefferson, T.A., Marsh H., Wang, J.Y., et al. (eds) 2005. Report on the second workshop on the biology and conservation of small Cetaceans and Dugongs of Southeast Asia. Convention on Migratory Species (CMS) Technical Series publication no. 9, UNEP/CMS Secretariat, Bonn, Germany

Ponnampalam, L. 2012. An updated checklist of marine mammals in Malaysia is an opportunistic observation of the distribution of cetaceans in the Malaysian South China, Sulu, and Sulawesi Seas. *The Raffles Bulletin of Zoology* 60(1): 221-231.

Reeves R. R, Smith B. D., Crespo, E. and G. Notarbartolo di Sciara (compilers). 2003. Dolphins, Whales, and Porpoises: 2000–2010 Conservation Action Plan for the World's Cetaceans. IUCN/SSC Cetacean Specialist Group. IUCN, Gland, Switzerland, and Cambridge, UK. xi + 139pp.

Rodríguez-Vargas, L. H., Rajamani, L., Dolar, L. and L. Porter. 2019. Population size, distribution, and daylight behavior of Irrawaddy dolphins (*Orcaella brevirostris*) in Penang Island, Malaysia. *Raffles Bulletin of Zoology*, 67: 671–683.

Salim, Z. (2019, July 18). Jaga-jaga...paus pembunuh berbahaya. *Harian Metro Online*. https://www.hmetro.com.my/mutakhir/2019/07/476854/jaga-jagapaus-pembunuh-berbahaya.

Teoh, S. W., Jaaman, S. A. and P. M. Palaniappan. 2013. A preliminary study of the population size of Irrawaddy Dolphins (*Orcaella brevirostris*) in Cowie Bay, Sabah, Malaysia. *Journal of Tropical Biology and Conservation*, 10: 23-26.

Zulkifli Poh, A. N., Peter, C., Ngeian, J., Tuen, A.A., and G. Minton. 2016. Abundance estimates of Indo-Pacific humpback dolphins (*Sousa chinensis*) in Kuching Bay, East Malaysia. *Aquatic Mammals*, 42(4): 462-465.

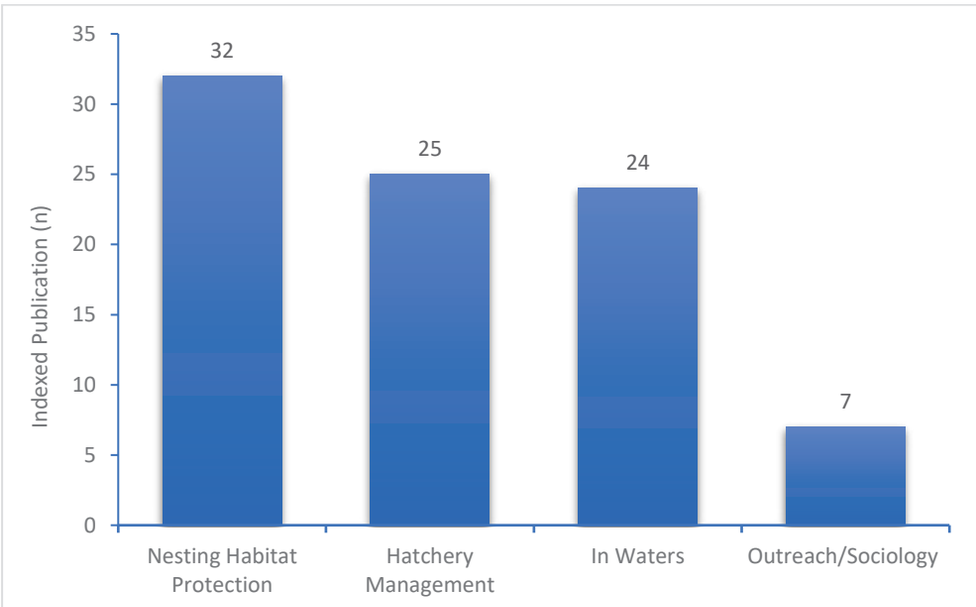
2.0 SEA TURTLES

2.0 INTRODUCTION

Sea turtles are iconic in Malaysia, with a conservation history in the 1950s. Over the last century, a dramatic decline in sea turtle population has occurred for all species, particularly the leatherbacks, olive-ridleys, green turtles, and hawksbills in most areas, and remains in a small fraction (de Veyra, 1994; Limpus, 1994; Sloan et al., 1994). The declining sea turtle population resulted in listing the leatherback turtle and Olive Ridley as Vulnerable species, the green turtle as Endangered, and the hawksbill turtle as Critically Endangered on the IUCN Red List. The decline of the sea turtle population mainly occurs in developing countries where the countries often contribute to sea turtle declines. The Convention on International Trade in Endangered Species of Flora and Fauna (CITES) has listed in Appendix 1 that all sea turtles were prohibited from international trade or to signatory countries (Pritchard, 1996).

Sea turtles constitute a threatened group of fauna; thus, to know caveats in their knowledge, it is crucial to lead research efforts. Knowledge of the abundance of sea turtles on nesting beaches around Malaysia rookeries was essential for sea turtle conservation management. Accurate data on the population distribution and abundance were vital for significantly improving animal species' effective management improving animal species' effective management. The Department of Fisheries (DOF) has monitored the sea turtle population abundance for decades with the support of NGOs and community-based conservation projects. Hence, many scientific reports have been produced at various levels considering the nesting activity, egg production, incubation success, habitat utilization, genetic population, and many more. According to years of publication, this section reviewed some journal and written sources of sea turtle abundance in Malaysia.

The present report analyzes the scientific literature published on sea turtles in Malaysia utilizing a bibliographic analysis. We examined the temporal and geographical variation in the publications and the extent of the study of different research topics. 89 indexed (SCOPUS/WOS) papers were found and categorized according to the field of study (Figure 2.1). The number of publications grew through the analyzed period (1956-2022), and the number of authors. The State with the highest number of publications was Terengganu. Research areas of more significant investigation effort were "Nesting Habitat & Protection," followed by "Hatchery Management," and "In Waters Biology." This analysis contributes to understanding trends and caveats in sea turtle knowledge that could help guide future research in areas of particular concern.



2.2 OBJECTIVES

i. Record, document, and analyze marine mammal information/data from previous studies in Malaysian waters to be translated into a comprehensive inventory report, including the production of geospatial maps of the distribution of sea turtles.

ii. To analyze the temporal and geographical variation in the publications and the extent of study of different research topics by species.

2.3 MATERIALS AND METHODS

i. Desktop Study – Collecting data/information on sea turtle inventory based on previous studies and published and unpublished literature. The list of published scientific papers from the Web of Science and SCOPUS has been retrieved by using these combinations of keywords; "turtles," "sea turtles," and "penyu," and redefined according to the origin of authors and study locations in Malaysia.

ii. Scientometric: We analyze the scientific literature on marine turtles in Malaysia using a bibliographic analysis. We examined the temporal and geographical variation in the publications and the extent of the study of different research topics by species.

iii. Data Analysis and Mapping - Spatial analysis to identify information gaps.

iv. Workshops and Publications – Focus group discussions (FGD), seminars on progress, and final reports have been conducted.

2.4 RESULTS

2.4.1 Nesting Habitat Protection

In 1952, John Hendrickson began some of the world's first efforts to monitor green turtles using copper tags drilled onto the rear edge of the carapace of the Talang Talang and Satang Islands; the State of Sarawak in Malaysia has played a significant role in the history of turtle tracking (Hendrickson, 1958). Later, Hendrickson switched to using

'Hasco' Monel cow ear tags (Hendrickson, 1958), which became the most used flipper tagging technique today. The Turtle Islands Park in Sabah, the Sarawak Turtle Islands, the Redang Turtle Islands, and other essential rookeries in Malaysia also employ these same flipper tagging procedures today.

Malaysian beaches support nesting green turtles *Chelonia mydas,* which nest in large numbers (more than 1,000s), and the hawksbill *Eretmochelys imbricata* with more average nesting numbers (low 100s; deSilva, 1982; Siow & Moll, 1982; Chan, 1991). Malaysia used to host one of Southeast Asia's largest leatherback *Dermochelys coriacea* populations, with upwards of 10,000 nests deposited in the 1950s at Rantau Abang, Terengganu (Chan & Liew, 1996). These numbers declined to some 10 per year by 2000 (Chan & Liew, 1996), and the population went functionally extinct in Terengganu in 2010 (DOFM, unpublished data). Solitary nesting olive ridley turtles *Lepidochelys olivacea* now nest extremely infrequently in Malaysia (Chan, 1991, 2006), with occasional nesting events occurring on Penang Island, the Turtle Islands Park in Sabah, and the Talang-Satang National Park in Sarawak.

Green turtles nest predominantly at the Turtle Islands Park and on Sipadan Island of Sabah; at the Talang-Satang National Park in Sarawak; and numerous beaches in peninsular Malaysia, including Ma'Daerah, Redang Island, and Setiu in Terengganu, and Segari in Perak. Hawksbills nest predominantly at Gulisaan Island (Turtle Islands Park) in Sabah, Upeh Island, and several mainland sites in Malacca. Chagar Hutang also hosts several hawksbills that frequently breed every 2-3 years (Chan & Liew, 1999; Chan, 2013; see Figure 1 for locations). Hawksbill nesting elsewhere in the country is only occasional and widely distributed.

Terengganu, Pahang, Johor, Sabah, and Sarawak are the primary nesting beaches for sea turtles in Malaysia facing the South China Sea (Figure 2.2). Historically, hatcheries in Malaysia were established in 1949 in Sarawak, in 1961 in Kelantan and Terengganu, and 1966 in Sabah following the alarming sea turtle population decline. Meanwhile, to have better management in protecting the sea turtle eggs, more than 15 artificial hatcheries are currently operating near most of the nesting beaches in Malaysia to stop human poachers. Over the years, sea turtle hatcheries and sanctuaries helped slowly restore the sea turtle population.

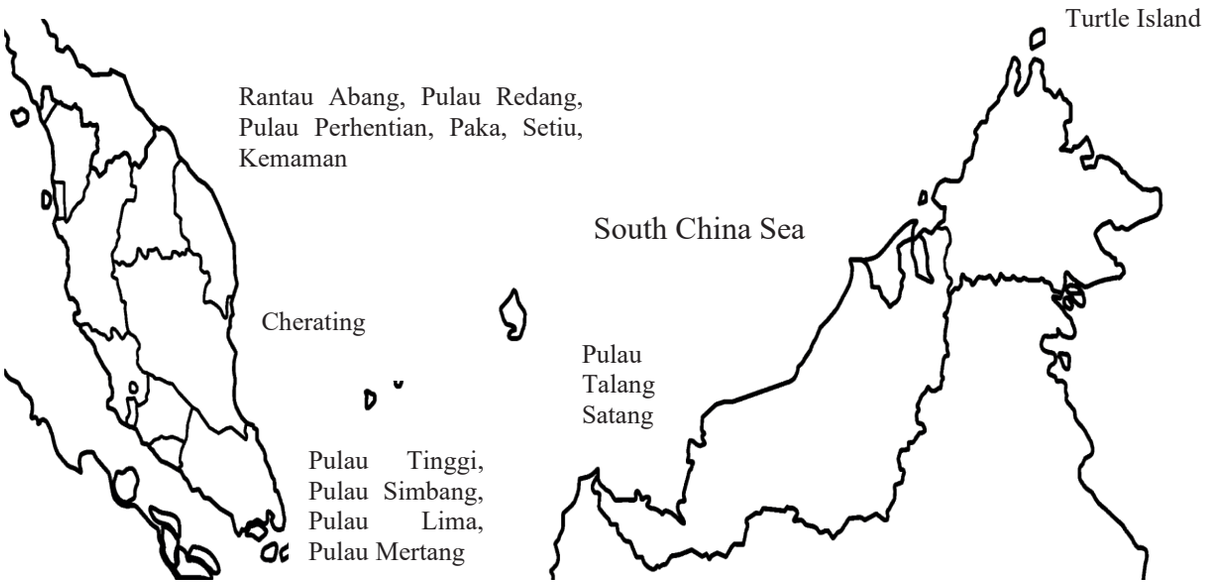
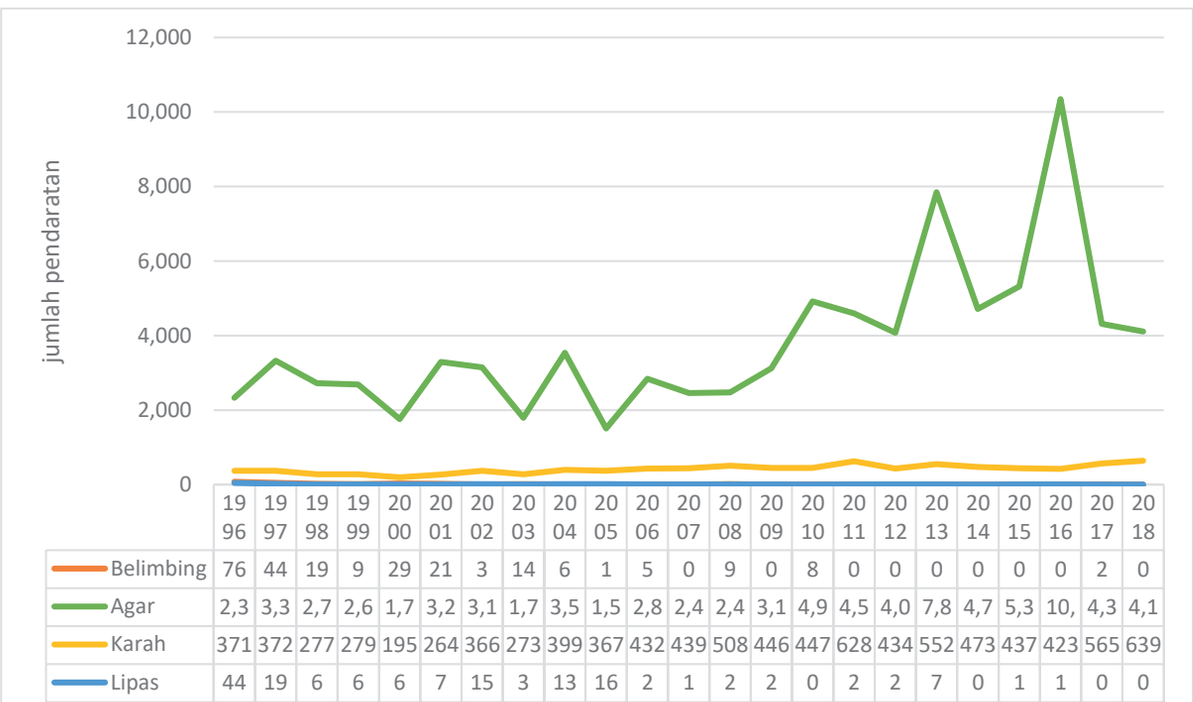


Figure 2.2: Five major nesting beaches of sea turtles in Terengganu, Pahang, Johor, Sabah, and Sarawak facing the South China Sea.

A report from SEAFDEC by Talib et al. in 2003 showed a decreasing number of sea turtle hatchlings had been released to the sea in recent years due to decreasing numbers of females landing on the nesting beaches. About 50 years ago, 262 million green sea turtle hatchlings were released into the sea. Between 1949 and 1960, more than 127 million hatchlings were released, 128,676,865 hatchlings between 1961 and 1995, and between 1996 and 2002, 5,576,706 hatchlings were released.

The critical nesting population of green turtles occurs in both Sabah and Sarawak Turtle Islands. According to Chan (2006), the green turtle population at Sabah Turtle Islands was at the stage of recovery where there was an increment threefold, with current densities of over 8,000 nests per year recorded in early 1980 (Figure 2.3). The recovery phase reflects the State Government's seriousness in conservation efforts over the last 30 years in protecting the nesting beaches and eggs on the islands. Since the Sabah's conservation program was launched, it is estimated that about 17 million sea turtle hatchlings have been released into the sea (Santos, 2017). Moreover, the Sabah State government allocated RM 1 million for turtle conservation under the State Budget 2018 last year (Borneo Post Online, 2017).



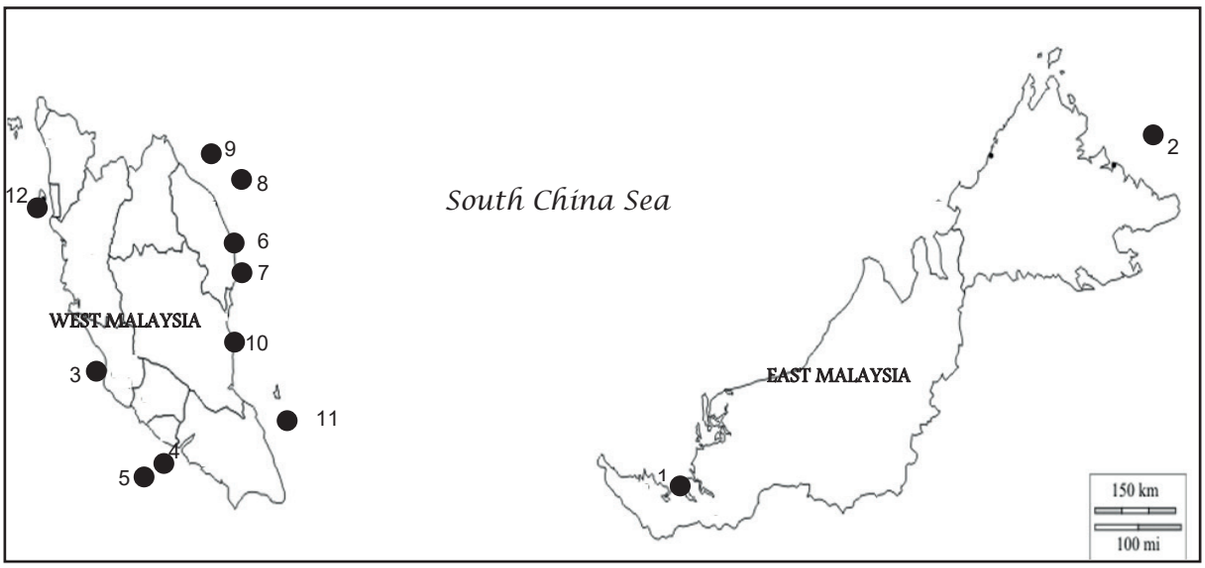
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Belimbing	76	44	19	9	29	21	3	14	6	1	5	0	9	0	8	0	0	0	0	0	0	2	0
Agar	2,3	3,3	2,7	2,6	1,7	3,2	3,1	1,7	3,5	1,5	2,8	2,4	2,4	3,1	4,9	4,5	4,0	7,8	4,7	5,3	10,	4,3	4,1
Karah	371	372	277	279	195	264	366	273	399	367	432	439	508	446	447	628	434	552	473	437	423	565	639
Lipas	44	19	6	6	6	7	15	3	13	16	2	1	2	2	0	2	2	7	0	1	1	0	0

Figure 2.3: Nesting trend of sea turtles according to species in Peninsular Malaysia from 1996-2018. (Adapted from Ruslan et al, unpublished report).

In contrast, the population of green turtles in Sarawak Turtle Islands (Talang Talang Besar, Talang Talang Kecil, and Satang Besar) was at equilibrium over the last 30 years with two to three thousand nests per year (Chan, 2006). Since the 1950s, the number of green turtles in Sarawak has declined by over 80% (Kaur et al., 2009). However, the protection of Turtle Islands in Sarawak has assisted in the growth of the green, and the government has provided the hawksbill turtle population in that area with annual grants since 1980. According to Bali (2010), about 2.86 million sea turtle hatchlings have been released from the Sarawak Turtle Islands in the past 40 years. However, no published data on hatchling production from Pahang and Johor is available.

2.4.2 Hatchery Management

The turtle sanctuary sites are designated as reserved and protected areas, and no humans are allowed at the sites or on the beaches at all times or only during set times (Mortimer, 1999). This ensures that the nesting sea turtles are not disturbed on the beaches. The turtle sanctuaries are usually facilitated with fenced hatcheries near the coast to incubate egg clutches (Hamann *et al.*, 2000a). This is to stop human poachers from stealing eggs for consumption and from natural predators like birds, crabs, and monitor lizards (Stancyk, 1982). In Peninsular Malaysia, the sea turtle sanctuaries are managed mainly by the Department of Fisheries (Chan, 2004). However, in Sarawak, they are administered by the Sarawak Forestry, while in Sabah, the turtle sanctuaries and marine parks are run by the Sabah Parks administration. Figure 2.4 shows turtle sanctuaries established in Malaysia since the 1980s.



No. Marked	State	Name of Sanctuary and Location	Year established
1	Sarawak	Talang-Satang National Park	1999
2	Sabah	Turtle Island Park, Sandakan	1984
3	Perak	Turtle Management Center Segari	1990
4	Melaka	Turtle Management Center Padang Kemunting	1990
5	Melaka	Turtle Hatchery Centre Pulau Upeh	2006
6	Terengganu	Rantau Abang Turtle Sanctuary	1988
7	Terengganu	Ma' Daerah Turtle Sanctuary	2003
8	Terengganu	Nesting beaches on Redang Island (e.g., Chagar Hutang, Mak Kepit, Mak Simpan, and Pulau Pinang)	2005
9	Terengganu	Nesting beaches on Perhentian Island (e.g. Tiga Ruang)	2005
10	Pahang	Cherating Turtle Sanctuary and Information Center	1997
11	Pahang	Tengku Arif Temenggung Sanctuary, Tioman Island	2009
12	Penang	Turtle Hatchery Center Pantai Kerachut	2003

Figure 2.4: Turtle sanctuaries and hatcheries that have been established in Malaysia.

a) *In-situ* Eggs Incubation

The *in-situ* egg incubation method does not involve the relocation of the egg clutches. The natural nest that the nesting females selected is believed to produce an unbiased male-to-female hatchling ratio in their population (Eckert *et al.*, 1999). Hence, UMT initiated the *in-situ* program at Chagar Hutang in Redang Island, Terengganu. In addition, this location is considered safe from poaching as it is located in a very isolated area. Yet, beach patrols have been conducted nightly by project staff and assisted by volunteers. The only threat to these nests is the natural predators (i.e., monitor lizards, red ants, and ghost crabs).

Each nest is marked with a 1.5 m wooden stake labelled by sanctuary management with the nest number and date of the clutch being laid (Chan, 2010). Details of the nesting mother turtle are noted on a datasheet. Nests will be relocated to the protected area if and only if they are attacked by predators and below the highest tide level. Nests are usually checked after 45 days of incubation (Morita *et al.*, 2005). If these nests remain unhatched, they will be rechecked for three days. All hatched nests were excavated to determine hatching success by counting the empty egg shell during nest excavation (Chan, 2010). Hatchlings that emerge at night crawl unassisted toward the water line (Chan and Liew, 1995a).

b) *Ex-situ* Eggs Incubation

Sea turtle eggs are best left in their natural nest, which usually produces the highest hatching success (Boulon, 1999). However, in certain circumstances, the nests must be relocated to a safer location so that the eggs are not exposed to dangers such as sea water inundation and predation by humans or other animals (Pritchard *et al.*, 1983). Chan *et al.* (1985) stated that hatchery operation is essential in sea turtle conservation if an *in-situ* practice is not applicable. The e*x-situ* hatchery incubation is considered the last option if nests cannot be protected (Mortimer, 1999). Hitchins *et al.* (2004) listed that the factors that decrease hatching success include egg infertility, egg mortality by dehydration or predation, nest destruction by tides, extreme weather conditions, and human poaching. The hatchery is secured and guarded with surrounding fences. Beach hatcheries and styrofoam boxes are two different methods to incubate egg clutches after relocation (*ex-situ*).

However, relocation practices sometimes have adverse effects such as embryo mortality (Eckert and Eckert, 1990; Rees *et al.*, 2002) and strongly female-biased sex ratio of hatchlings as produced in Malaysia (Chan and Liew, 1995b; Tiwol and Cabanban, 2000), Florida (Mrosovsky and Provancha, 1991), Mediterranean (Godley *et al.,* 2001) and Costa Rica (Brinckley *et al.*, 1998). On average, the hatching success for all hatcheries in Malaysia is always more than 65% (Ahmad *et al.* 2004), and they are still working hard to achieve a hatching success of more than 80%.

The styrofoam box incubation technique uses a container with extra air-holes punched in the sides (Figure 2.8) (Wood and Wood, 2009). A few centimetres of sand are spread at the bottom; then, the eggs are placed. Eggs will then be covered by sand. These boxes are kept on shelves in a shed on the beach or inside a room with good ventilation and kept undisturbed until the eggs have hatched (Wood and Wood, 2009).

Styrofoam boxes are washable, stackable, not too expensive, and, most importantly, yield reasonable hatching success rates to achieve a superb rate of around 95% (Woody, 1981). This high percentage of emergence success is related to the fact that such clutches are not subjected to the potentially damaging effects of natural environmental factors such as weather (e.g., heavy rain or dry season), presence of predators (e.g., mainly red ants and ghost crab), beach erosion, and sea water inundation (Wood and Wood, 2009).

On the other hand, there are some disadvantages to using the styrofoam box incubation method. A masculinizing bias was found in the sex ratio of hatchling leatherbacks (Dutton *et al.*, 1985) and green turtles (Mrosovsky,1982) from eggs incubated artificially in styrofoam boxes in Suriname. Mortimer (1999) suggested that in some cases, sand in a styrofoam box can be dried up due to the warming in the sun or with artificial heat sources; careful application of fresh water spray to the sand surface is needed to keep conditions humid (Mortimer, 1999).

2.4.3 In water movements

Despite decades of flipper tagging involving thousands of sea turtles, little has been learned about long-distance migrations and connections between breeding and foraging regions. Hence, satellite monitoring has been utilized to identify relationships between nesting and foraging sites to assist better management, and conservation organizations have seen a marked increase in expenditure in recent years. Malaysia has made somewhat reasonable efforts to use satellite transmitters since 1991.

Pilcher et al. (2019) have summarised the 15 satellite tracking projects conducted by various government agencies and Non-Profit Organizations (NGOs) in Malaysia that took place over 23 years, from 1993 to 2016 (Table 2.1). Most of these projects were carried out in collaboration with the Department of Fisheries as the primary stakeholder and occasionally with universities and outside agencies, as stated in the table.

Table 2.1. Data of the 15 deployment projects from 1993 until 2016 in Malaysia (Adapted from Pilcher et al. 2019).

Year Started	Location	State	Species	Number	Life Stage	Capture Method	PTT Type	Partners	Citation
1993	Chagar Hutang	Terengganu	Green	4	Adult	Post-nesting	Telonics ST-3	SEATRU; DOFM	Liew *et al.*, 1995; Papi *et al.*, 1995
1998	Turtle Islands Park	Sabah	Green	4	Adult	Post-nesting	Telonics ST-14	Sabah Parks; OneOcean	Sabah Parks, unpubl. data
1999	Talang-Satang NP	Sarawak	Green	9	Adult	Post-nesting	Telonics ST-14	Sarawak Forestry Corporation; SEATRU	Bali *et al.*, 2002
1999	Talang-Satang NP	Sarawak	Hawksbill	1	Adult	Post-nesting	Telonics ST-14	Sarawak Forestry Corporation; SEATRU	Bali *et al.*, 2002
2000	Turtle Islands Park	Sabah	Hawksbill	3	Adult	Post-nesting	Telonics ST-14	Sabah Parks; US National Marine Fisheries Service	NMFS & Sabah Parks, unpubl. data
2001	Chagar Hutang	Terengganu	Hawksbill	1	Adult	Post-nesting	KiwiSat 101	SEATRU; DOFM	SEATRU, unpubl. data
2005	Ma'Daerah	Terengganu	Green	4	Adult	Post-nesting	KiwiSat 101	Griffith University; DOFM	van de Merwe *et al.*, 2009
2007	Mantanani	Sabah	Green	5	Juvenile	Rodeo	Kiwisat 101	MRF	MRF, unpubl. data
2008	Upeh Island; Terendak Camp	Malacca	Green	15	Adult	Post-nesting	KiwiSat 101	WWF Malaysia; DOFM	Lau *et al.*, 2009
2008	Tioman	Pahang	Green	1	Adult	Post-nesting	Kiwisat 101	DOFM; Japanese Trust Fund IV Program	DOFM, unpubl. data

2008	Ma'Daerah; Setiu; Chagar Hutang	Terengganu	Green	24	Adult	Post-nesting	KiwiSat 101	WWF Malaysia; DOFM; Terengganu State Department of Fisheries	Lau *et al.*, 2009
2011	Chagar Hutang	Terengganu	Hawksbill	2	Juvenile	Head-started	Telonics TGM4325	SEATRU; KLCC Aquaria; Body Shop Foundation	Liew *et al.*, 2012
2013	Segari	Perak	Green	1	Adult	Post-nesting	Kiwisat 101	DOFM; Malakoff Corporation	DOFM, unpubl. data
2015	Kerachut	Penang	Green	1	Juvenile	Head-started	Kiwisat 101	DOFM; Malakoff Corporation	DOFM, unpubl. data
2015	Turtle Islands	Sabah	Green	27	Adult	Post-nesting	SPOT-293A	MRF; Sabah Parks	MRF, unpubl. data

Overall, only four states had shown significant numbers of satellite deployments, and most of the tracking had concentrated in the South China Sea (release sites from Terengganu, Sarawak, Sabah, and Pahang), Malacca Straits (release sites from Malacca, Perak, and Penang) and Sulu Sea (released site from Sabah).

Table 2.2: Comparison of released sites according to states

No.	State	Total Deployment
1	Sabah	39
2	Terengganu	35
3	Malacca	15
4	Sarawak	10
5	Perak	1
6	Penang	1
7	Pahang	1

2.4.4 Conservation History

This section summarised the conservation history based on our findings, emphasizing Peninsular Malaysia.

- **1951 – Introduction of The Turtle Enactment in Terengganu**
    - Focusing on the conservation of leatherback turtles

- **1961 – Nesting Status in Terengganu; Leatherback Turtles by E. H. Chan**
    - The eggs deposited on beaches were collected for commercial purposes
    - The hatchery program initiated this year has not been as effective as it could have been.

- **1963 – Introduction of the Fisheries Act 1963**

- **1984 – Sea Turtle Research Unit (SEATRU) establishment** to enhance scientific works

- **1987 – The Amendment of Terengganu State Turtle Enactment**

Provides for establishing turtle sanctuaries, protecting nesting turtles from human disturbances, and increasing penalties for violation of rules.

- **1987, December – Workshop on Sea Turtle Conservation and Management in Malaysia**

Outcome: Malaysia's sea turtle population is in a critical state of decline, specifically the Leatherback turtle population n Terengganu. It was stated to be declined to approximately 100 females at the mentioned workshop.

Objectives:

1. To develop a proposed legal framework
2. To draft an outline management plan for Rantau Abang Turtle Sanctuary
3. To prepare an outline of a national strategy for sea turtle conservation in Malaysia

The proposed research in the workshop:
Stimulating and conducting basic biological and applied research and sustaining good working relationships between researchers in governmental departments and universities

A) Hatchery Management
   a. Methods of collecting and translocating the sea turtle eggs (More research is heavily recommended to determine the best approach).
      i. The delivery period by egg collectors to turtle sanctuary is suggested within three (3) hours of egg laying to minimize damage to the embryo development and cause dehydration and movement/shock.

   b. Hatchery sites' usage frequency
      i. Suggested for hatchlings should be released at nighttime (no specific time mentioned during the night period).
      ii. A sanctuary to have three (3) hatchery sites consisting of Public Use Areas and Strict Reserve Areas.
      iii. Each site is used NOT more than once every three (3) years.
      iv. Incubation of nests should be within about one (1) meter apart.

   c. Usage of red lights during patrolling nesting sea turtles

B) Restricted Fishing Zone
   a. Types of nets used by the fishing vessels.
   b. The restricted fishing zone is extended if the research indicates more extensive inter-nesting areas.

C) National Survey by the Department of Fisheries to identify all turtle nesting areas in Peninsular Malaysia, Sabah, and Sarawak.
   a. Habitat Protection
      i. Foraging, inter-nesting, and nesting grounds.

D) Management of adults and sub-adult
   a. The usage of Trawling Efficiency Device (TED) by fishing vessels.
   b. Teach the fishing community to resuscitate drowned turtles caught in their fishing nets.

E) Control of Exploitation
   a. Surveys and suggestions for law amendments and enforcement.

F) Education and Interpretation
   a. Performing and collaborating awareness to local and school communities.

G) Legislation
   a. National: Different in each State in Malaysia
   b. International: To comply with the standard of IUCN/CITES

H) Funding; Trust Fund
   a. By Working Group consisting of UNEP Terengganu, WWF, DOFM (Chair and Secretary – autonomously selected as the leader): Draft and finalize the Term of Reference to study the Modus Operandi of the various NGOs and make appropriate recommendations.
   b. Launching Grant: Initiated by the Terengganu State Government and contributed by other states and the federal government.

I) Population Assessments
   a. Nesting sea turtles
      i. National surveys
      ii. Tagging for long-term monitoring
      iii. Locating inter-nesting habitats such as feeding grounds and migration routes

   b. Hatchlings, juveniles, and sub-adults
      i. Locating habitats

   c. Determining the extent of turtle mortalities at sea and the Cause of Death

   d. Determining the best methodologies to maximize hatchlings' emergence from nests and release of healthy hatchlings to the sea

   e. Response of nesting turtles to light (varying wavelengths and intensity)

   f. Microclimate changes in nesting beaches
      i. Temperature profiles: The effects on sexual differentiation
      ii. Shoreline characteristics
      iii. Natural and anthropogenic pollution, such as erosion, etc.

- **2005 – The First Regional Technical Consultation (RTC) on Finalization of the Implementation Plan on Research for Stock Enhancement of Sea Turtles**

A) Japanese Trust Fund IV; Research and Development of Stock Enhancement for Species Under International Concern Component II: Research for Stock Enhancement of Sea Turtles – collaborations of SEAFDEC member countries
    a. DNA study
    b. Tagging study
    c. Feasibility study on head-starting technique

- **2005 – Department of Fisheries Malaysia**
  A) Turtles tagged in Pantai Kerteh, Terengganu migrated to Sabah, Philippines, Vietnam, Java (Indonesia), and Singapore.

- **2006 – Regional Projects: Research for Stock Enhancement of Sea Turtles**
  A) Turtle Stock Identification

  B) Multiple Paternities Detection
    a. MFRDMD-SEAFDEC developed an SOP for the collection of tissue samples for DNA studies.
    b. The DNA study was determined through microsatellite markers.

  C) Tagging and Satellite Telemetry
    a. Tagging using Inconel tags was conducted in Malaysia, Thailand, Myanmar, Vietnam, Cambodia, the Philippines, Brunei Darussalam, and Indonesia.
    b. One each hawksbill and green were attached with PTT and released at Pulau Uteh, Melaka, and Sangalaki Island, Kalimantan, Indonesia, respectively; the hawksbill moved to the southern part of Bintan Island in Indonesia, while the green moved to Tambisan Island in Sabah after three weeks.

  D) Head-starting and Cloning
    a. A symposium on the cloning of sea turtles organized by MFRDMD-SEAFDEC and the DOFM was held by Malaysian scientists and researchers majoring in genetics, molecular biology, cytogenetics, biology, and physiology.
    b. Objectives:
      i. To formulate appropriate techniques for implementing research on advanced reproductive biotechnology.
      ii. To identify challenges in implementing research programs and follow-up actions.
      iii. To identify Malaysian scientists for the implementation of research on advanced reproductive biotechnology.
      iv. To formulate the master plan for cloning sea turtles.

NOTE:
Head-starting as a conservation measure was HEAVILY DISCOURAGED in December 1987 – Workshop on Sea Turtle Conservation and Management in Malaysia as its effectiveness and severe doubts about its conservation value have not been proven.

2.5 GAP ANALYSIS

This section has been constructed by analyzing the published National Plan of Action (NPOA) and comparing it with the available scientific works that responded to the suggestions written in the document.

2.5.1 Nesting Habitat Protection

1. Beach dynamic: To identify temporal changes in beach morphology and to determine beach stability by studying beach development of nesting and potential nesting areas.
2. Turtle tagging: To estimate the nesting population in Malaysia and determine possible fluctuation trends according to climate (effects of El Nino and La Nina), which enables conservationists to forecast nesting trends and their reasons. (Big challenges using Inconel tags: Insufficient Inconel tags supplied to conservation groups for turtle projects in Malaysia, lack of well-trained officers in tagging procedures, and inconsistent tagging activity and monitoring by the authority)
3. Cloud database: To store mass data on the cloud consisting of conservation projects in Malaysia and activation of the database to monitor and check nesting, tagging, and stranded information by conservation groups and the public.
4. Light pollution: By using satellite images to measure light emission at nesting and potential nesting grounds
5. Nesting beach suitability: Identify the status of beaches such as gazette, sanctuary, or open and search for potential nesting beach potential by using the GIS application
6. Nesting density (per square meter): In studying the effects of nesting density on the quality of nesting and hatching success at the nesting beach
7. Tarball distribution: Dispersal tar balls from known or unknown spillers and response protocols on oiled wildlife by studying the effects on nature.
8. Marine debris: To maintain beach quality in avoiding nest failure. Study on spatial and temporal effects involving post-monsoon towards nesting and potential nesting beach.

2.5.2 Hatchery Management

1. Hatching success: In determining the hatching trends (consistent/downtrend) according to nesting beaches and the effects of predation caused on the trends. To maintain a good quality of hatchlings, all conservation groups must comply with 75% of hatching success as suggested by NPOA.
2. Primary Sex ratio: To determine the threshold temperature of the nest as it directly impacts the hatchlings' sex ratio and the effects of shaded or non-shaded nests towards the percentage of sex ratio within a clutch of hatchlings. It can also do a paternity study of a grip to determine the variation of genetic stock.
3. Return of Investment: To sustain a conservation-business model organized by NGOs/resorts and community-based conservation. Enhance public awareness through hatchery visits and other conservation activities by including all community (update list of the community involved)

4. Volunteer tourism: Determining motivation and willingness to pay to participate in conservation projects.
5. SOP evaluation: To study the effects of human interactions on the quality of hatchlings produced.

2.5.3 In Water Movement

1. Post-nesting migration route: In determining potential migration routes of sea turtles by using satellite tracking able to enhance safety and security that may cause harmful events such as boat strikes and mortality of the sea turtles caused by commercial boats industrial ships.
2. Inter-nesting movement: To map sea turtles' distribution during nesting season and enhance security for the sea turtles during their stay at the nesting grounds.
3. Bycatch study: Able to determine the route and diet of sea turtles and the ability to release them safely without any harmful incident.
4. Oiled wildlife response: To determine proper protocols in handling oil spills in the ocean and on the beach toward possible wildlife in the affected areas.
5. Turtle tourism: To determine the effects of human interactions (snorkeling/swimming) on sea turtles' health while enhancing eco-tourism of the State's economic values.
6. Male population: In estimating the male stock of sea turtles in the waters by using aerial (drone) surveys at the routes of sea turtles.
7. Sea turtle health: Establish a Summarized Health Index of wild and captive sea turtles to monitor their health and preparedness for any possible infectious (FP virus) outbreak and response to rehabilitation and rescue.
8. Stranded turtles: To seek the cause of death of stranded sea turtles and report the reasons to help decision-making to respond. Study on death analysis of location and frequency at site able to assist in seeking clarification of the environment's health and human activities.
9. Foraging ground: Barnacle study and stable isotope analysis can be proxies in mapping seagrass distribution.
10. Demographic of Genetic stock: Able to estimate population dynamic at foraging grounds and Malaysia waters, such as numbers of males vs. females and juveniles vs. adults and differences of species identified.
11. Hatchling's dispersal: Able to study sea turtles' lost years by identifying early and potential feeding areas and their relationship with local productivity.
12. Predation rate: hatchlings' release activity conducted by conservation groups is released at the exact location and time, which will highly invite predators and must be monitored regularly.

2.6 DISCUSSION

Sea turtles are long-lived reptiles that inhabit terrestrial, oceanic, neritic, and estuarine habitats as they progress from one life-history stage to another. Complex life cycles and long-distance migrations in the marine environment result in many unobservable states throughout the life history of sea turtles; thus, monitoring programs focus on the relatively accessible adult nesting females. Nesting beach studies are, therefore, the cornerstone of sea turtle population monitoring and assessment, as the nesting beach habitat is critical for the oviparity mode of reproduction and the species' recovery (Ehrhart, Redfoot, Bagley, & Mansfield, 2014).

Female sea turtle begins to nest when they have reached their maturity age which they mates every 2-3 years (Wibbels, Owens, Limpus, Reed, & Amoss, 1990; Conant et al., 2009; and Hays, Fossette, Katselidis, Schofield, & Gravenor, 2010). Female sea turtles do not breed every year (Sims, Bjorkland, Mason, & Crowder, 2008; van Houtan & Halley, 2011; and Thorson, Punt, & Nel, 2012) because energetics costs are high (Rivalan et al., 2005; and Cubaynes, Doherty, Schreiber, & Gimenez, 2011). As oviposition is an energy-demanding process, they often skip reproductive years if they do not have sufficient fat reserves, instead remaining in foraging areas to continue to feed and accumulate the energy required (see Santos, Freire, Bellini, & Corso, 2010).

The female sea turtle will return to nest in the same geographic region where they hatched-a behavioural pattern known as natal homing. In principle, sea turtles might recognize their natal beach or part using information about the target area that has either been learned or inherited. Both female and male sea turtles migrate asynchronously from foraging to breeding areas several weeks to months before the nesting season (Limpus, 1985). Female sea turtles can store sperm and mate with more than one male in a breeding season (Pearse & Avise, 2001; Moore & Ball, 2002; and Sakaoka, Sakai, Yoshii, Okamoto, & Nagasawa, 2013) and may lay more than one clutch in a season with intervals of approximately two weeks (Dodd, 1988; and Margaritoulis et al., 2003).

Even though female sea turtle has landed at the nesting beach to lay eggs, they might cross the beach without digging and return to the water- a false crawl act. An event that stimulates false crawl is environmental needs were not met or that they felt threatened by a predator or human activity (Davis Jr., Fitzgerald, & Terry, 1999; Weishampel, Bagley, Ehrhart, & Rodenbeck, 2003; and Zavaleta-Lizárraga & Morales-Mávil, 2013). Therefore, sea turtles are known to nest at night, when threats are at their lowest. The nesting of sea turtles is varied from one species to another. However, generally, for all nesting, female sea turtles follow a series of steps: 1) emerge from the ocean, 2) select a nesting site by digging a body pit, 3) dig an egg chamber within the body pit, 4) deposit eggs inside of the egg chamber, 5) cover the eggs using rear flippers, 6) camouflage the nesting site, and 7) make a return crawl to the ocean (Witherington et al., 2011).

Moreover, female sea turtles choose the site location at the nesting beach where they want to nest. Selecting a suitable nesting site is a crucial aspect influencing the reproductive process, fitness, and hatching success (Sarahaizad, Shahrul Anuar, & Mansor, 2012). Factors affecting nest site selection may be microhabitat conditions, beach morphology, dune vegetation, and sediment attributes (e.g., sand temperature,

moisture, and grain size) (Salleh, Sah, & Chowdhury, 2018). A study from Zavaleta-Lizárraga & Morales-Mávil (2013) stated that the nesting site is directly related to beach characteristics where beaches with fine sands, moderate slopes, proper humidity, and drainage are favorable environmental variables for oviposition to take place.

Sea turtle nesting site preferences can differ between species and populations (Kelly, Leon, Gilby, Olds, & Schlacher, 2017). Green turtles are known to prefer sites with clear access from the sea (Mortimer, 1990), Olive ridley turtles usually select flat, open, and unobstructed areas and deposit their clutches between the high tide line and the vegetational line (Reina, Mayor, Spotila, Piedra, & Paladino, 2002; and Cornelius, 1976 in Barrientos-Munoz; Ramirez-Gallego, & Paez, 2014)**,** Leatherback turtle nest below high tide level more often than do green turtles (see Whitmore & Dutton, 1985), and Loggerhead turtles nested preferentially in the sand zone, while Hawksbill turtles demonstrated no preferences for either sand or vegetation zone (Serafini, Lopez, & Bernardo da Rocha, 2009). Relocating nests close to the sea increases the likelihood of inundation and egg loss to erosion. In contrast, placement of nests farther inland increases the possibility of desiccation, hatchling misorientation, and predation on nesting females, eggs, and hatchlings (Bustard & Greenham, 1968; Fowler, 1979; Whitmore & Dutton, 1985; Spencer, 2002; López-Castro, Carmona, & Nichols, 2004; and Madden et al., 2008). As described above, female sea turtles will leave their nest and return to the sea. Hatchlings-to-be is left to incubate without parental care. Hence, researching sea turtle nesting biology is crucial as it can influence their hatchlings' sex, fitness, and emergence behaviour.

Malaysia still has some healthier green and hawksbill sea turtle populations in Southeast Asia despite the local extinction of the leatherback and the near end of olive ridley breeding (Shanker & Pilcher, 2003). Given the extensive movements and genetic connections between foraging and nesting stocks, these turtles are a shared resource (see Joseph, 2006; Joseph et al., 2014, 2016). With increasing pressures on the marine environment, it is crucial to comprehend the movements and connections between nesting populations and foraging stocks. Regional Management Units (RMUs; Wallace et al., 2010) are formed at the regional level when turle unite based on related genetic origins, foraging grounds distribution, and known migrations.

REFERENCES

Abd Mutalib, A. H., Fadzly, N., Ahmad, A., & Nasir, N. (2015). Understanding nesting ecology and behaviour of green marine turtles at Setiu, Terengganu, Malaysia. *Marine Ecology*, *36*(4), 1003-1012.

Allen, M. S. (2007). Three millennia of human and sea turtle interactions in remote Oceania. *Coral Reefs*, *26*(4), 959-970.

Arso Civil, M., Cheney, B., Quick, N. J., Thompson, P. M., & Hammond, P. S. (2017). A new approach to estimate fecundity rate from inter-birth intervals. *Ecosphere*, *8*(4), e01796.

Bean, M. (1980). Sea turtle conservation. Retrieved from https://doi.org/10.1126/science.207.4437.1297. ISSN0036-8075.

Becker, S. L., Brainard, R. E., & Van Houtan, K. S. (2019). Densities and drivers of sea turtle populations across Pacific coral reef ecosystems. *PloS one*, *14*(4), e0214972.

Carr, A., Thomson, J. A., Gulick, A. G., & Heithaus, M. R. (2016). *Intraspecific competition in a green turtle Chelonia mydas* [Brochure]. Florida International University, United State of America.

Cassill, D. L. (2019). Extending r/K selection with a maternal risk-management model that classifies animal species into divergent natural selection categories. *Scientific reports*, *9*(1), 1-8.

Ceriani, S. A., Casale, P., Brost, M., Leone, E. H., & Witherington, B. E. (2019). Conservation implications of sea turtle nesting trends: elusive recovery of a globally important loggerhead population. *Ecosphere*, *10*(11), e02936.

Chan, E. H. (2013). A report on the first 16 years of a long-term marine turtle conservation project in Malaysia. *Asian Journal of Conservation Biology*, *2*(2), 129-135.

Cole, T. J. (2012). The development of growth references and growth charts. *Annals of human biology*, *39*(5), 382-394.

Donaton, J., Durham, K., Cerrato, R., Schwerzmann, J., & Thorne, L. H. (2019). Long-term changes in loggerhead sea turtle diet indicate shifts in the benthic community associated with warming temperatures. *Estuarine, Coastal and Shelf Science*,*218*, 139-147.

Eguchi, T., Seminoff, J. A., LeRoux, R. A., Prosperi, D., Dutton, D. L., & Dutton, P. H. (2012). Morphology and Growth Rates of the Green Sea Turtle (*Chelonia mydas*) in a Northern-most Temperate Foraging Ground. *Journal of Herpetologica, 68*(1): 76–87.

Ekanayake, E. M. L., Kapurusinghe, T., Saman, M. M., Rathnakumara, D. S., Samaraweera, P., & Rajakaruna, R. S. (2016). Reproductive output and morphometrics of green turtle, *Chelonia mydas* nesting at the Kosgoda rookery in Sri Lanka. *Ceylon Journal of Science*, *45*(3).

Fabian, D. & Flatt, T. (2012) Life history evolution. *Journal of Nature Education Knowledge, 3*(10):24.

Fischer, W., Schneider, W. & Scialabba, N. (1990). FAO species catalogue volume 11: sea turtles of the world. Rome, Italy: Food and Agriculture Organization (FAO).

Florida Marine Research. (2001). Unit Three Migration Studies: Sea Turtles. Project Oceanography. United State: Florida Fish and Wildlife Conservation Commission.

Fuentes-Farias, A. L., Gutiérrez-Ospina, G., Herrera, E. M., Camarena-Ramírez, V., Ochoa-Tovar, G., Mendoza-Torreblanca, J., ... & Zepeda, M. L. G. (2011). Marine turtle hatchlings use multiple sensory cues to orient their crawling towards the sea: biological and conservation policy implications. *Advances in Bioscience and Biotechnology*, *2*(2), 47.

Gomez, L. & Krishnasamy, K. (2019). *A Rapid Assessment on the Trade in Marine Turtles in Indonesia, Malaysia and Vietnam*. TRAFFIC Southeast Asia.

Hays, G. C., Fossette, S., Katselidis, K. A., Schofield, G., & Gravenor, M. B. (2010). Breeding periodicity for male sea turtles, operational sex ratios, and implications in the face of climate change. *Conservation Biology*, *24*(6), 1636-1643.

Hendrickson, J. R., & Alfred, E. R. (1961). Nesting populations of sea turtles on the east coast of Malaya. *Bull Raffles Mus*, *26*, 190-196.

Heylighen, F., & Bernheim, J. (2004). From Quantity to Quality of Life: rK selection and human development.*Soc. Indic. Res*, 1-14.

Höök, M., Li, J., Oba, N., & Snowden, S. (2011). Descriptive and predictive growth curves in energy system analysis. *Natural Resources Research, 20*(2), 103-116.

Hutchings, J. A. (2005). Life history consequences of overexploitation to population recovery in Northwest Atlantic cod (Gadus morhua). *Canadian Journal of Fisheries and Aquatic Sciences*, *62*(4), 824-832.

Jani, J. M., Jamalludin, M. A., & Long, S. (2019). To ban or not to ban? Reviewing an ongoing dilemma on sea turtle egg trade in Terengganu, Malaysia. *Frontiers in Marine Science*, *6*, 762.

Karmeshu & Lara-Rosano, F. (1987). Modelling data uncertainty in growth forecasts*. Applied Mathematical Modelling, 11*(1), 62-68.

Kemf, E., Groombridge, B., Abreu, A., & Wilson, A. (2005, April). Marine Turtles in The Wild. 2000–A WWF Species Status Report. In *of the Twenty-First Annual Symposium on Sea Turtle Biology and Conservation* (p. 212).

Kot, M. (2001). *Elements of Mathematical Ecology*. Cambridge, United Kingdom: Cambridge University Press.

Liew, H. C. (2011). Tragedy of the Malaysian Leatherback population. In *Conservation of Pacific Sea Turtles* (pp. 97-107). United States of American: University of Hawaii Press.

Limpus, C. J. (1993). Recommendations for conservation of marine turtles in Peninsula Malaysia. *Report to Department of Fisheries, Ministry of Agriculture, Malaysia. Brisbane, Australia: Queensland Department of Environment and Heritage*.

Lohmann, K. J., & Lohmann, C. M. (2019). There and back again: Natal homing by magnetic navigation in sea turtles and salmon. *Journal of Experimental Biology*, *222*(Suppl 1).

McGuire, M., Francis-Floyd, R., Flint, M. & Flint, J. B. (2017). One in a Thousand: Those Amazing Sea Turtles in Zimmerman, D and Palmer, D. (Eds). UF/IFAS University of Florida, United State of American.

McLellan, E., Arps, E., & Donnelly, M. (2009). *WWF Global Marine Turtle Strategy 2009–2020*. Gland, Switzerland: WWF.

Muhammad Dahri, A.S., Rusli, M.U., & Mohd Roslan, U. M (2022b). Efficiency of The Mixed-Conservation System Based on Current Sea Turtle Nesting Density in Terengganu, Malaysia. (Unpublished Paper).

Muhammad Dahri, A.S., Rusli, M.U., Mohd Roslan, U. M., & Kamaludin, M. (2022a). *Assessment of Sea Turtle Conservation in Terengganu Based on Ecological Models* (Master's thesis, Universiti Malaysia Terengganu, Terengganu, Malaysia).

Ocana, M., Harfush-Melendez, M., & Heppell, S. S. (2012). Mass nesting of olive ridley sea turtles Lepidochelys olivacea at La Escobilla, Mexico: linking nest density and rates of destruction. *Endangered Species Research*, *16*(1), 45-54.

Owens, D. W., & Blanvillain, B. (2013). Captive reproduction of sea turtles: An important success story. In *Proceedings of the international symposium on Reproduction of Marine Life, Birth of New Life* (pp. 23-40).

Palmer, J. L., Beton, D., Çiçek, B. A., Davey, S., Duncan, E. M., Fuller, W. J., ... & Broderick, A. C. (2021). Dietary analysis of two sympatric marine turtle species in the eastern Mediterranean. *Marine Biology*, *168*(6), 1-16.

Pardo, S. A., Cooper, A. B., & Dulvy, N. K. (2013). Avoiding fishy growth curves. *Methods in Ecology and Evolution*, *4*(4), 353-360.

Reznick, D., Bryant, M. J., & Bashey, F. (2002). r-and K-selection revisited: the role of population regulation in life-history evolution. *Ecology*, *83*(6), 1509-1520.

Rusli, M. U. (2016). *The energetics of nest escaping by turtle hatchlings*. (Doctoral dissertation, The University of Queensland).

Salisbury, A. (2011). *Mathematical models in population dynamics* (Degree's thesis). New College of Florida, United State of American.

Seminoff, J. A. (2002). IUCN red list global status assessment: green turtle (*Chelonia mydas*). *IUCN Marine Turtle Specialist Group Review*, *93*.

Siow, K. T., & Moll, E. O. (1982). Status and conservation of estuarine and sea turtles in West Malaysian waters. *Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, DC, USA*, 339-347.

Stokes, H. J., Mortimer, J. A., Hays, G. C., Unsworth, R. K., Laloë, J. O., & Esteban, N. (2019). Green turtle diet is dominated by seagrass in the Western Indian Ocean except amongst gravid females. *Marine biology*, *166*(10), 1-12.

Tsoularis, A. (2001), Analysis of logistic growth models. *Information and Mathematical Sciences*, *2*, 23-46.

Tsoularis, A., & Wallace, J. (2002). Analysis of logistic growth models. *Mathematical biosciences*, *179*(1), 21-55.

United State Wildlife Service. (2015). Green sea turtle (*Chelonia mydas*) fact sheet. Retrieved from https://www.fws.gov/northflorida/SeaTurtles/Turtle%20Factsheets/green-sea-turtle.htm.

Wei, H., Jiang, Y., & Zhang, Y. (2015). A review of two population growth models and an analysis of factors affecting the Chinese population growth. *Asian J. Econom. Model*, *3*(1), 8-20.

Zabadi, A. M., Assaf, R., & Kanan, M. (2017). A Mathematical and statistical approach for predicting the population growth. *World Wide Journal of Multidisciplinary Research and Development*, *3*(7), 50-59.

3.0 SHARKS AND RAYS

3.1 INTRODUCTION

Sharks, rays, and chimaeras, collectively called cartilaginous fish, are a direct source of income from the fishing and tourism industries as essential food sources in many parts of the world and play critical ecological roles in aquatic ecosystems. It contributes to humans through significant economic benefits (Ferretti et al., 2010; Gallagher and Hammerschlag, 2011; WWF, 2021). However, cartilaginous fish is one of the most threatened groups in the world, with more than a third of all known species at risk of extinction due to overfishing or other human activities.

There is extensive literature on the biology of Malaysian cartilaginous fish. The research and conservation of cartilaginous fish also seem to have received increasing interest and investment in recent years. However, a slight improvement in local fisheries management and limited policy development may prevent action from existing research. Malaysia currently has few policies and regulations on chondrichthyans conservation and fisheries management, especially compared to other Asian countries. Regarding fisheries management in Malaysia, the traditional paradigm of single-species management is largely followed locally. This approach has been criticized for addressing isolated species and ignoring ecosystem interactions, human interactions, and social goals (NOAA, 2021). Additionally, it relies on data-intensive inventory valuations that may be limited in Malaysian conditions.

The Ecosystem Approach to Fisheries Management (EAFM) is a newer, more holistic form of fisheries management that combines the concepts of biodiversity and ecosystem conservation with those of fisheries management, food security, and livelihoods. Understanding the availability and quality of existing data can support updating and implementing these management approaches. These points highlight the need to consider cartilaginous fish studies in Malaysia to understand previous studies' applicability and inform future research and conservation efforts. Therefore, we conducted a comprehensive scoping review of chondrichthyans studies in Malaysia with the overall aim of evaluating the relevance of this study to the conservation of this endangered species. We examined the distribution and bias of the chondrichthyans literature across research topics, taxa, and locations. We assessed the availability of data and whether they could potentially contribute to different fisheries management frameworks. Through this review, we identified critical research gaps and priorities that must be addressed in future efforts to guide policy more effectively.

3.2 OBJECTIVE

i. Record, document, and analyze marine mammal information/data from previous studies in Malaysian waters to be translated into a comprehensive inventory report, including the production of geospatial maps of the distribution of sharks and rays.
ii. To analyze the temporal and geographical variation in the publications and the extent of study of different research topics by species.

3.3 MATERIALS AND METHODS

i. Desktop Study – Collecting data/information on sea turtle inventory based on previous studies and published and unpublished literature. The list of published scientific papers from the Web of Science and SCOPUS has been retrieved using these keywords; elasmobranch* OR batoid* OR shark* OR Selachi* OR Yu* OR Pari* OR Ray* AND marine* OR ocean*. And redefine according to the origin of authors and study locations in Malaysia.

ii. Scientometric: We analyze the scientific literature published on marine turtles in Malaysia employing a bibliographic analysis. We examined the temporal and geographical variation in the publications and the extent of the study of different research topics by species.

iii. Data Analysis and Mapping - Spatial analysis to identify information gaps.

iv. Workshops and Publications – A focus group discussion (FGD), workshops on progress, and final reports have been conducted.

3.4 RESULTS

Year	Theme	Location	Taxa	Author
2001	Biology (movement)	South China Sea	whale sharks	Eckert et al
2009	Biology (nutrient)	Perak	P. hypophthalmus	Phumee et al
2009	Biology (nutrient)	Perak	P. hypophthalmus	Asdari et al
2013	Biology (bacteria)	Tioman, Pahang	Elasmobranchs	Ahmad et al
2013	Biology (morphology)	Pahang and Johor Timur	Carcharhinus melanopterus	Nor-Fazilla et al
2014	Biology (genetic)	Peninsular Malaysia	Bamboo sharks	Masstor et al
2017	Biology (Heavy Metal)	Terengganu	Elasmobranchs	Ong and Gan
2018	Biology (Status)	Malaysia	Elasmobranchs	Friedman et al
2018	MPA (tourism)	Sabah	Elasmobranchs	Vianna et al
2019	Biology (paleontology)	Malaysia	Elasmobranchs	Teng et al
2020	Biology (physiology)	Terengganu	spot-tail sharks	Bashir et al
2020	Biology (gut microbiota)	Kuantan	Blacktip shark	Hamid et al. l
2020	Biology (predation)	Terengganu	Blacktip shark	Bashir et al
2021	Biology (genetic)	Malaysian waters	Bamboo sharks	Lim et al
2021	Biology (genetic)	Indo-Malay region	Bamboo sharks	Fahmi et al
2021	Fisheries (landing)	Sarawak	Elasmobranchs	Booth et al
2021	Fisheries (product DNA)	Peninsular Malaysia	Elasmobranchs	Seah et al
2022	Biology (genetic)	Malaysian waters	Spadenose shark	Lim et al
2022	MPA	ASEAN waters	Elasmobranchs	Du et al
2022	Fisheries (trade)	Pahang	Elasmobranchs	Yusof et al
2022	Biology (diversity)	Sabah	Elasmobranchs	Farhana-Azmi et al

The table of research studies on sharks and rays in Malaysia provides valuable insights into the state of knowledge concerning these iconic marine species. Analyzing the data reveals a diverse range of research themes, including biology, fisheries, conservation, and more. While many facets of shark and ray biology have been explored, there are notable gaps in the research landscape. Geographic distribution of studies shows variation, with some regions being better represented than others.

Additionally, while Elasmobranchs receive significant attention, there's a need for studies encompassing a wider range of species. To build a more comprehensive understanding of these creatures and address ongoing conservation challenges, future research efforts should focus on these underrepresented areas, integrate multiple disciplines, involve local communities, and explore the impacts of climate change. By bridging these research gaps, Malaysia can better inform its conservation policies and management strategies, ultimately contributing to the preservation of these vital marine species and their ecosystems.

Here is the summary from the literature analysis:

1. Research Themes:

- Biology-related themes, such as movement, nutrients, bacteria, morphology, heavy metals, genetics, physiology, gut microbiota, and predation, are well-covered in the literature. This suggests a diverse range of biological research has been conducted.
- Fisheries-related studies, including landing data, product DNA, and trade, indicate some attention to the economic and management aspects of shark and ray populations.
- MPA (Marine Protected Area) and tourism-related research is evident, reflecting an interest in conservation and the economic value of these species.
- There's one paleontology-related study, which may be considered a niche area of research.

2. Geographic Distribution:

- Studies cover various locations within Malaysia, including South China Sea, Perak, Tioman, Pahang, Terengganu, Peninsular Malaysia, Sabah, Sarawak, and ASEAN waters.
- However, there seems to be a lack of studies from certain regions, potentially leaving gaps in our understanding of shark and ray populations in those areas.

3. Taxa:

- While there is a focus on Elasmobranchs (a subclass of cartilaginous fish that includes sharks and rays), there are studies on specific species like whale sharks, *P. hypophthalmus, Carcharhinus melanopterus*, bamboo sharks, spot-tail sharks, and blacktip sharks.
- Other species of sharks and rays may not have been extensively studied, suggesting a need for more comprehensive research that includes a wider range of species.

4. Research Gaps and Recommendations:

- **Taxonomic Diversity:** While there's a focus on Elasmobranchs, more studies on lesser-known or locally important species are needed to ensure their conservation.
- **Geographic Gaps:** The distribution of studies seems uneven across different regions within Malaysia. Encourage researchers to explore understudied areas to obtain a more comprehensive picture of shark and ray populations in the country.
- **Integrated Approaches:** Encourage research that integrates various aspects of biology, fisheries, and conservation to develop a holistic understanding of the interactions between these factors.
- **Data Sharing:** Promote data sharing and collaboration among researchers to maximize the utility of existing data and minimize duplication of efforts.
- **Policy and Management Studies:** Given the threat of overfishing, studies on the effectiveness of fisheries management policies, especially for elasmobranchs, are essential.
- **Community Involvement:** Encourage studies that involve local communities and traditional knowledge, as they can play a crucial role in conservation efforts.
- **Climate Change Impacts:** Given the global concern for climate change, research into how changing ocean conditions affect shark and ray populations is becoming increasingly important.

Malaysia is rich in shark and ray diversity. As of 2016, Malaysia has recorded 85 species of rays, 70 species of sharks, six species of skates, and one species of chimera. A total of 18 sharks, 12 beams, two families of rays, and one family of delusions were recorded. New species are constantly being discovered, and numbers are expected to increase in the future, as many deep-sea species are still unknown due to limited research activity (Abd Haris Hilmi et al., 2017).

The life cycles of most of these fish were characterized by late sexual maturation, long lifespan, long gestation period, and few well-developed offspring (Dulvy et al., 2008). Shark and ray landings in Malaysia contributed approximately 1% and 2%, respectively, to the total marine landings from 2015 to 2016 (Abd Haris Hilmi et al., 2017). However, sharks and rays are often bycatch in many fishing gears, such as trawlers and driftnets, rather than being intentionally caught. Bycatch is the inadvertent capture of the juvenile size range of non-target or target species by non-selective gear (Hall, 1996; Crowder and Murawski, 1998).

3.5 DISCUSSION

The conservation of sharks is paramount not only for the preservation of these apex predators but also for the overall health and balance of marine ecosystems. In light of the critical ecological roles sharks play and their significance as a source of income from both fishing and tourism industries in many parts of the world, it is imperative to enhance shark conservation efforts. Several strategic recommendations can facilitate this endeavor.

Firstly, robust monitoring and research efforts are fundamental to informed conservation. Supporting ongoing research endeavors focused on tracking shark movements, behaviors, and habitat preferences is paramount for understanding their needs and vulnerabilities. Employing advanced technologies, such as satellite tagging and genetic analysis, can yield invaluable data that underpins shark conservation efforts. Shark conservation transcends national borders, as these creatures are highly migratory. Hence, international cooperation is indispensable. Collaborating with international organizations and governments is essential to establish and enforce global agreements aimed at protecting sharks during their extensive migrations. Moreover, combating the illegal trade of shark fins, a principal driver of overfishing, necessitates coordinated efforts on a global scale.

Reducing the demand for shark products is another critical aspect of conservation. Raising awareness about the unsustainable and often inhumane practices associated with shark finning is vital for diminishing the demand for shark products, particularly shark fin soup. Educating consumers about the ethical and ecological implications of shark product consumption and promoting sustainable seafood choices can further contribute to this goal.

Advocating for comprehensive shark conservation policies and laws at various governance levels, from local to international, is essential. These policies should be tailored to address the unique needs of different shark species, encompassing measures to safeguard critical habitats, restrict fishing activities, and promote sustainable practices.

The establishment of shark sanctuaries in key areas is an effective means of protecting critical habitats and migration routes. These sanctuaries provide secure zones where sharks can reproduce and thrive without the constant threat of fishing pressure. Additionally, promoting the creation of networks of protected areas enhances the overall effectiveness of shark conservation efforts.

Funding conservation initiatives is pivotal to their success. Allocating resources and financial support for shark conservation research, enforcement, and education initiatives is essential. Encouraging public-private sector partnerships to invest in these endeavors can significantly bolster available financial resources.

Lastly, ongoing monitoring and adaptability are vital aspects of conservation efforts. Regular assessments of the effectiveness of conservation measures are necessary, and strategies should be adapted as required. Engaging with stakeholders, including local communities and fishermen, is essential to ensure that conservation efforts remain practical and sustainable over the long term. Collaboration and feedback from those directly affected by conservation measures can foster successful outcomes and garner support from all stakeholders. In amalgamating these recommendations, stakeholders can collaboratively work toward the protection and conservation of shark populations, securing the future of these iconic marine species and the health of marine ecosystems they inhabit.

REFERENCES

Eckert, S. A., Dolar, L. L., Kooyman, G. L., Perrin, W., & Rahman, R. A. (2002). Movements of whale sharks (Rhincodon typus) in South-east Asian waters as determined by satellite telemetry. Journal of Zoology, 257(1), 111–115. https://doi.org/10.1017/S0952836902000705

Phumee, P., Hashim, R., Aliyu-Paiko, M., & Shu-Chien, A. C. (2009). Effects of dietary protein and lipid content on growth performance and biological indices of iridescent Shark (Pangasius hypophthalmus, Sauvage 1878) fry. Aquaculture Research, 40(4), 456–463. https://doi.org/10.1111/j.1365-2109.2008.02116.x

Asdari, R., Aliyu-Paiko, M., Hashim, R., & Ramachandran, S. (2011). Effects of different dietary lipid sources in the diet for Pangasius hypophthalmus (Sauvage, 1878) juvenile on growth performance, nutrient utilization, body indices and muscle and liver fatty acid composition. Aquaculture Nutrition, 17(1), 44–53. https://doi.org/10.1111/j.1365-2095.2009.00705.x

Ahmad, A., Hamid, R., Dada, A. C., & Usup, G. (2013). Pseudomonas putida Strain FStm2 Isolated from Shark Skin: A Potential Source of Bacteriocin. Probiotics and Antimicrobial Proteins, 5(3), 165–175. https://doi.org/10.1007/s12602-013-9140-4

Nor-Fazilla, M., Samat, A., & Mazlan, A. G. (2013). Morfologi struktur halus organ deria-elektro (ampullae of lorenzini) ikan yu carcharhinus melanopterus, c. limbatus dan chiloscyllium griseum. Sains Malaysiana, 42(6), 737–742.

Ong, M. C., & Gan, S. L. (2017). Assessment of metallic trace elements in the muscles and fins of four landed elasmobranchs from Kuala Terengganu Waters, Malaysia. Marine Pollution Bulletin, 124(2), 1001–1005. https://doi.org/10.1016/j.marpolbul.2017.08.019

Friedman, K., Gabriel, S., Abe, O., Adnan Nuruddin, A., Ali, A., Bidin Raja Hassan, R., Cadrin, S. X., Cornish, A., De Meulenaer, T., Dharmadi, Fahmi, Huu Tuan Anh, L., Kachelriess, D., Kissol, L., Krajangdara, T., Rahman Wahab, A., Tanoue, W., Tharith, C., Torres, F., ... Ye, Y. (2018). Examining the impact of CITES listing of sharks and rays in Southeast Asian fisheries. Fish and Fisheries, 19(4), 662–676. https://doi.org/10.1111/faf.12281

Masstor, N. H., Samat, A., Nor, S. M., & Md-Zain, B. M. (2014). Molecular phylogeny of the bamboo sharks (Chiloscyllium spp.). BioMed Research International, 2014. https://doi.org/10.1155/2014/213896

Vianna, G. M. S., Meekan, M. G., Rogers, A. A., Kragt, M. E., Alin, J. M., & Zimmerhackel, J. S. (2018). Shark-diving tourism as a financing mechanism for shark conservation strategies in Malaysia. Marine Policy, 94(May), 220–226. https://doi.org/10.1016/j.marpol.2018.05.008

Teng, Y. H., Sone, M., Hirayama, R., Yoshida, M., Komatsu, T., Khamha, S., & Cuny, G. (2019). First Cretaceous fish fauna from Malaysia. Journal of Vertebrate Paleontology, 39(1), 1–14. https://doi.org/10.1080/02724634.2019.1573735

Bashir, Z., Abdullah, M. M., Ghaffar, M. A., & Rusli, M. U. (2020). Exclusive predation of sea turtle hatchlings by juvenile blacktip reef sharks Carcharhinus melanopterus at a turtle nesting site in Malaysia. Journal of Fish Biology, 97(6), 1876–1879. https://doi.org/10.1111/jfb.14550

Hamid, T. H. T. A., Ahmad Zahli, K. I., & Alotaiby, M. (2020). Lactococcus Lactis Strains From Intestinal Organ of Black Tips Shark Carcharhinus Limbatus Producing Nisin-Like Bacteriocin Active Against Shrimp and Fish Pathogens (Vibrio Parahaemolyticus and Vibrio Alginolyticus). Journal of Microbiology, Biotechnology and Food Sciences, 10(3), 354–360. https://doi.org/10.15414/jmbfs.2020.10.3.354-360

Bashir, Z., Abdullah, M. M., & Rusli, M. U. (2020). Comparisons between tissues, preservation, and desiccation methods on stable isotopes δ13c and δ15 n of spot-tail sharks (Carcharhinus sorrah) from the south China sea. Turkish Journal of Fisheries and Aquatic Sciences, 20(9), 711–716. https://doi.org/10.4194/1303-2712-v20_9_01

Lim, K. C., White, W. T., Then, A. Y. H., Naylor, G. J. P., Arunrugstichai, S., & Loh, K. H. (2022). Integrated Taxonomy Revealed Genetic Differences in Morphologically Similar and Non-Sympatric Scoliodon macrorhynchos and S. laticaudus. Animals, 12(6). https://doi.org/10.3390/ani12060681

Fahmi, Tibbetts, I. R., Bennett, M. B., Ali, A., Krajangdara, T., & Dudgeon, C. L. (2021). Population structure of the brown-banded bamboo shark, Chiloscyllium punctatum and its relation to fisheries management in the Indo-Malay region. Fisheries Research, 240(1), 105972. https://doi.org/10.1016/j.fishres.2021.105972

Booth, H., Chaya, F., Ng, S., Tan, V., Rao, M., Teepol, B., Matthews, E., Lim, A., & Gumal, M. (2021). Elasmobranch fishing and trade in Sarawak, Malaysia, with implications for management. Aquatic Conservation: Marine and Freshwater Ecosystems, 31(11), 3056–3071. https://doi.org/10.1002/aqc.3688

Seah, Y. G., Kibat, C., Hew, S., & Wainwright, B. J. (2022). DNA barcoding of traded shark fins in Peninsular Malaysia. Reviews in Fish Biology and Fisheries, 32(3), 993–999. https://doi.org/10.1007/s11160-022-09713-y

Lim, K. C., Then, A. Y. H., Wee, A. K. S., Sade, A., Rumpet, R., & Loh, K. H. (2021). Brown banded bamboo shark (Chiloscyllium punctatum) shows high genetic diversity and differentiation in Malaysian waters. Scientific Reports, 11(1), 1–15. https://doi.org/10.1038/s41598-021-94257-7

Du, J., Ding, L., Su, S., Hu, W., Wang, Y., Loh, K. H., Yang, S., Chen, M., Roeroe, K. A., Songploy, S., Liu, Z., & Chen, B. (2022). Setting Conservation Priorities for Marine Sharks in China and the Association of Southeast Asian Nations (ASEAN) Seas: What Are the Benefits of a 30% Conservation Target? Frontiers in Marine Science, 9(June), 1–15. https://doi.org/10.3389/fmars.2022.933291

Yusof, R., Shuib, A., Ramachandran, S., Ali, A., & Ismail, I. (2022). Factors Influencing the Effectiveness of Supply Chain Traceability System Implementation for Shark and Ray Products in Pahang, Malaysia: Insights From Key Informant Interviews. International Journal of Business and Society, 23(1), 297–325. https://doi.org/10.33736/ijbs.4614.2022

Farhana-Azmi, N., Manjaji-Matsumoto, B. M., Maidin, N., John, J. B., Bavoh, E. M., & Saleh, E. (2022). Checklist of coral reef fishes of Darvel Bay, Sabah, Malaysian Coral Triangle, with a note on the biodiversity and community structure. Biodiversity Data Journal, 10. https://doi.org/10.3897/BDJ.10.e79201

CHAPTER 4

MARINE HABITAT AND ECOLOGICAL PROCESSES

Maizah Mohd Abdullah
Zainudin Bachok
Ryon Siow
Abd. Haris Hilmi Ahmad Arshad
Nurulafifah Yahya
Nur Sanim Azlan

1.0 INTRODUCTION

Ecology is the science of all the relations of organisms to their environment, i.e., habitats, and it is one of the most useful and essential of the sciences. Harmonies, acceptable habitat use, and efficient conservation of natural resources can be obtained only through programs based on a sound ecological foundation (Taylor, 1936). Ecological principles such as the maintenance and restoration of native species diversity, habitat diversity and heterogeneity, key species, and connectivity are critical to be understood and taken into account in marine ecosystem management and the framework of marine spatial planning, or MSP (Foley et al., 2010).

According to Hall et al. (1997), habitat is defined as

> *"The resources and conditions present in an area that produce occupancy, including survival and reproduction by a given organism. Habitat is organism-specific; it relates the presence of a species, population, or individual, either animal or plant, to an area's physical and biological characteristics. Habitat implies more than vegetation or vegetation structure; it is the sum of the specific resources needed by organisms. Wherever an organism is provided with resources that allow it to survive, that is habitat. Thus, migration and dispersal corridors and the land animals occupy during breeding and nonbreeding seasons are also considered habitat".*

The oceans represent a vast, complex, and poorly understood ecosystem. The timing of biological events, for example, spawning, is susceptible to environmental change. Although many species can change their feeding habits and diets, anthropogenic threats can disrupt biological systems, making them more susceptible to perturbations (Field et al., 2010).

In general, ecological processes are ecosystem specific. Many environmental process's structure habitat and ecosystem functioning, including anthropogenic influences in the complex dynamics and changing marine ecosystems. The coming decades will see continuing ecological changes in marine environments. In this study, we review the scientific literature to examine the knowledge and research gaps concerning the marine habitat and environmental processes within Malaysian waters to align future conservation and research priorities for proactive species and habitat management. However, it is essential to note here that the research on this subject is enormous, which explains why the selected study is included in this analysis.

2.0 OBJECTIVES

1. To identify data and information gaps in the description and distribution of marine habitats and ecological processes in Malaysian waters based on the published records.

2. Suggest and highlight the critical marine habitats and the associated ecological processes that should be emphasized for the future research direction in Malaysian waters.

This report must be read with the GIS maps produced as this desktop study's primary output.

3.0 MATERIALS AND METHODS

Secondary data collection from the publication of journals, reports, articles, plans, and others referring to the scope of habitat and marine ecological processes includes but is not limited to habitat location that is the habitat of interest, such as spawning area, nesting area, grazing, nursing, connectivity, migratory route, habitat for endemic species, oceanography, bathymetry, upwelling, habitat area, threats, and others.

This research looked at 434 papers. Data were collected from 1981 to 2022 and were restricted to investigations of marine habitat and ecological processes. All Malaysian states are represented, including Labuan. However, other publications addressed the locations in general (e.g., Peninsular Malaysia's East and West Coasts, the Malacca Straits). The coordinates were recorded based on the latitude and longitude provided in the reports or publications, but if these were not available, we referred to the areas' nearest space and longitude. The information was gathered from books, book chapters, conference proceedings, EIA reports, journal articles, conferences, and reports. All research and analysis were done on a desktop research format. Online platforms were used for interviews and discussion sessions.

4.0 RESULTS/ DATA ANALYSIS

4.1 Scope of Marine Ecological Research in Malaysia

Based on the dataset obtained, research on Malaysia's marine habitat and ecological processes can be divided into six (6) indicators, as shown in Figure 1. Most of the research done in Malaysia falls under the categories of: i) biological community structure research; ii) population dynamics; iii) threats and pollution; and iv) the attributes of ecological process studies. The other research areas that received minimum highlights were under the topics of v) trophic dynamics and vi) seascape and connectivity studies (Figure 1).

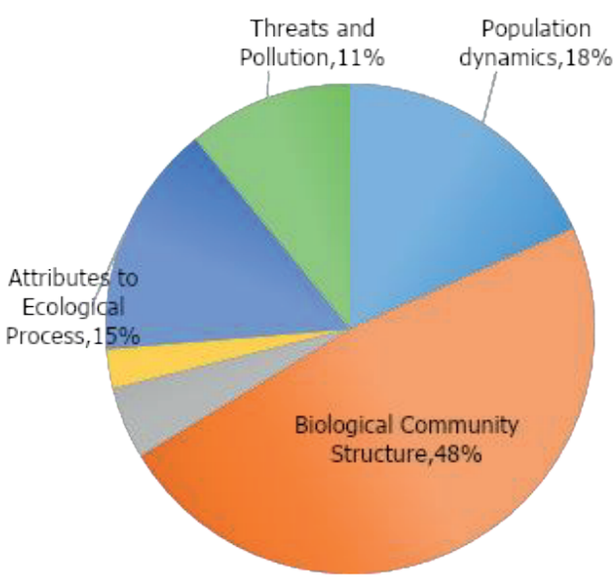


Figure 1 The main field of marine ecological research that has been done and reported within Malaysian waters

Biological Community Structure in Mangroves, Seagrass, and Estuarine Habitats

Mangroves serve as a habitat for a diverse array of species, with certain species existing in dense populations and others establishing symbiotic relationships with mangrove plants, such as wood borers (Singh and Sasekumar, 1994), or residing in the sediment, known as benthos, with benthic infauna like meiofauna (Somerfield et al., 1998). Nematodes typically exhibit the highest level of dominance within the meiofauna community, which is also referred to as meiobenthos. Chen and Long (2015) discovered a new species of marine nematode, *Metalinhomoeus ramsarensis* (Linhomoeidae Filipjev, 1922), within the confines of Kuching Wetland National Park in Sarawak, Malaysia. Furthermore, taxonomic studies of the polychaete population in mangroves and estuary settings are common (Ibrahim et al., 2017).

Other marine species associated with mangroves are the green mud crab, *Scylla paramamosain* (Ikhwanuddin et al., 2015), the hermit crab, *Clibanarius longitarsus* (Faridah et al., 2017), and other types of crabs, including brachyuran and fiddler crabs (Zakirah et al., 2017; Faridah et al., 2017). A new record on variability in different body measurements of the horseshoe crab *Carcinoscorpius rotundicauda* (Latreille) has also been discovered at Setiu and Gelang Patah habitats in Peninsular Malaysia (Srijaya et al., 2010). Meanwhile, examples of mollusks include mudsnails, climbing gastropods, bivalves (Wan Bayani and Zaleha, 2015; Baharuddin et al., 2017; Faridah et al., 2017), and the ark shell *Scapharca cornea* (Mohd and Bachok, 2017).

Two ecological studies have been conducted on the plankton associated with mangroves. The first study by Yong et al. (2016) examines the variability in abundance and community structure of microzooplankton in the Terusan mangrove creek, specifically focusing on the influence of monsoonal and lunar factors. The second study by Redzuan (2021) investigates the monthly diversity and abundance of Chaetocerotales, a type of plankton, in Pulau Carey. This study also explores the relationship between Chaetocerotales and physicochemical water parameters as well as phytoplankton diversity. Additional significant microscopic biological groupings include marine fungus (Alias and Jones, 2000; Pang et al., 2010) and microorganisms (Saadu et al., 2021). In recent years, there has been a growing body of research examining the relationship between prawn ecology and abundance, particularly in the context of mangroves. Notably, studies conducted by Rosle and Ibrahim (2017) as well as Jamizan and Chong (2017) have explored this association, focusing specifically on the species *Penaeus monodon*.

The significance of estuarine ecosystems in driving nearshore fish productivity has been widely acknowledged. According to Naylor et al. (2000), approximately 30% of commercial fish species globally rely on mangroves for their survival. Mangrove fish species, including the giant mudskipper (*Periophthalmodon schlosseri*) and others, have been documented in Malaysian mangroves and estuaries (Mazlan and Rohaya, 2008; Ng et al., 2019). Additionally, studies have reported the presence of the spotted catfish (*Arius maculatus*) in these habitats (Mazlan et al., 2008). Furthermore, investigations have been conducted on the demersal fish population in relation to hydrogeomorphological metrics of mangroves (Jamizan and Chong, 2017). The study conducted by Cong et al. (2010), Jalal et al. (2012), Nyanti et al. (2012), and Zainal Abidin

et al. (2021) investigated the fish diversity in Sungai Merbok Mangrove Forest Reserve in the northwest of Peninsular Malaysia, and the Semariang mangrove area of Kuching, Sarawak, as well as the Semerak Estuary and Pahang Estuary.

Previous research has examined the composition of various organisms within seagrass habitats, including epifaunal marine bivalves, macrogastropods, sea cucumber, polychaetes, macrophytes, phytoplankton, benthic harpacticoid, and planktonic copepod assemblages. These studies have been conducted in specific locations such as Merambong Shoal, Pulai River Estuary, and the Straits of Malacca. (The et al., 2014; Shi et al., 2014; Woo et al., 2014; Wong et al., 2014; Lim et al., 2014; Mahadi et al., 2014; Matias-Peralta and Yusoff, 2015). Furthermore, Ismail et al. (2021) have provided a comprehensive account of the species composition and diversity of zooplankton within the seagrass ecosystem of Lawas, Sarawak, Malaysia. Additional research has been conducted on the presence of the boring bivalve species (Genus Zachsia) within a tropical seagrass meadow located in Pulau Gaya, Sabah, Malaysia. This study, conducted by Tzuen Kiat in 2018, explores the potential ecological consequences associated with the occurrence of this species. Furthermore, Ilias conducted a study in 2015 that focuses on the habitat and distribution patterns of the sandfish species Holothuria scabra in Peninsular Malaysia. The investigation of echinoderm diversity within seagrass meadows has been documented by several scholars, such as Teoh and Woo (2021). Pinn et al. (2014) have recently reported novel findings regarding the echinoderms that inhabit seagrass meadows. The fish groups inhabiting the seagrass bed of Merchang Lagoon in Terengganu, Peninsular Malaysia were documented by Aziz et al. (2006).

Biological Community Structure in Coastal and Coral Reefs Habitats

The Proceedings of the Second Technical Seminar on Marine Fishery Resources Survey in the East Coast of Peninsular Malaysia, Sabah, and Sarawak, published by the Southeast Asian Fisheries Development Centre, contain comprehensive studies regarding the distribution, abundance, and species composition of zooplankton, phytoplankton, and microplankton in the South China Sea (Boonyapiwat, 1999; Shamsudin et al., 1999; Jivaluk, 1999). Previous studies have presented comprehensive analyses of the phytoplankton in Malaysian Waters. Tengku Rozaina et al. (2011) and Ali et al. (2006) have contributed extensive reports on the spatial distribution and population density of phytoplankton and zooplankton in Sarawak waters. Additionally, Abd. Haris Hilmi et al. (2009) have conducted surveys focusing on plankton and fish larvae in the West Coast of Peninsular Malaysia. Adam & Ahmad Ishak (2018) have recently published a taxonomic review of the Family Doliolidae Bronn, 1862 (Chordata, Tunicata, Thaliacea, and Doliolida) from the East Coast of Peninsular Malaysia. This revision includes an updated global distribution of the family. The distribution of the zooplankton community in Toli shad Tenualosa toli habitats, as well as the influences of monsoonal and geographical factors on zooplankton variation, have been investigated by Aiman et al. (2020) and Muthurajah et al. (2021) in North Borneo and Sarawak. Additional ecological research encompasses investigations into the spatial distribution, population size, and species composition of microplankton within the coastal waters of the East Coast of Peninsular Malaysia, as documented by Ahmad et al. (2002). Furthermore, Tan and Ransangan (2017) have examined the impacts of nutrient levels and zooplankton on the

structural composition of the phytoplankton community in Marudu Bay. Lastly, Lim et al. (2021) have conducted investigations into the underlying factors that influence the rates of phytoplankton growth and grazing losses in the waters surrounding Peninsular Malaysia.

Meanwhile, extensive reports on macrobenthos and microphytobenthos studies have been reported in the Proceedings of the Second Technical Seminar on Marine Fishery Resources Survey in the East Coast of Peninsular Malaysia, Sabah, and Sarawak by the Southeast Asian Fisheries Development Center (Boonyapiwat, 1994; Lirdwitayaprasit, 1999; Piamthipmanus, 1999), including another report produced from the fisheries survey in the exclusive economic zone (EEZ) of Malaysia 1997-1999 by Solahuddin and Wan Mohd Lotfi (2001). Other studies on the diversity and abundance of soft sediment macrobenthic communities and invertebrates have been reported by Ahmad et al. (2002), Muhamad Darif et al. (2016), and Mohd Rafi et al. (2020), while John et al. (2013) described the macrobenthic diversity in horseshoe crab nesting grounds in Balok, Pahang. There are also checklist updates of the marine epibenthic invertebrate species from Mersing, Johor (Wan-Lotfi et al., 2010) and the checklist of gastropods from the EEZ of Sarawak (Wan Zabidii et al., 2017), in addition to a report on the biodiversity and conservation status of the marine gastropods (Mollusca; Gastropoda) in Pulau Bidong, Terengganu, Malaysia (Baharuddin and Zakarian, 2018). A new species of *Pereionotus* (Amphipoda, Senticaudata, Phliantidae) from Pulau Tinggi, Sultan Iskandar Marine Park, has also been reported (Feirulsha and Abdul Rahim, 2020). In addition, the sea cucumber *Holothuria scabra* (sandfish) habitat and distribution in Peninsular Malaysia have been described by Ilias (2006), while advances in the usage of spicules as a sea cucumber identification method for *Stichopus horrens* from Pulau Langkawi and Pulau Pangkor (Ilias, 2006) and morphological and molecular identification of sea cucumber *Holothuria scabra*, *Stichopus horrens*, and *Stichopus ocellatus* from Kudat, Sabah are also available (Kamarudin et al., 2017).

Other ecological studies on macrobenthos groups, i.e., polychaetes, include the effects of environmental factors on polychaete assemblage in Penang National Park, Malaysia (Gholizadeh et al., 2012) and polychaetous annelid community structure about soft bottom sediment characteristics in the continental shelf of the Southern China Sea (Rosli et al., 2018). Meanwhile, much less popular types of marine benthos studies, such as an ecological study of free-living marine nematodes in Teluk Awar, Sarawak (Chen et al., 2013), marine palynomorphs dominated by heterotrophic organisms remain in the tropical coastal shallow-water sediment; the case of the Selangor coast and the estuary of the Sungai Manjung (Matsuoka et al., 2017), the ecological approaches and spatial distributions of dinoflagellates (Hamdan et al., 2017), and the distribution and zonation of barnacles around the intertidal shores of Pulau Pinang (Amir et al., 2013). Other studies include the detailed description of the distribution and population biology of cephalopods in the EEZ of Malaysia (Samsudin, 2001), reproductive seasonality and maturation of the sergestid shrimp *Acetes japonicus* (Decapoda: Sergestidae) in coastal waters of Melaka, Peninsular Malaysia (Amin et al., 2010), the first record of jellyfish *Anomalorhiza shawi* Light, 1921 (Cnidaria: Scyphozoa) and its associated organisms in Sabah (Chuan et al., 2020), the first record in Peninsular Malaysia and morphological redescription of *Lychnorhiza malayensis* (Scyphozoa: Rhizostomeae: Lychnorhizidae)

(Syazwan et al., 2020), and preliminary investigation of marine microbial diversity in Peninsular Malaysia (Mohd Effendy Abd. Wahid et al., 2011).

Species composition and diversity of fish have been reported in the Proceedings of the Second Technical Seminar on Marine Fishery Resources Survey in the East Coast of Peninsular Malaysia, Sabah, and Sarawak by the Southeast Asian Fisheries Development Center (Vidthayanon, 1999; Rumpet et al., 1999; Vidthayanon, 1999). Other studies include the potential resources and species composition of commercial fish in the untrawlable areas off the Sarawak coast (Basir et al., 2006), Chondrichthyan biodiversity in Malaysia and Brunei Darussalam (Ahmad et al., 2011), and commercially important marine fish and invertebrate species landed by fishermen in Pulau Mantanani (Ransangan and Madin, 2015).

Other studies include the fish diversity and abundance in Pulau Bidong, South China Sea (Rumeaida et al., 2014), ichthyofauna on a tropical mudflat: implications of spatial and temporal variability in assemblage structure and abundance (Lee et al., 2016), terminal report data collection on sharks and rays by species in Tawau, Sabah (Abd Haris Hilmi et al., 2020), and mapping the distribution of *Rastrelliger kanagurta* in the EEZ of Malaysia using the maximum entropy modeling approach (Yusop and Mustapha, 2018). Specific reports on the occurrence of particular species have also been recorded, such as the occurrence and ecological implications of a tropical anguillid eel, *Anguilla marmorata,* from Peninsular Malaysia (Abdul Kadir et al., 2017), including those that are the first records of *Opistognathus nigromarginatus* Rüppell, 1830 (Perciformes, Opistognathidae), bridled jawfish (Jaafar et al., 2019), the first record of a tropical mottled eel, *Anguilla bengalensis bengalensis* (Actinopterygii: Anguillidae) from the Langkawi Islands (Arai, 2014), and the first records of the sole *Aseraggodes kobensis* (Steindachner, 1896) by Okamoto et al. (2019).

Population Dynamics

Research on population dynamics covers mainly studies on fish stock status, such as the stock status and management scheme of Kerisi *Nemipterus peronii* on the East Coast of Peninsular Malaysia (Kimoto and Johari, 1996), the population structure of some commercially important fishes in Malaysian waters (Mansor et al., 2001), potential resources and species composition of the commercial fish in the untrawlable areas off Sarawak coast (Basir et al., 2006), a preliminary study report, and the status of resources and habitats in Batuan Tengah and Tubir Selatan waters, Johor (Department of Fisheries, 2009). In addition, there were studies on temporal variation in the community structure of dragnet (pukat tarik) fishery concerning ecological variables in an inshore area of Sarawak (Abu Hena et al., 2021), demersal fish stock assessment in the inshore area of the East Coast of Peninsular Malaysia (Sharum, 2002), the population structure of some commercially essential fishes in coastal fisheries of the East Coast of Peninsular Malaysia (Syed Abdullah et al., 2002), determination of fishing grounds distribution of the Indian Mackerel in Malaysia's EEZ off the South China Sea using boosted regression trees model (Kamaruzzaman et al., 2021) and fishery, biology, and population characteristics of Kawakawa in Perlis the West Coast Of Peninsular Malaysia (Jamon et al., 2016).

Other studies include stock assessment and biomass estimation by the hydro-acoustic method in Sabah, Sarawak, and Peninsular Malaysia (Rajali et al., 1999; Theparoonrat, 1999; Theparoonrat et al., 1999), multi-species fish stock assessment by the acoustic method in the East Coast of Peninsular Malaysia (Gambang et al., 1999), acoustic and pelagic fish resource survey on the West Coast of Peninsular Malaysia (Raja Bidin et al., 2009), the influence of weather condition on marine fish landings in Kota Kinabalu, Sabah, Malaysia (Ho et al., 2013), length-frequency distribution and age composition of groupers (Serranidae) of EEZ of East Coast of Peninsular Malaysia and its implication to fisheries management (Piah et al., 2018), the establishment of fisheries refugia as a new approach to sustainable management of fishing in Malaysian waters (Siow et al., 2019). In addition, there are also studies on the population parameters of dominant finfish and cephalopod species caught in the offshore areas of Malaysia (Mahyam et al., 2001) and the prawn resource assessment of Lawas (Sarawak), Federal Territory (FT) Labuan, and Sabah coastal waters (Rajali et al., 2016).

Spawning and Nesting Grounds

Most studies reported fish spawning (53%), followed by invertebrates, macrobenthos, and corals (Figure 2). There were varieties of fish species that have been reported during its spawning events in Malaysia. For example, there are studies on the kinds, abundance, and distribution of fish larvae in the East Coast of Peninsular Malaysia, Sabah, and Sarawak (Termvidchakorn, 1999; Daud et al., 2006), the distribution of fish larvae in the coastal area of the East Coast of Peninsular Malaysia (Zilkifli et al., 2020), and the relative abundance and growth of the male and female *Nemipterus furcosus* population (Amira et al., 2016). In addition, Arai and Abdul Kadir studied the opportunistic spawning of tropical anguillid eels, *Anguilla bicolor*, and *A. bengalensis bengalensis* (2017).

Even though it is limited but the descriptions of spawning activities among the invertebrates group included the species composition, abundance, and distribution of cephalopod paralarvae in Sabah and Sarawak (Thapthim, 2002), morphometric relationship, and the spawning season of *Acetes intermedius* from the coast of Miri Sarawak (Musel et al., 2019), sex ration, spawning season, and the size at maturity of *Parapenaeopsis sculptilis* (Heller 1862) in the coastal water of Perak (Arshad et al., 2016), distribution of zooplankton community in Toli shad *Tenualosa toli* habitats in Sarawak (Aiman et al., 2020), study on coastal oceanographic processes associated with blood cockle *Anadara granosa* induce spawning season in Kapar, Selangor (Harith et al., 2016), semi-lunar and lunar spawning periodicity in some tropical littorinid gastropods (Berry, 1986), and gonad development and spawning in *Anadara granosa* (Broom, 1983). Meanwhile, studies on the reproductive aspects of marine organisms are also included in this study, such as a study on the reproductive characteristics of *Nemipterus peronii* from the East Coast of Peninsular Malaysia (Zaki et al., 1994), jellyfish *Chrysaora* sp. in Pulau Pinang (Maghsoudlou, 2017), the sergestid shrimp *Acetes indicus* in coastal waters of Melaka, Peninsular Malaysia (Amin et al., 2009), reproductive characteristics the razor clam *Solen regularis* in the western part of Sarawak based on gonadal condition index (Rinyod and Rahim, 2011), and a study on the effects of physicochemical parameters on the reproductive pattern of sea cucumber *Holothuria scabra* in Sabah (Arsad et al., 2020).

In comparison to other forms of marine creatures, reports of coral spawning are infrequent. Publications on coral spawning, when accessible, primarily cover dispersal and synchronous spawning patterns. Coral spawning research includes the first record of multi-species synchronous coral spawning from Malaysia (Chelliah et al., 2015), dispersal pattern of coral larvae in Kuantan coastal waters (Mohd Hanapiah et al., 2020), in situ observations of coral spawning and spawn slick at Lankayan Island, Sabah (Gan et al., 2021), broadcast spawning pattern and pelagic larvae duration of *Acropora cytherea* and *A. clathrata* from inshore reef area in Kuantan coastal region (Mohd Hanapiah et al., 2020), and multispecific synchronous coral spawning on Pulau Bidong, Malaysia, South China Sea (Chun Hong Tan et al., 2020).

Spawning and nesting behaviour of *Tachypleus gigas* along the East Coast of Peninsular Malaysia (Zaleha et al., 2012), trailing the spawning horseshoe crab *T. gigas* at designated natal beaches on the East Coast of Peninsular Malaysia (Manca et al., 2016; Mat Zauki et al., 2019), spermiogram of wild and captive Malaysian horseshoe crab *T. gigas* from Pantai Balok, Pahang (Hassan et al., 2019), and the horseshoe crab and its spawning ground condition in Johor Lama, Johor (Md Razak et al., 2022). In addition, Fairuz-Fozi et al. (2018) conducted research on the *Carcinoscorpius rotundicauda* population status and spawning behaviour on the Pendas coast of Peninsular Malaysia.

There were also studies on the spawning activities for the marine species associated with seagrass, mangrove, and estuarine habitats such as a report on the environment and diversity of ichthyoplankton in the seagrass beds of Sungai Pulai estuary (Ara et al., 2011), larval fish assemblages in a tropical mangrove estuary and adjacent coastal waters associated with offshore–inshore flux of marine and estuarine species (Ooi and Chong, 2011), influence of environmental parameters on shrimp post-larvae in the Sungai Pulai seagrass beds of Johor Strait, Peninsular Malaysia (Arshad et al., 2011), larval fish composition and spatio-temporal variation in the estuary of Sungai Pendas, southwestern Johor (Arshad et al., 2012), population structure and reproduction of the mysid shrimp *Acanthomysis thailandica* (Ramarn et al., 2012), fish larval occurrence and distribution in the seagrass-mangrove ecosystems of the Johor Straits (Ara et al., 2014), composition and diversity of larval fish in the mangrove estuarine area of Marudu Bay, Sabah (Rezagholinejad et al., 2016), study on the identification of the spawning estuaries of the tropical shad, terubok *Tenualosa toli*, using otolith microchemistry (Milton et al., 1997).

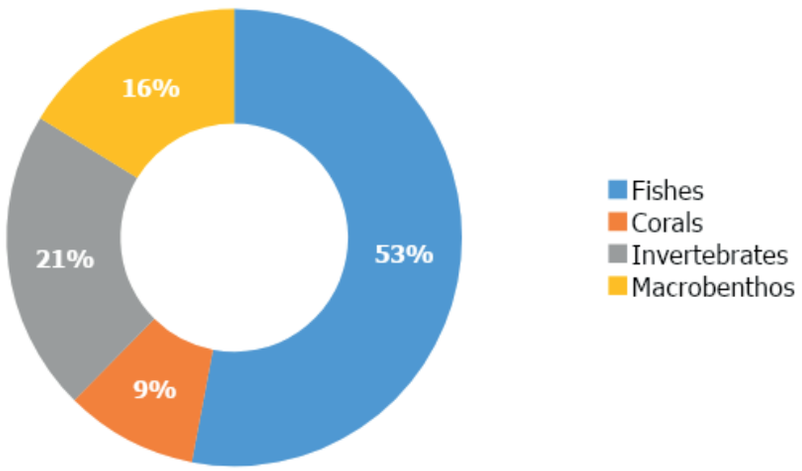


Figure 2 The percentage of the number of studies that report on the occurrence of the spawning process of different marine organisms within Malaysian waters

Trophic Dynamic

Examples of trophic dynamics include studies on the relative importance of benthic microalgae, phytoplankton, and mangroves as sources of nutrition for penaeid prawns and other coastal invertebrates (Newell et al., 1995), natural diet of blue swimming crab, *Portunus pelagicus* at Strait of Tebrau, Johor (Ikhwanuddin et al., 2014), food sources of ark shell, *Scapharca cornea* as indicated by fatty acid markers (Bachok, 2017), filtration rate of mud clam *Polymesoda erosa,* subjected to their function on the intertidal flat of Setiu Wetlands (Mohd Saleh et al., 2017), food availability estimation of the blood cockle, *Anadara granosa* from the aquaculture grounds of the Selangor coast (Yurimoto et al., 2021), feeding mechanisms of adult tropical horseshoe crab, *Tachypleus gigas* towards feed conditions (Kassim, 2019), investigating factors driving phytoplankton growth and grazing loss rates in waters around Peninsular Malaysia (Lim et al., 2021).

Meanwhile, trophic dynamics studies of fishes include feeding habits and temporal variation of diet composition of fish larvae Family Sparidae, Clupeidae and Gobiidae in the Sungai Pulai seagrass bed, Johor (Azwady and Mazlan, 2009; Ara et al., 2010; Ara et al., 2011), identification of food and feeding habits of mullet fish *Liza subviridis* and *Valamugil buchanani* from Merbok Estuary, Kedah (Fatema et al., 2013), feeding behaviour and stomach content analysis of *Leivistrombus canarium* from the Merambong Shoal, Johor (Cob et al., 2014), dynamic fatty acid profiles of Asian sea bass *Lates calcarifer* from Setiu Wetlands, Terengganu (Chan et al., 2021), length-weight relationship, condition factor and feeding habit of fishes from mangrove of Santubong estuary, Sarawak (Idrus et al., 2021), influence of season and feeding intensity on the fatty acid composition of wild cobia *Rachycentron canadum* in the Dungun coast (Babatunde et al., 2020), feeding habits of five dominant fish species from Matang mangrove estuaries based on stomach contents and stable isotope analyses (Azim et al., 2020), and fatty acid profiles of fin fish in Pulau Langkawi (Osman et al., 2007).

Seascape and Connectivity

Seascape and connectivity studies typically incorporate both physical and biological elements of research to elucidate the leading biological research questions concerning habitat connectivity, such as the movements or migration of endangered marine megafauna such as whale sharks (*Rhincodon typus)* using satellite telemetry (Eckert et al., 2022) or the study of coastal oceanographic processes associated with blood cockle (*Anadara granosa)* spawning events (Harith et al., 2016). Another example includes studies on the hydrology and ecology of the nesting grounds for some marine endangered species, namely the horseshoe crab and the green sea turtle, *Chelonia mydas*. It has been shown that satellite telemetry is also helpful for movement tracking studies on other marine species, such as sea turtles. Also, a recent study by Fairuz-Fozi et al. (2021) showed that the maternal marker sequence (COI) can be used to tell the genetic difference between horseshoe crab populations in the Straits of Malacca and along the southern coasts of Peninsular Malaysia.

Attributes of Ecological Processes

Numerous additional characteristics are integral to the functioning of marine ecosystems, including physicochemical processes that are not biologically mediated but can significantly impact other vital processes within our marine systems. These processes encompass the nutrient cycle, as well as biological activities like respiration, photosynthesis, and productivity. For instance, Saadon et al. (1999) and Snidvongs (2021) conducted research on the physical attributes of water masses, eostrophic currents, as well as divergence and convergence phenomena in the South China Sea. Additional examples encompass the distribution pattern and mapping of sea surface temperature and total suspended particles (Ku-Kassim and Mohd Nasir, 2001; Ku-Kassim, 2001). Akhir et al. (2015) revealed a significant instance of physical oceanography research, which pertained to the identification of upwelling along Peninsular Malaysia during the Southwest Monsoon.

Two recent studies (Zainol and Akhir, 2016; Uning et al., 2022) have examined the variations in nutrient levels during the upwelling season along the East Coast of Peninsular Malaysia. These studies have also investigated the relationship between upwelling events and factors such as hydrography, current circulation, and phytoplankton biomass in the coastal waters. By integrating physical oceanography with key biological and ecological processes, these studies contribute to our understanding of the complex interactions occurring in marine environments. Previous researchers, like Tengku Rozaina and Yusoff (1999) and Tengku Rozaina (2001), have conducted investigations on chemical elements, specifically ortho-phosphate and dissolved carbonate-carbon dioxide, in the South China Sea. Furthermore, extensive research has been conducted into the distribution and composition of photosynthetic pigments, as evidenced by experiments conducted by Snidvongs in 1999.

Numerous vital ecological processes transpire not alone inside the water column of the ocean, but also at the profound depths of its seabed. The previous researchers have conducted studies on the sedimentological characteristics and nutrient diagenesis in the bottom sediments of coastal waters (Chareonpanich et al., 1999; Chareonpanich and Seurungreong, 1999; Mohd-Lokman Husain et al., 1999). These studies have

examined the physical and chemical properties of the sediment samples. In addition to sedimentological processes, recent studies have focused on the marine habitat and bathymetry mapping in Malaysian Waters (Said et al., 2017; Hashim et al., 2021; Tang and Mahmud, 2021).

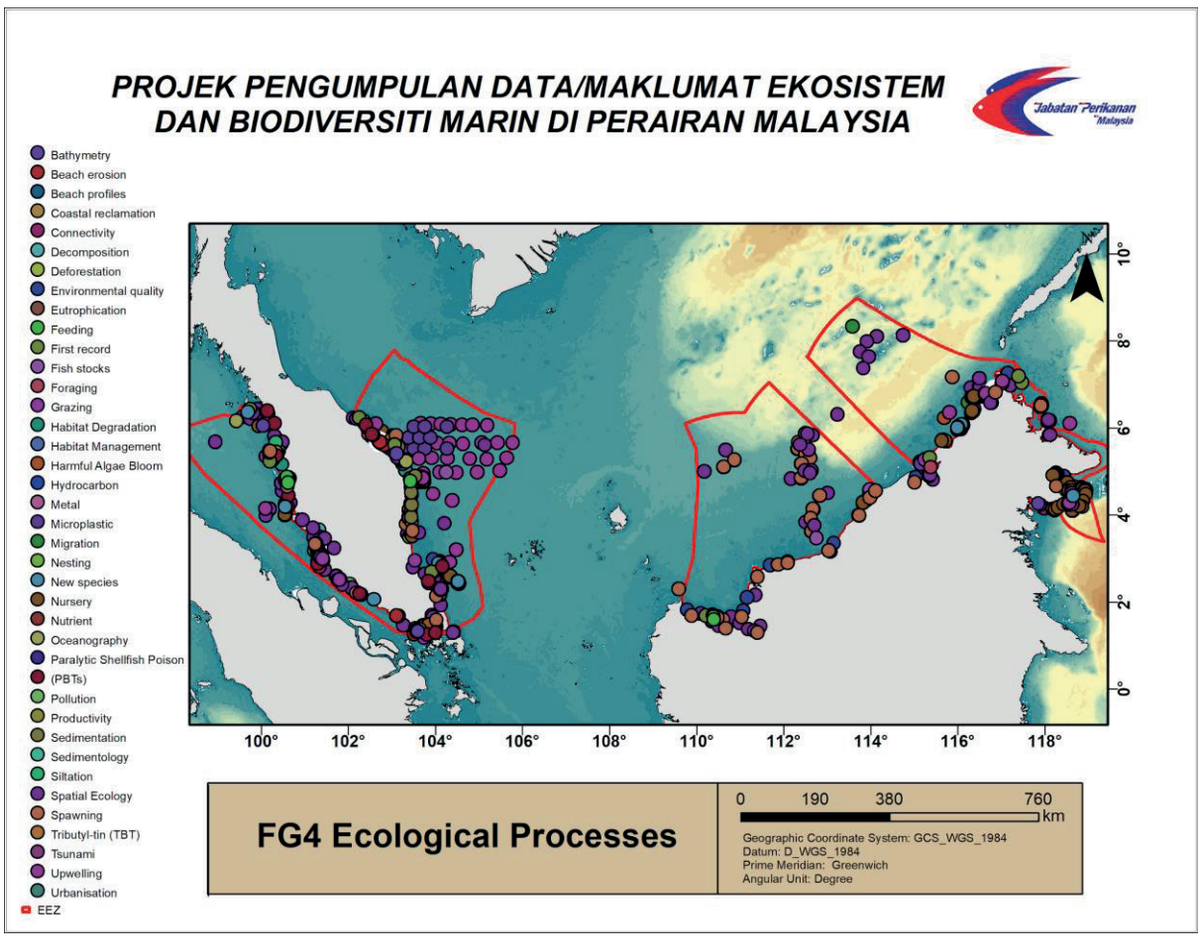


Figure 3 GIS map of the marine habitat and ecological processes, as described in this study.

Threats and Pollution

The predominant focus of research on threats has concentrated on metal pollution, with further attention given to persistent, bioaccumulative toxins (PBTs), harmful algae blooms (HABs), and microplastics. In contrast, there is a relatively smaller number of research that focuses on coastal reclamation, beach erosion, the paralytic fish poison, hydrocarbons, tsunamis, and siltation when compared to the other categories, as depicted in Figure 4.

The literature encompasses various studies examining the issue of heavy metals pollution. These studies include the analysis of metal pollution data in estuarine and coastal sediments of the Straits of Malacca (Din, 1994), investigations into trace metal concentrations and distributions in seawater of the South China Sea along the East Coast of Peninsular Malaysia, Sabah, and Sarawak (Shazili et al., 1999; Utoomprurkporn and Snidvongs, 1999), examinations of the biogeochemical implications of dissolved trace metal concentration and distribution (Utoomprurkporn et al., 1999), assessments of heavy metal contamination in water and sediment of the Port Klang coastal area, Teluk

Bahang, and Kuala Perlis (Sany et al., 2012; 2013; Zubir et al., 2018; Zanuri et al., 2020), as well as investigations on metal concentration (CO, Ni, Pb, Zn) in the estuarine and coastal waters of the western parts of the Johor Straits (Juen et al., 2014). The study conducted by Lias et al. (2013) investigated the levels of heavy metal concentrations in marine bivalves, specifically *Marcia marmorata*, as well as sediments obtained from the coastal region of Kuala Perlis in northern Malaysia.

The study conducted by Ong et al. (2018) investigated the levels of heavy metal concentration in commercially available fish during various seasons. The fish samples were obtained from the Fisheries Development Authority of Malaysia Complex, located in Kuala Terengganu, Malaysia. The study conducted by Nik-Nurasyikin et al. (2018) investigated the accumulation of metals in cultured tiger groupers (*Epinephelus fuscoguttatus*) and assessed their weekly intake levels from the East Coast of Peninsular Malaysia. In the field of hydrocarbon research, notable instances include the examination of polynuclear aromatic hydrocarbon (PAH), total aliphatic hydrocarbon (TAH), and petroleum hydrocarbon levels in the seawater and sediment found along the East Coast of Peninsular Malaysia (Rashid, 1999; Wongnapapan et al., 1999) as well as Langkawi Island (Nasher et al., 2013).

Research on microplastics in Malaysia has gained attention in recent years. For instance, studies have been conducted on the presence of marine macro- and microplastic litter in the coastal area of Kuala Perlis (Mohd Odli, 2020). Additionally, investigations have focused on the spatiotemporal distribution and isolation of microplastics in the fish species Lates calcarifer and its surrounding environment in the Setiu Wetlands (Ibrahim et al., 2017; 2021). Furthermore, research has been conducted on microplastics found in seawater and zooplankton samples collected from the Terengganu estuary and offshore waters of the South China Sea (Taha et al., 2021). Additional instances encompass the evidence pertaining to the incidence, prevalence, and dispersion of microplastic contamination within the Sungai Klang estuary (Zaki et al., 2021) and the correlation between terrestrial utilisation and marine debris within the coastal vicinity of Kuala Perlis (Odli et al., 2020).

The presence of benthic harmful dinoflagellate assemblages has been documented in the fringing reef of Pulau Sampadi in Sarawak, as well as in the coastal seas of Sabah and Johor. These findings have been reported by Tan et al. (2013), Jipanim et al. (2019), Chai et al. (2021), and Hii et al. (2021). Previous research has focused on the dinoflagellate species *Alexandrium tamiyavanichii*, which is known to produce paralytic shellfish toxins, in the vicinity of Kuantan Port (Liow et al., 2019). Additionally, investigations have been conducted on the blood cockle species *Tegillarca granosa* along the Selangor coast in Peninsular Malaysia. In the meantime, the evaluation of tsunami risks in Sabah (Tongkul et al., 2020) and their influence on demersal fish communities in the waters of Kedah and Pulau Pinang (Abu Talib et al., 2006) have been conducted.

Several studies have been conducted to examine the effects of habitat degradation on various ecosystems. For instance, Hussin (2014) investigated the implications of marine fish farming on the structure and functional diversity of benthic communities in Pulau Bidong. Another study by Yurimoto et al. (2014) focused on a mass mortality event of the

blood cockle species *Anadara granosa* in aquaculture grounds along the Selangor coast in Peninsular Malaysia. Additionally, a temporal investigation was carried out to assess the influence of aquaculture on modern foraminifera and sediments in the estuary and lagoon of Setiu Wetlands, Terengganu. The impact of human activities on the population of *Tachypleus gigas* in Tanjung Selangor has been examined in a study conducted by Raveen et al. (2015). Additionally, Nelson et al. (2017) investigated the influence of human intervention on the spawning grounds of horseshoe crabs, specifically focusing on the effects on egg development. Previous research has examined the effects of urbanisation and coastal development on mangrove forests, as well as the influence on brachyuran crabs in Pulau Pinang and the number of larval fish in Klang Strait (Stiepani et al., 2021; Chu et al., 2021).

In the field of sedimentation research, investigations have been conducted to examine the potential impacts of land-use practises on coastal seagrass populations and coral reefs located in Gaya Bay and Sepangar Bay, both situated in Sabah. These studies have been conducted by Waheed et al. (2007) and Freeman et al. (2008). Furthermore, the investigation of sedimentation has implications on the growth rates of the scleractinian coral Acropora formosa, in the fringing reefs located in Pulau Tioman (Nakajima et al., 2013). Furthermore, the scholarly works of Japar Sidek and Zakaria (2011), Abdullah and Anscelly (2016), and Hossain et al. (2019) have extensively examined the impact of urbanisation and coastal reclamation on seagrass habitats in the region spanning from Pulau Pinang to Sungai Pulai and the neighbouring Malaysian waters. The Northern Straits of Malacca, Pulau Pinang, and Klang Strait have been the subject of studies examining coastal development, reclamation, and their associated impacts (Abdullah and Dusuki, 2018; Rauff et al., 2020; Chu et al., 2021). The phenomenon of coastal or beach erosion has been the subject of investigation in three specific locations in Malaysia, namely the Kuala Setiu coastline in Terengganu, Tanjung Piai in Johor, and Pulau Carey. These studies were conducted by Hussain et al. in 1995, Awang et al. in 2014, and Fitri et al. in 2015, respectively.

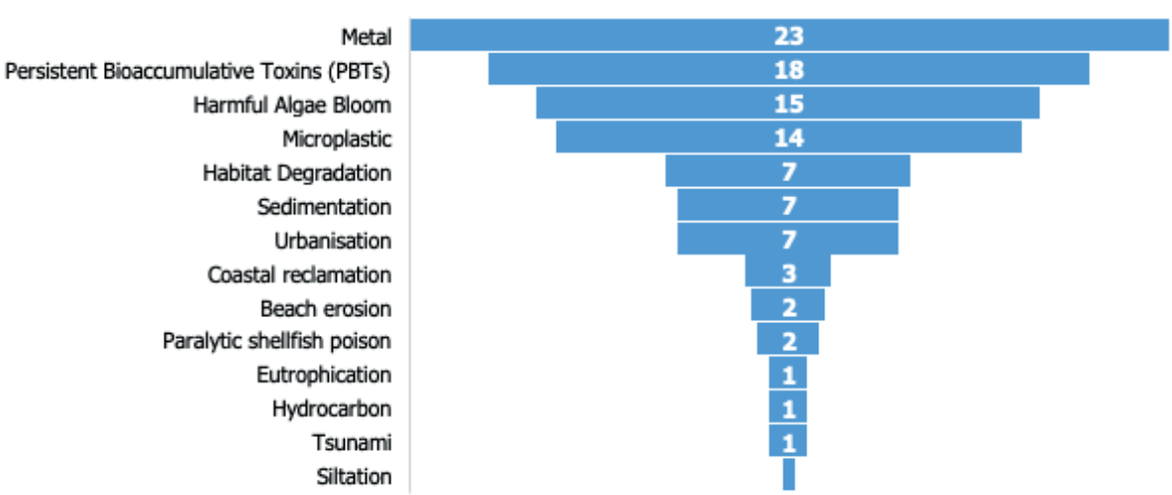


Figure 4 Types of threats and pollution studies in Malaysian coastal waters. Values represent the contribution of each category in percentage.

4.2 Habitat and Ecological Processes

Most ecological studies have been conducted in Sabah, Terengganu, Sarawak, and Johor, which encompass 18, 15, 13, and 13% of total studies (Figure 5). Other states showed less than 10% contributions to the dataset, while other states such as Perlis, Kelantan, Negeri Sembilan, and Melaka showed relatively the least amount of research with only 2% contributions.

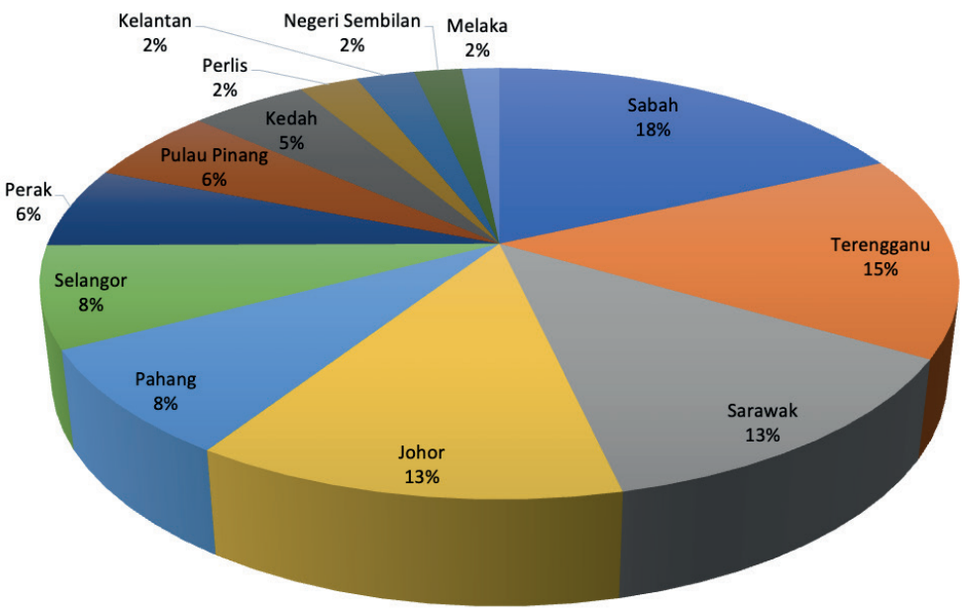


Figure 5 Relative comparison of the percentage contribution of studies conducted in different states in Malaysia.

Table 1 shows a list of marine habitats at different locations in Malaysian coastal waters with descriptions related to the ecological processes of the habitats. The table includes information on current designations for habitat protection and the species of concern for spawning or first record (if any). IUCN Status: DD = Data Deficient; EN = Endangered; VU = Vulnerable; LC = Least Concern.

Sabah

Location	Current Designation	Ecological Studies	Habitat	Species of Concern / IUCN Status
Banggi Group of Islands		Environmental	Coral reef	
Belaruan		First record	Coral reef	
Bodgaya		Biodiversity	Seagrass bed	
Bohay Dulang		Biodiversity	Seagrass bed	
Cape Layak-Layak		Biodiversity	Mangroves	
Cowie Bay		Connectivity	Coastal	
Darvel Bay		Environmental	Coral reef	
Edgell Patches, Pulau Sapi		New species	Coral reef	
Inderasabah		Biodiversity	Coastal	Tri-spine horseshoe crab (*Tachypleus tridentatus*): EN
Kapalai		Biodiversity	Coral reef	
Kota Belut		Biodiversity	Coral reef	
Kudat		Biodiversity Environmental Upwelling	Coastal Coral reef	
Pulau Langkayan		*Spawning and spawning slick	Coral reef	*Coral *Grouper (*Plectropomus leopardus)* - LC
Limau-Limauan		Biodiversity Spawning*	Coastal	*Sea cucumber (*Holothuria scabra*) - EN
Lungisan		Environmental	Sandy Beach	
Maiga		Biodiversity	Seagrass bed	
Manampilik		Biodiversity	Seagrass bed	
Marudu Bay		Spawning*	Mangroves Coastal Seagrass bed	*Fish larvae Mangrove horseshoe crab (*Carcinoscorpius rotundicauda*) - DD

Menggatal River		Biodiversity	Mangroves	*Mangrove horseshoe crab (*Carcinoscorpius rotundicauda*) – DD
Menumbok		First record	Seagrass bed	
Permatang Penyu		Biodiversity	Coral reef	
Permatang Ubi		Biodiversity	Coral reef	
Pulau Bakungan Kecil				
Pulau Bum-Bum		New species	Coral reef	
Pulau Gaya	National/State Park	Biodiversity Threats	Seagrass bed Coastal Coral reef	
Pulau Layang-layang		Biodiversity	Coral reef	
Pulau Mabul		Biodiversity	Sandy beach Rocky beach Coral reef Mangroves	
Pulau Mantanani Besar		Biodiversity Environmental	Sandy beach Coastal Coral reef	
Pulau Mantanani Kecil		Biodiversity Environmental Threats	Sandy beach Coastal Coral reef	
Pulau Bakungan Kecil		Biodiversity Threats	Seagrass bed	
Pulau Selingan	Turtle Sanctuary	Biodiversity Threats	Seagrass bed Artificial reef Coral reef	
Pulau Sipadan	National/State Park	Biodiversity	Seagrass bed Coastal Coral reef	
Pulau Tiga	National/State Park	Biodiversity	Coral reef Seagrass bed	
Pulau Udar		New species	Coral reef	
Pulau Usukan		Connectivity	Coastal	
Punang Sari		Biodiversity Threats	Seagrass bed	
Sandakan		Biodiversity Upwelling	Coastal Coral reef	
Sebangkat		Biodiversity	Seagrass bed	
Selakan		Biodiversity	Seagrass bed	
Semporna	Marine Park	Biodiversity	Coral reef	

Sepangar Bay		Biodiversity Threats	Seagrass bed Coastal Artificial reef Coral reef	
Simaggot		First record	Coral reef	
Sibaliu N		First record	Coral reef	
Sibuan		Biodiversity	Seagrass bed	
Spratly Island		Connectivity	Coastal	
Tanjung Limau		Biodiversity	Coastal	Tri-spine horseshoe crab (*Tachypleus tridentatus*) - EN
Tawau		Biodiversity* Environmental Upwelling	Coastal	*Tri-spine horseshoe crab (*Tachypleus tridentatus*) - EN
Telaga Tujuh Kunak		Biodiversity Spawning*	Coastal	*Sea cucumber (*Holothuria scabra*) - EN
Terumbu Laya		Biodiversity	Coral reef	
Terumbu Mantanani		Biodiversity	Coral reef	
Terumbu Peninjau		Biodiversity	Coral reef	
Terumbu Siput		Biodiversity	Coral reef	
Tunku Abdul Rahman Park	National/State Park	Biodiversity	Seagrass bed Coral reef	
Turtle Island		Biodiversity	Coral reef	
Tun Sakaran Marine Park	Marine Park	Biodiversity	Coral reef	

Labuan

Location	Current Designation	Ecological Studies	Habitat	Species of Concern / IUCN Status
Labuan		Environmental Upwelling	Coastal	
Pulau Kuraman	Marine Park	Biodiversity	Coral reef	
Pulau Rusukan Besar	Marine Park	Biodiversity	Coral reef	
Pulau Rusukan Kecil	Marine Park	Biodiversity	Coral reef	

Terengganu

Location	Current Designation	Ecological Studies	Habitat	Species of Concern / IUCN Status
Batu Rakit		Environmental	Sandy beach	
Besut		Environmental Biodiversity Threats	Sandy beach	
Dungun		Biodiversity	Coastal	
Kelulut		Environmental	Sandy beach	
Kemaman Harbour		Environmental Threats	Sandy beach	
Kemasik		Environmental	Sandy beach	
Kuala Abang		Environmental	Sandy beach	
Kuala Terengganu		Biodiversity Upwelling Spawning*	Estuary Coastal	*Notched butterfly bream (*Nemipterus peronii)*
Merchang Lagoon		Biodiversity	Seagrass bed	
Paka		Biodiversity Environmental Threats	Seagrass bed Sandy beach	
Penarik		Environmental Threats	Sandy beach Coastal	
Pengkalan Nangka		Biodiversity Environmental Threats	Seagrass bed	
Pantai Vietnam		Biodiversity	Coastal	*Coral *Coral fishes
Pulau Bidong		Biodiversity Spawning* First record**	Coral reef Coastal	**Milkfish sole (*Aseraggodes kobensis)* - LC **Bridled Jawfish (*Opistognathus nigromarginatus*) - LC
Pulau Kapas	Marine Park	Biodiversity	Estuary Coastal Seagrass bed	
Pulau Karah		Biodiversity	Coral reef Coastal	
Pulau Kerengga Besar	Marine Park	Biodiversity	Coral reef Coastal	
Pulau Kerengga Kecil	Marine Park	Biodiversity	Coral reef Coastal	

Pulau Lima	Marine Park	Biodiversity	Coral reef Coastal	
Pulau Paku Besar	Marine Park	Biodiversity	Coral reef Coastal	
Pulau Paku Kecil	Marine Park	Biodiversity	Coral reef Coastal	
Pulau Perhentian	Marine Park	Biodiversity Environmental Threats	Coral reef Seagrass bed	
Pulau Pinang	Marine Park	Biodiversity	Coastal	
Pulau Rawa	Marine Park	Biodiversity	Coral reef	
Pulau Redang	Marine Park	Biodiversity Trophic dynamic	Artificial reef Seagrass bed Sandy beach Rocky beach Mangroves Coral reef Coastal	
Pulau Tenggol	Marine Park	Upwelling	Coastal	
Setiu		Biodiversity Environmental Threats Spawning*	Mangroves Estuary Coastal	*Blood cockle (*Anadara cornea*) - Commercial species *Mangrove clam (*Geloina expansa*)
Tanjung Kupang		Environmental Threats	Sandy beach	
Telaga Simpul		Biodiversity Environmental Threats		Seagrass bed
Teluk Gadung		Environmental	Sandy beach	
Teluk Mak Nik		Environmental	Sandy beach	
Tok Jembal		Environmental	Sandy beach	

Sarawak

Location	Current Designation	Ecological Studies	Habitat	Species of Concern / IUCN Status
Asajaya Laut		Biodiversity	Estuary	
Batang Lupar		Biodiversity	Coastal	
Batang Sadong		Biodiversity	Coastal	
Baram Betong		Spawning Biodiversity Threats	Estuary Sandy beach	Terubok / Toli shad (*Tenualosa toli*) - VU
Bintulu Coast		Spawning	Estuary	Terubok / Toli shad (*Tenualosa toli*) - VU

Buntal River Demak River		Biodiversity Biodiversity	Estuary Estuary	
Hempasan Bentin	National/State Park	Biodiversity	Coral reef	
Hempasan Dang Ajar (Seahorse Breakers)	National/State Park	Biodiversity	Coral reef	
Jerijih		Biodiversity	Coastal	
Kabong		Biodiversity	Coastal	
Kuching		First record	Sandy beach Estuary	
Lassa		Spawning	Estuary	Terubok / Toli shad (*Tenualosa toli*) - VU
Lawas		Biodiversity	Coastal Seagrass bed Mangroves	
Limbang Lundu Lupar Lutong River	National/State Park	Spawning Spawning Spawning Biodiversity	Estuary Estuary Estuary Mangroves Rocky beach Coastal	Terubok / Toli shad (*Tenualosa toli*) – VU Terubok / Toli shad (*Tenualosa toli*) - VU Terubok / Toli shad (*Tenualosa toli*) - VU
Maludam	National/State Park	Spawning	Estuary	Terubok / Toli shad (*Tenualosa toli*) - VU
Miri Muara Tebas Mukah Niah Oya Penambir River	National/State Park	Spawning Spawning Spawning Biodiversity Spawning Biodiversity	Estuary Estuary Estuary Coastal Estuary Estuary	Terubok / Toli shad (*Tenualosa toli*) - VU Terubok / Toli shad (*Tenualosa toli*) - VU Terubok / Toli shad (*Tenualosa toli*) - VU Terubok / Toli shad (*Tenualosa toli*) - VU
Pulau Sampadi		Biodiversity Threats	Coastal	
Punang		Biodiversity	Coastal	
Samarahan		Biodiversity	Sandy beach	
Semariang Mangrove Area		Biodiversity	Mangroves	
Sematan		Biodiversity	Coastal	

Similajau		Biodiversity	Coastal	
Sibuti River estuary	Wildlife Sanctuary/ Reserve	Biodiversity	Estuary	Terubok / Toli shad (*Tenualosa toli*) - VU
Teluk Awar		Biodiversity	Coastal	
Terumbu Asun (Hardie Reef)	National/State Park	Biodiversity	Coral reef	
Terumbu Datuk Landih (Aitken Reef)	National/State Park	Biodiversity	Coral reef	
Terumbu Permaisuri (Moody Reef)	National/State Park	Biodiversity	Coral reef	
Terumbu Sahab (Stignant Reef)	National/State Park	Biodiversity	Coral reef	
Terumbu Saji (Herald Reef)	National/State Park	Biodiversity	Coral reef	
Terumbu Semarang Barat Besar		Biodiversity	Coral reef	
Sadong		Spawning	Estuary	Terubok / Toli shad (*Tenualosa toli*) - VU

Johor

Location	Current Designation	Ecological Studies	Habitat	Species of Concern / IUCN Status
Batuan Tengah		Fish stock	Coastal	
Gelang Patah		Biodiversity	Coastal Estuary Seagrass bed	
Iskandar Marine Park	Marine Park	Biodiversity	Seagrass bed	
Kota Tinggi		Biodiversity Spawning*	Coastal	* Mangrove horseshoe crab (*Carcinoscorpius rotundicauda*) – DD *Horseshoe crab (*Tachypleus gigas*) - DD
Mersing		Biodiversity	Coastal	
Muar		Environmental Biodiversity Threats	Coastal Estuary	
Pantai Lido		Biodiversity Environmental Threats	Sandy beach	Mangrove horseshoe crab (*Carcinoscorpius rotundicauda*)
Pantai Punggur		Environmental	Coastal	
Pasir Puteh		Biodiversity Environmental Threats	Sandy beach	Mangrove horseshoe crab (*Carcinoscorpius rotundicauda*)
Pendas		Biodiversity Connectivity Fish stocks* Spawning**	Estuary Mangroves Seagrass bed	*Ray-finned fish (Family Clupeidae) - Commercial species **Mangrove horseshoe crab (*Carcinoscorpius*

		Trophic dynamic Threats		*rotundicauda*) - DD
Pulai Estuary		Biodiversity	Coastal Seagrass bed	
Pulau Aur	Marine Park	Biodiversity	Sandy beach Rocky beach Coral reef Mangroves Seagrass bed	
Pulau Besar		Biodiversity Connectivity	Coral reef Coastal Seagrass bed	
Pulau Merambong		Biodiversity Trophic dynamic The first record* Threats	Sandy beach Rocky beach Coral reef Mangroves Coastal Seagrass bed	*Sea stars (Order Paxillosida and Valvatida)
Pulau Pemanggil	Marine Park	Biodiversity	Coral reef	
Pulau Pisang		Biodiversity	Coastal	
Pulau Rawa	Marine Park	Biodiversity Connectivity*	Coastal	*Dugong (*Dugong dugon*)
Pulau Seribuat		Biodiversity	Coastal	
Pulau Sibu	Marine Park	Biodiversity Connectivity*	Coral reef Seagrass bed Coastal	*Dugong (*Dugong dugon*)
Pulau Tinggi	Marine Park	Biodiversity Connectivity* New species**	Coastal Estuary Seagrass bed	*Dugong (*Dugong dugon*) **Amphipoda (*Aciconula tinggiensis*)
Rengit		Biodiversity	Estuary Mangroves	
Sungai Johor		Biodiversity	Coastal Estuary Seagrass bed	
Sungai Pulai		Fish stock* Biodiversity Environmental Trophic dynamic Threats	Seagrass bed Estuary	*Family Gobiidae
Tanjung Adang Shoals		Biodiversity Environmental Threats	Seagrass bed	

Tanjung Kupang		Environmental Threats	Seagrass bed Coastal	
Tanjung Langsat		Biodiversity	Estuary Mangroves	
Tanjung Leman		Biodiversity Spawning*	Coastal	*Lobster (*Panulirus* spp. and *Thenus orientalis*)
Tanjung Piai	National/State Park	Biodiversity Threats	Estuary Mangroves	
Tebrau Strait		Biodiversity Environmental Trophic dynamic Threats	Mangroves Coastal	Blue swimming crab (*Portunus pelagicus*)
Tg. Penyabong		Biodiversity	Coastal	
Tubir Selatan		Fish stock	Coastal	

Pahang

Location	Current Designation	Ecological Studies	Habitat	Species of Concern / IUCN Status
Balok		Biodiversity Connectivity Spawning* Nesting** Threats	Mangroves Sandy beach Coral reef Estuary Muddy beach	*Coral */**Horseshoe Crab (*Tachypleus gigas*) – DD */**Mangrove horseshoe crab (*Carcinoscorpius rotundicauda)* – DD
Cherating		Biodiversity Spawning*	Sandy beach	*Horseshoe crab (*Tachypleus gigas*) - DD
Cherok Paloh		Biodiversity Nesting	Sandy beach	Horseshoe crab (*Tachypleus gigas)* – DD
Kuala Pahang		Biodiversity Connectivity	Coastal Estuary	
Kuantan Port		Biodiversity Environmental Threats	Coastal	
Pekan		Biodiversity Connectivity Nesting* Spawning*	Sandy beach Muddy beach Mangroves	*Horseshoe crab (*Tachypleus gigas*) - DD
Pulau Berhala		Biodiversity	Coral reef	
Pulau Chebeh	Marine Park	Biodiversity	Coral reef	
Pulau Sembilang - Pulau Seri Buat	Marine Park	Biodiversity Connectivity	Seagrass bed	

Pulau Tioman	Marine Park Wildlife Sanctuary/ Reserve	Biodiversity Upwelling The first record* Threats	Sandy beach Rocky beach Coral reef Mangroves Coastal	Blue-pigmented Acartiid copepod
Pulau Tulai	Marine Park	Biodiversity Environmental Threats	Coral reef	
Pulau Tumuk	Marine Park	Biodiversity Spawning	Coral reef	
Pulau Ular		Biodiversity Spawning	Coral reef	
Raja Muda		Biodiversity Spawning*	*Coral reef	
Renggis		Environmental Threats	Coral reef	
Kg. Sekokoh		Biodiversity Nesting* Connectivity	Sandy beach	*Mangrove horseshoe crab (*Carcinoscorpius rotundicauda*)
Tanjung Gosong		Biodiversity Nesting*	Sandy beach	*Horseshoe crab (*Tachypleus gigas)* – DD *Mangrove horseshoe crab (*Carcinoscorpius rotundicauda*)
Tanjung Selangor		Biodiversity Nesting* Threats	Sandy beach	*Horseshoe crab (*Tachypleus gigas)* - DD
Teluk Tekek, Pulau Tioman		Biodiversity	Sandy beach Rocky beach Coral reef Mangroves	

Selangor

Location	Current Designation	Ecological Studies	Habitat	Species of Concern / IUCN Status
Carey Island		Biodiversity Threats	Mangroves Coastal	
Kapar		Biodiversity	Coastal	
Klang Strait		Biodiversity Environmental Fish stock The first record* Threats	Mangroves Estuary Muddy beach Coastal	*Scyphozoa (*Lychnorhiza malayensis*)

Morib		Biodiversity	Mangroves	
North Selangor Peat Swamp Forest Reserve	Forest Reserve	Biodiversity	Peat swamp	
Pulau Indah		Biodiversity	Mangroves	
Port Klang		Biodiversity Environmental	Mangroves Coastal	
Selangor coast		Biodiversity Spawning Trophic dynamic	Mangroves Estuary Coastal	
Sementa		Biodiversity Environmental Threats	Mangroves Coastal	
Sepang		Biodiversity	Mangroves	
Sungai Buloh estuary		Biodiversity Environmental Threats	Estuary Coastal	
Sungai Pulai		Biodiversity Nesting	Sandy beach	Mangrove horseshoe crab (*Carcinoscorpius rotundicauda*)
West Port		Biodiversity	Mangroves Coastal	

Perak

Location	Current Designation	Ecological Studies	Habitat	Species of Concern / IUCN Status
Coral Bay		Biodiversity	Coastal	
Coral Garden		Biodiversity	Coastal	
Kuala Sepetang		Biodiversity Environmental Connectivity Threats	Mangroves Coastal	Mangrove horseshoe crab (*Carcinoscorpius rotundicauda*) - DD
Larut Matang		Biodiversity Environmental Threats	Coastal	
Lumut	Turtle Sanctuary	Biodiversity	Mangroves	
Manjung River		Biodiversity Environmental Threats	Coastal	
Matang Mangrove Forest Reserve	Forest Reserve	Biodiversity Spawning* Threats	Mangroves Coastal	*Banana prawn (*Penaeus merguiensis*) *Mysids (*Acanthomysis thailandica*)
Pengkalan Baharu		Environmental Threats	Coastal	

Permatang		Connectivity	Sandy beach	Mangrove horseshoe crab (*Carcinoscorpius rotundicauda*)
Pulau Jarak		Biodiversity	Coral reef	
Pulau Mentanggor		Biodiversity	Coastal	
Pulau Pangkor		Biodiversity	Coral reef Coastal Estuary Seagrass bed	
Pulau Sembilan	National/State Park	Biodiversity	Coral reef	
Teluk Belanga		Biodiversity	Coastal	
Terong		Biodiversity Spawning	Coastal	Rainbow shrimp (*Parapenaeopsis sculptilis*)

Pulau Pinang

Location	Current Designation	Ecological Studies	Habitat	Species of Concern / IUCN Status
Balik Pulau	Forest Reserve	Biodiversity Threats	Rocky beach Mangroves	
Batu Ferringhi		Biodiversity	Rocky beach	
Gelugor		Biodiversity	Rocky beach	
Gertak Sanggul		Biodiversity	Rocky beach	
Gurney		Biodiversity	Rocky beach	
Jelutong		Biodiversity Threats	Rocky beach Mangroves	
Jeti Pantai Jerejak		Biodiversity	Rocky beach	
Kampung Sg. Batu		Biodiversity	Rocky beach	
Kuala Juru		Biodiversity Environmental	Sandy beach	Mangrove horseshoe crab (*Carcinoscorpius rotundicauda*)
Pantai Miami		Biodiversity	Rocky beach	
Penang National Park		Biodiversity	Coastal	
Permatang Pasir		Threats	Mangroves	
Pondok Upeh River		Biodiversity	Coastal	
Pulau Betong		Environmental Threats	Coastal	
Pulau Pinang		Biodiversity	Coral reef	
Pulau Gazumbo		Biodiversity	Seagrass bed	
Queensbay		Biodiversity	Rocky beach	
Seagate		Biodiversity	Rocky beach	
Sungai Pinang Estuary		Biodiversity	Rocky beach	
Sungai Sembilang		Threats	Mangroves	

Tanjung Bungah		Biodiversity	Coastal	
Tanjung Tokong		Biodiversity Threats	Rocky beach Coastal	
Teluk Ayer Tawar		Threats	Mangroves	
Teluk Bahang		Biodiversity Threats	Rocky beach	

Kedah

Location	Current Designation	Ecological Studies	Habitat	Species of Concern / IUCN Status
Anemone Garden		Biodiversity	Coastal	
Kuala Kedah		Environmental Threats	Coastal	
Lembu Rock		Biodiversity	Coastal	
Merbok Estuary	Marine Park	Biodiversity Trophic dynamic	Mangroves Estuary	
Pantai Merdeka		Threats	Coastal	
Pulau Kaca	Marine Park	Biodiversity	Coral reef	
Pulau Langgun		Biodiversity	Coastal	
Pulau Langkawi		Biodiversity Trophic dynamic Threats	Coral reef Coastal Estuary Seagrass bed	
Pulau Lembu	Marine Park	Biodiversity	Coral reef	
Pulau Payar	Marine Park	Biodiversity	Coral reef Coastal	
Pulau Perak		Biodiversity	Coral reef	
Pulau Segantang	Marine Park	Biodiversity	Coral reef	
Pulau Singa		Biodiversity	Coastal	
Pulau Singa Besar	Sea Cucumber Protection Area	Biodiversity	Coral reef	
Pulau Songsong Tanjung Dawai		Biodiversity Threats	Coral reef Coastal	

Perlis

Location	Current Designation	Ecological Studies	Habitat	Species of Concern / IUCN Status
Kuala Perlis		Biodiversity Environmental Threats	Mangrove forest Coastal	

Kelantan

Location	Current Designation	Ecological Studies	Habitat	Species of Concern / IUCN Status
Bachok		Biodiversity	Mangroves Estuary	
Delta Kelantan		Biodiversity	Mangroves	
Kuala Besar		Environmental Threats	Coastal	
Pantai Irama		Biodiversity Environmental Threats	Coastal	
Semerak Estuary		Biodiversity Environmental Threats	Estuary Mangroves	
Sungai Gali		Environmental Threats	Coastal	

Negeri Sembilan

Location	Current Designation	Ecological Studies	Habitat	Species of Concern / IUCN Status
Cape Rachado		Biodiversity	Mangroves	
Chuah		Biodiversity Connectivity	Coastal	Mangrove horseshoe crab (*Carcinoscorpius rotundicauda*)
Linggi		Environmental Threats	Estuary	
Port Dickson		Biodiversity Environmental Threats	Coastal	
Tanjung Tuan	Fisheries Prohibited Area	Biodiversity	Coastal	

Melaka

Location	Current Designation	Ecological Studies	Habitat	Species of Concern / IUCN Status
Klebang Besar		Biodiversity	Coastal	
Pengkalan Balak		Biodiversity	Coastal	
Merlimau		Biodiversity Connectivity	Sandy beach	Horseshoe crab (*Tachypleus gigas)* Mangrove horseshoe crab (*Carcinoscorpius rotundicauda*)
Teluk Gong		Biodiversity	Coastal	

5.0 GAP ANALYSIS

Research Gaps within Locations Under Protection Designation

Based on the current gap analysis, there is a lack of studies reported in several locations that already belonged to protection designation (Table 2).

Table 2 shows the locations assigned under specific habitat designations, but much less information on the habitat and its ecological processes is available.

State	Location	Designation
Terengganu	Rantau Abang	Fisheries Prohibited Area
	Pulau Ekor Tebu	Marine Park
	Pulau Lang Tengah	Marine Park
	Pulau Nyireh	Marine Park
	Pulau Perhentian Besar	Marine Park
	Pulau Perhentian Kecil	Marine Park
	Pulau Susu Dara	Marine Park
	Pulau Yu Besar	Marine Park
	Pulau Yu Kecil	Marine Park
	Ma' Daerah	Turtle Sanctuary
	Pasir Chakar Hutan	Turtle Sanctuary
	Pasir Che Keling	Turtle Sanctuary
	Pasir Mak Kepit, Pasir Bujang dan Pasir Mak Simpan	Turtle Sanctuary
	Rantau Abang	Turtle Sanctuary
Sarawak	Pulau Satang Besar	Fisheries Prohibited Area
	Pulau Talang-talang Kecil	Fisheries Prohibited Area
	Miri-Sibuti Coral Reefs	National/State Park
	Rajang Mangrove	National/State Park
	Similajau	National/State Park
	Talang Satang	National/State Park
	Pulau Tukong-Ara & Banun (Bird Island)	Wildlife Sanctuary/Reserve
Johor	Pulau Babi Besar	Marine Park
	Pulau Babi Tengah	Marine Park
	Pulau Babi Hujong	Marine Park
	Pulau Gual	Marine Park
	Pulau Harimau	Marine Park
	Pulau Mensirip	Marine Park
	Pulau Mentigi	Marine Park
	Pulau Sibu Hujong	Marine Park
	Pulau Kukup	National/State Park
Pahang	Pulau Jahat	Marine Park
	Pulau Labas	Marine Park
	Pulau Sepoi	Marine Park
	Pulau Tokong Bahara	Marine Park
Melaka	Nine Islands	Wildlife Sanctuary/Reserve
	Tanjung Tuan	Wildlife Sanctuary/Reserve
	Pulau Besar	Fisheries Prohibited Area
	Tanjung Tuan	Fisheries Prohibited Area
	Padang Kemunting	Turtle Sanctuary

Gap Analysis on the Ecological Importance of Different Marine Habitats in Malaysian Waters

Overall, the research gaps in studies on Malaysia's marine habitat and ecological processes are summarized in the matrix table below (Table 3).

Table 3 shows the ecological importance and habitat present at each location.

STATE	LOCATION	ECOLOGICAL IMPORTANCE												HABITAT									
		BIOD	ENV	TH	UPW	SPA	FIR	NEW	NES	NUR	FIS	CON	TD	MG	CR	SG	CO	SB	RB	MB	AR	ES	PS
Sabah	Banggi Group of Islands		/												/								
	Belaruan						/								/								
	Bodgaya	/														/							
	Bohay Dulang	/														/							
	Cape Layak-Layak	/												/									
	Cowie Bay											/					/						
	Daryel Bay		/												/								
	Edgell Patches, Pulau Sapi							/							/								
	Inderasabah	/															/						
	Kapalai	/													/								
	Kota Belut	/													/								
	Kudat	/	/		/	/									/		/						

	Pulau Langkayan					/									/							
	Limau-Limauan Kudat	/				/											/					
	Lungisan		/															/				
	Maiga	/														/						
	Manampilik	/														/						
	Marudu Bay					/								/		/	/					
	Menggatal River	/												/								
	Menumbok						/									/						
	Permatang Penyu	/																				
	Permatang Ubi	/																				
	Pulau Bum-Bum							/							/							
	Pulau Gaya	/		/											/	/	/					
	Pulau Layang-layang	/													/							
	Pulau Mabul	/												/	/			/	/			

	Pulau Mantanani Besar	/	/												/		/	/					
	Pulau Mantanani Kecil	/	/	/											/		/	/					
	Pulau Bakungan Kecil	/		/												/							
	Pulau Selingan	/		/											/	/					/		
	Pulau Sipadan	/													/	/	/						
	Pulau Tiga	/													/	/							
	Pulau Udar							/							/								
	Pulau Usukan											/					/						
	Punang Sari	/		/												/							
	Sandakan	/			/										/		/						
	Selakan	/														/							
	Semporna	/													/								
	Sepangar Bay	/		/											/	/	/				/		
	Simaggot						/								/								

	Sibaliu N						/								/								
	Sibuan	/														/							
	Spratly Island											/					/						
	Tanjung Limau	/															/						
	Tawau	/	/		/												/						
	Telaga Tujuh Kunak	/				/											/						
	Terumbu Laya	/																					
	Terumbu Mantanani	/																					
	Terumbu Peninjau	/																					
	Terumbu Siput	/																					
	Tunku Abdul Rahman National Park	/													/	/							
	Turtle Island	/													/								
	Tun Sakaran Marine Park	/													/								
Labuan	Labuan		/		/												/						

	Pulau Kuraman	/													/								
	Pulau Rusukan Kecil	/													/								
	Pulau Rusukan Besar	/													/								
Terengganu	Batu Rakit		/															/					
	Besut	/	/	/														/					
	Dungun	/															/						
	Kelulut		/															/					
	Kemaman Harbour		/	/														/					
	Kemasik		/															/					
	Kuala Abang		/															/					
	Kuala Terengganu	/			/	/											/					/	
	Merchang Lagoon	/														/							
	Paka	/	/	/												/		/					
	Penarik		/	/													/	/					

	Pengkalan Nangka	/	/	/												/							
	Pantai Vietnam	/															/						
	Pulau Bidong	/				/	/								/		/						
	Pulau Kapas	/														/	/					/	
	Pulau Karah	/													/		/						
	Pulau Kerengga Besar	/													/		/						
	Pulau Kerengga Kecil	/													/		/						
	Pulau Lima	/													/		/						
	Pulau Paku Besar	/													/		/						
	Pulau Paku Kecil	/													/		/						
	Pulau Perhentian	/	/	/											/	/							
	Pulau Pinang	/															/						
	Pulau Rawa	/													/								

	Pulau Redang	/								/			/	/	/	/	/	/	/		/		
	Pulau Tenggol				/													/					
	Setiu	/	/	/		/								/			/					/	
	Tanjung Kupang		/	/														/					
	Telaga Simpul	/	/	/												/							
	Teluk Gadung		/															/					
	Teluk Mak Nik		/															/					
	Tok Jembal		/															/					
Sarawak	Asajaya Laut	/																				/	
	Batang Lupar	/															/						
	Batang Sadong	/															/						
	Baram					/																/	
	Betong	/		/														/					
	Bintulu Coast					/																/	
	Buntal River	/																				/	
	Demak River	/																				/	
	Hempasan	/													/								

	Bentin																						
	Hempasan Dang Ajar (Seahorse Breakers)	/													/								
	Jerijih	/															/						
	Kabong	/															/						
	Kuching						/											/				/	
	Lassa					/																/	
	Lawas	/														/	/						
	Limbang					/																/	
	Lundu					/																/	
	Lupar					/																/	
	Lutong River	/												/									
	Maludam					/																/	
	Miri					/																/	
	Muara Tebas					/																/	
	Mukah					/																/	
	Niah	/															/						

	Oya					/																/	
	Penambir River	/																				/	
	Pulau Sampadi	/		/													/						
	Samarahan	/																/					
	Semariang Mangrove Area	/												/									
	Sematan	/															/						
	Sibuti River estuary	/																				/	
	Teluk Awar	/															/						
	Terumbu Asun (Hardie Reef)	/													/								
	Terumbu Datuk Landih (Aitken Reef)	/													/								
	Terumbu Permaisuri (Moody Reef)	/													/								
	Terumbu	/													/								

	Sahab (Stignant Reef)																						
	Terumbu Saji (Herald Reef)	/													/								
	Terumbu Semarang Barat Besar	/													/								
	Sadong					/																/	
Johor	Batuan Tengah										/						/						
	Gelang Patah	/														/	/					/	
	Iskandar Marine Park, Station 4 (IMP-ST4)	/														/							
	Kota Tinggi	/				/											/						
	Mersing	/															/						
	Muar	/	/	/													/					/	
	Pantai Lido	/	/	/														/					
	Pantai Punggur		/														/						
	Pasir Puteh	/	/	/														/					

	Pendas	/		/		/					/	/	/	/		/						/	
	Pulai Estuary	/														/	/						
	Pulau Aur	/												/	/	/		/	/				
	Pulau Besar	/										/			/	/	/						
	Pulau Merambong	/		/			/						/	/	/	/	/	/	/				
	Pulau Pemanggil	/													/								
	Pulau Pisang	/															/						
	Pulau Rawa	/										/					/						
	Pulau Seribuat	/															/						
	Pulau Sibu	/										/			/	/	/						
	Pulau Tinggi	/						/				/				/	/					/	
	Rengit	/												/								/	
	Sungai Johor	/														/	/					/	
	Sungai Pulai	/	/	/							/		/			/						/	
	Tanjung Adang Shoals	/	/													/							
	Tanjung		/	/												/	/						

	Kupang																						
	Tanjung Langsat	/												/								/	
	Tanjung Piai	/		/										/								/	
	Tebrau Strait	/	/	/									/										
	Tg. Penyabong	/															/						
	Tubir Selatan										/						/						
Pahang	Balok	/		/		/			/			/		/	/			/		/		/	
	Cherating	/				/												/					
	Cherok Paloh	/							/									/					
	Kuala Pahang	/										/					/						
	Kuantan Port	/	/	/													/						
	Pekan	/				/			/			/		/				/		/			
	Pulau Berhala	/													/								
	Pulau Chebeh	/													/								
	Pulau Sembilang - Pulau Seri Buat	/										/				/							

	Pulau Tioman	/		/	/		/							/	/		/	/	/				
	Pulau Tulai	/	/	/											/								
	Pulau Tumuk	/				/									/								
	Pulau Ular	/				/									/								
	Raja Muda	/				/									/								
	Renggis		/	/											/								
	Kg. Sekokoh	/							/			/						/					
	Tanjung Gosong	/							/									/					
	Tanjung Selangor	/		/					/									/					
	Teluk Tekek, Pulau Tioman	/												/	/			/	/				
Selangor	Carey Island	/		/										/			/						
	Kapar	/															/						
	Klang Strait	/	/	/			/				/			/			/			/		/	
	Morib	/												/									
	North Selangor Peat Swamp Forest	/																					/

	Reserve																						
	Pulau Indah, Klang	/												/									
	Port Klang	/	/											/			/						
	Selangor coast	/				/							/	/			/					/	
	Sementa	/	/	/										/			/						
	Sepang	/												/									
	Sungai Buloh estuary	/	/	/													/					/	
	Sungai Pulai	/							/									/					
	West Port	/												/			/						
Perak	Coral Bay	/															/						
	Coral Garden	/															/						
	Kuala Sepetang	/	/	/	/							/		/			/						
	Larut Matang	/	/	/													/						
	Lumut	/												/									
	Manjung River	/	/	/													/						
	Matang	/		/		/								/			/						

	Mangrove Forest Reserve																						
	Pengkalan Baharu		/	/													/						
	Permatang											/						/					
	Pulau Jarak	/													/								
	Pulau Mentanggor	/															/						
	Pulau Pangkor	/													/	/	/					/	
	Pulau Sembilan	/													/								
	Teluk Belanga	/															/						
	Terong	/				/											/						
Pulau Pinang	Balik Pulau	/		/										/					/				
	Batu Ferringhi	/																	/				
	Gelugor	/																	/				
	Gertak Sanggul	/																	/				
	Gurney	/																	/				

	Jelutong	/		/										/					/				
	Jeti Pantai Jerejak	/																	/				
	Kampung Sg. Batu	/																	/				
	Kuala Juru	/	/															/					
	Pantai Miami	/																	/				
	Penang National Park	/															/						
	Permatang Pasir			/										/									
	Pondok Upeh River	/															/						
	Pulau Betong		/	/													/						
	Pulau Pinang	/													/								
	Pulau Gazumbo	/														/							
	Queensbay	/																	/				
	Seagate	/																	/				
	Sungai Penang Estuary	/																	/				

	Sungai Sembilang			/										/									
	Tanjung Bungah	/															/						
	Tanjung Tokong	/		/													/		/				
	Teluk Ayer Tawar			/										/									
	Teluk Bahang	/		/															/				
Kedah	Anemone Garden	/															/						
	Kuala Kedah		/	/													/						
	Lembu Rock	/															/						
	Merbok Estuary	/											/	/								/	
	Pantai Merdeka			/													/						
	Pulau Kaca	/													/								
	Pulau Langgun	/															/						
	Pulau Langkawi	/		/									/		/	/	/					/	

	Pulau Lembu	/													/							
	Pulau Payar	/													/		/					
	Pulau Perak	/													/							
	Pulau Segantang	/													/							
	Pulau Singa	/															/					
	Pulau Singa Besar	/													/							
	Pulau Songsong	/													/							
	Tanjung Dawai	/		/											/		/					
Perlis	Kuala Perlis	/	/	/										/			/					
Kelantan	Bachok	/												/							/	
	Kelantan Delta	/												/								
	Kuala Besar		/	/													/					
	Pantai Irama	/	/	/													/					
	Semerak Estuary	/	/	/																	/	
	Sungai Gali		/	/													/					

Negeri Sembilan	Cape Rachado	/												/									
	Chuah	/										/					/						
	Linggi		/	/																		/	
	Port Dickson	/	/	/													/						
	Tanjung Tuan	/															/						
Melaka	Klebang Besar	/															/						
	Pengkalan Balak	/															/						
	Merlimau	/										/						/					
	Teluk Gong	/															/						

Ecological importance: BIOD=Biodiversity, ENV=Environmental, TH=Threats, UPW=Upwelling, SPW=Spawning, FIR=First record, NEW=New species, NES=Nesting area, NUR=Nursery area, FIS=Fish stock, CON=Connectivity, TD=Trophic dynamic; Habitat: MG=Mangrove, CR=Coral Reefs, SG=Seagrass, CO=Coastal, SB=Sandy Beach, RB=Rocky Beach, MB=Muddy Beach, AR=Artificial Reef, ES=Estuary, PS=Peat Swamp.

Recommendation for Future Research

In general, complicated forces, linkages, and interactions may promote or magnify the effects of ecological processes occurring within marine habitats. The warming of seawater, sea level rise, acidification of aquatic environments, fluxes of fresh water, and material transport to sea are examples of hydrodynamics and climate dynamics threats to our marine ecosystems. On top of that, pollution, eutrophication, invasion of alien species, habitat degradation, and urbanization are other types of threats that have been widespread across the world's marine environments, including Malaysia.

Here, the suggestions for future research are summarized in the list below:

1. Future research needs to be strategically planned to include many different research areas that are lacking, as understanding the current state of our marine habitats' resilience may prepare us for the increasing threats of climate change.
2. Studies on coastal and marine habitat profiles are critical to understand the essential ecological processes in our coastal waters. For example, the linkages of habitat mosaic and connectivity supports the efficiency of the fundamental ecological processes, thus optimizing the marine ecosystem's functioning.
3. In 2008, the ninth meeting of the Conference of the Parties to the Convention on Biological Diversity (COP 9) adopted the following scientific criteria for identifying ecologically or biologically significant marine areas in need of protection in open-ocean waters and deep-sea habitats namely i) Uniqueness or Rarity ii) Special importance for life history stages of species; iii) Importance for threatened, endangered or declining species and/or habitats; iv) Vulnerability, Fragility, Sensitivity, or Slow recovery; v) Biological Productivity; vii) Biological Diversity; and viii) Naturalness. To achieve this, an integrated and advance ecological approach is necessary.
4. Trophic dynamics includes studies on the sources of nutrition for commercial and non-commercial fish, feeding ecology, diet composition, and grazing activities are important to better understand and evaluate the food web dynamics in our marine ecosystems. There is a growth trend in applying biogeochemical markers such as fatty acid profiles and stable isotope analysis to study the feeding dynamics of marine species in Malaysia.

BIBLIOGRAPHY

Books/ Chapter in Books/ Reports

A

Abd. Haris Hilmi A. A., Hamizah N. A. Y., Muhammad Amirullah Al Amin A., Annie-Nunis B., Rosdi M. N., Nor Azman Z., Mohd Sukri M., & Noredzuan Hakimi G. (2021). Diversity of fish larvae on the shore of Terengganu and Pahang waters. Institut Sumber Marin Asia Tenggara, Jabatan Perikanan Malaysia. SEAFDEC/MFRDMD/SP/ pp. 60–69.

Abd. Haris Hilmi, B. A. A., Hamizah Nadia, B. A., Ahmad, A., Lawrence, K. J., Rosdi, & Mohd Sukri, B. M. (2020). Terminal report data collection on sharks and ray by species in Tawau, Sabah (Phase I) October 2018 – September 2019. SEAFDEC/MFRDMD/SP/48.

Abd. Haris Hilmi, B. A. A., Hamizah Nadia, B. A., Ahmad, A., Lawrence, K. J., Rosdi, & Mohd Sukri, B. M. (2020). Data collection on sharks and rays by species in Malaysia (August 2016 – July 2017). SEAFDEC/MFRDMD/SP/52.

Abd. Razak, L., Shahuntala, D., Ahmad Husin, A., Siow, R., Mazalina, A., Shazili, N.A.M., Yahya, K., Abdul Latip, N.S., Choo, K.M., & Bidai, J. (2009). Water quality, hydrocarbon, heavy metals, and macrobenthos surveys on the West Coast of Peninsular Malaysia. In *Abu Talib, A., Alias, M., and Mazalina, A. (Eds.). West Coast of Peninsular Malaysia: Acoustic, Fishery Oceanography, and Bottom Substrate Surveys*. pp. 59–101 Department of Fisheries.

Abd. Haris Hilmi, A. A., Mazalina, A., Mohammad Faisal, M. S., & Wan Maznah, W.O. (2009). Plankton and fish larvae surveys on the West Coast of Peninsular Malaysia. In *Abu Talib, A., Alias, M., and Mazalina, A. (Eds.). West Coast of Peninsular Malaysia: Acoustic, Fishery Oceanography, and Bottom Substrate Surveys.* pp. 30–57

Abd. Wahid, M. E., Ahmad, A. S., Segaran, T. C., Saidin, J., Mohamed Zain, N. A., Siong, J. Y. F., Yaakob, E. N. (2011). Preliminary investigation of marine microbial diversity in Peninsular Malaysia. *In Malaysia's Marine Biodiversity: Inventory and Current Status. Kamaruddin, I., Mohamed, C. A. R., Rozaimi, M. J., Kee Alfian, B. A. A., Fitra, A. Z., and Lee, J. N. (Eds.).* pp. 199–203. Department of Marine Park Malaysia, Malaysia.

Abdul-Aziz, Y., Ku-Kassim, K. Y., & Ibrahim, S. (2001). Sedimentological properties of Malaysia EEZ. In: *Mohd-Taupek, M.-N., Mansor, M.I. and Ahmad-Adnan, N. (Eds.). Fisheries Survey in the Exclusive Economic Zone of Malaysia 1997-1999: Biology and Environmental Conditions (Supplementary Volume),* pp. 225–244. Department of Fisheries, Ministry of Agriculture Malaysia.

Abdullah, A. L., & Anscelly, A. A. (2016). Application of spatial analysis in assessing the effect of coastal land reclamation and development on seagrass *Halophila ovalis* and *Halophila becarrii* distributions in Penang waters. In *Proceedings of International Conference on Development and Socio Spatial Inequalities 2015*. pp. 231.

Abdullah, M. A., Khalil, I., & Zakariya, R. (2016). Bathymetry Mapping Using Landsat 8 Satellite Imagery in Bidong Island. In *Emeritus Prof. Dr. Faizah Binti Mohd Sharoum, Chairman UMT International Annual Symposium on Sustainability Science and Management (UMTAS 2016)*. 2016 (42), pp. 27.

Abidin, D. H. Z., Nor, S. A. M., Lavoué, S., Rahim, M. A., Jamaludin, N. A., & Akib, N. A. M. (2021). DNA-based taxonomy of a mangrove-associated community of fishes in Southeast. Scientific Reports 11, pp. 17800.

Ahmad, A., Gambang, A. C., and Lim, A. P. K. (2011). Chondrichthyan biodiversity in Malaysia and Brunei Darussalam. In *Malaysia's Marine Biodiversity: Inventory and Current Status. Kamaruddin, I., Mohamed, C. A. R., Rozaimi, M. J., Kee Alfian, B. A. A., Fitra, A. Z., and Lee, J. N. (Eds.)*. Department of Marine Park Malaysia, Malaysia. pp. 33–45.

Ahmad, A., Jamaludin, I., Mahyam, M. I., and Sollahuddin, A. R. (2002). Distribution, abundance, and species composition of microplankton in the coastal waters of the East Coast of Peninsular Malaysia. In *Mansor, M.I. Demersal Fish Resources in Malaysian, Thirteenth*

Trawl Survey of the Coastal Waters off the East Coast of Peninsular Malaysia (April - June 2001). Department of Fisheries, Ministry of Agriculture Malaysia. pp. 109–124.

Ahmad, A., Jamaludin, I., Mahyam, M.I., and Sollahuddin, A.R. (2002). Sedimentological properties of the coastal waters of the East Coast of Peninsular Malaysia. In: *Mansor, M.I. Demersal Fish Resources in Malaysia, Thirteenth Trawl Survey of the Coastal Waters off the East Coast of Peninsular Malaysia (April–June 2001).* Department of Fisheries, Ministry of Agriculture Malaysia. pp. 95–107.

Ahmad, A., Sollahuddin, A. R., Jamaludin, I., and Mahyam, M. I. (2002). Distribution of macrobenthos in the coastal waters of the East Coast of Peninsular Malaysia. In *Mansor, M.I. Demersal Fish Resources in Malaysia, Thirteenth Trawl Survey of the Coastal Waters off the East Coast of Peninsular Malaysia (April– June 2001).* Department of Fisheries, Ministry of Agriculture Malaysia. pp. 83–94.

Al Azad, S. (2015). Dissolved inorganic nutrients in water and sediment quality of Mantanani Bay, Sabah, Malaysia. In *Mantanani Island Marine Scientific Expedition 2013. Madin, J., Saleh, E., Hamid, S. B. A., Juli, A. M. B., Ismail, N. B., and Chan, A. A. (Eds.).* Department of Marine Park Malaysia, Malaysia. pp. 33–46.

Ali, M., Daud, N., & Basir, S. (2006). Distribution and abundance of phytoplankton and zooplankton in Sarawak waters. In *Proceedings of 4th National Fisheries Symposium 2006. Chee, P. E., Nair, D. M., Ishak, I. H., Latiff, F. A., Nuruddin, A. A., Ramachandran, S. D., Rahim, M. A. (Eds.).* Fisheries Research Institute. pp. 305–316.

Amir, N. H. H., Talib, A., Ahmad, O., & Yahya, K. (2013). The distribution and zonation of barnacles around the intertidal shores of Penang Island. In *Proceedings of the 3rd Annual International Conference Syiah Kuala University (AIC Unsyiah) 2013 in conjunction with the 2nd International Conference on Multidisciplinary Research (ICMR) 2013, Banda Acheh, Indonesia.* pp. 139–143.

Anond Snidvong (1999). Distribution and composition of photosynthetic pigments in the South China Sea. Area II: Sabah, Sarawak and Brunei Darussalam. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II. West Coast of Sabah and Brunei Darussalam.* Southeast Asian Fisheries Development Center. pp. 156–164.

Anton, A., Andrew, A. R., and Kadir, A. N. A. (2015). Phytoplankton distribution and abundance in Mantanani Island, Sabah. In *Mantanani Island Marine Scientific Expedition 2013. Madin, J., Saleh, E., Hamid, S. B. A., Juli, A. M. B., I smail, N. B., and Chan, A. A. (Eds.).* Department of Marine Park Malaysia, Malaysia. pp. 83–105.

Apichart Termvidchakorn (1999). Kind, abundance, and distribution of the fish larvae in the South China Sea, Area II: Sabah, Sarawak, and Brunei Darussalam. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II. West Coast of Sabah and Brunei Darussalam.* Southeast Asian Fisheries Development Center. pp. 243.

Arshaad, W. M., Alian@Yusof, H. N., & Arshad, A. H. H. A. (2021). Special report: Sustainable Utilization and Management of Sharks and Rays in the Southeast Asian Region. SEAFDEC Newsletter 44(1), pp. 10–11.

Awang, D. and Morshidi, M. Z. (2006). First rig to reef in Malaysia. In *Proceedings of 4th National Fisheries Symposium 2006. Chee, P. E., Nair, D. M., Ishak, I. H., Latiff, F. A., Nuruddin, A. A., Ramachandran, S. D., Rahim, M. A. (Eds.).* Fisheries Research Institute. pp. 138–143.

Azhary, W. A. H. W., Awang, N. A., & Hamid, M. R. A. (2016). The Assessment of Rip Current at Kerachut Beach Using Hydrodynamic Modelling. In *IOP Conference Series: Materials Science and Engineering*. IOP Publishing. 136(1), pp. 012087.

B

Bachok, Z. (2017). Food sources of ark shell, *Scapharca cornea* as indicated by fatty acid markers. In *Invertebrates of Setiu Wetlands. Faridah, M., Ibrahim, Y. S., Baharuddin, N., Azmi, A. A. A. R., and Borkhanuddin, M. H. (Eds.).* Penerbit UMT, Malaysia. pp. 47–54.

Baharuddin, N., Jiksing, C., Juli, F. O., and Faridah, M. (2017). Diversity and abundance of mudsnails (Phylum Mollusca, Class Gastropoda) in mangrove forests, Setiu Wetlands. In *Invertebrates of Setiu Wetlands. Faridah, M., Ibrahim, Y. S., Baharuddin, N., Azmi, A. A. A. R., and Borkhanuddin, M. H. (Eds.).* pp. 95–105. Penerbit UMT, Malaysia.

Basir, S., Ahmad, A. T., and Gambang, A. C. (2006). Potential resources and species composition of the commercial fish in the untrawlable areas off Sarawak coast. In Proceedings of 4th National Fisheries Symposium 2006. Chee, P. E., Nair, D. M., Ishak, I. H., Latiff, F. A., Nuruddin, A. A., Ramachandran, S. D., Rahim, M. A. (Eds.). pp. 200–210. Fisheries Research Institute.

Boonyapiwat, S. (1994) of Macrobenthos in the South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the SEAFDEC First Technical Seminar on Fishery Resources*, pp. 111–134

Boonyapiwat, S. (1999). Distribution, abundance, and species composition of phytoplankton in the South China Sea, Area I: the Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia.* Southeast Asian Fisheries Development Center. pp. 111–134.

C

Chareonpanich, C. and Seurungreong, S. (1999). Some physical and chemical characteristics of bottom sediments in the South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia.* Southeast Asian Fisheries Development Center. pp. 12–33.

Charumas Chareonpanich, Siriporn Seurungreong, and Shettapong Meksumpun (1999). Nutrient diagensis in sediments of the South China Sea. Area II: Sabah, Sarawak and Brunei Darussalam. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II.* West Coast of Sabah and Brunei Darussalam. Southeast Asian Fisheries Development Center. pp. 111–128.

Chavalit Vidthayanon (1999). Species composition and diversity of fishes in the South China Sea, Area II: Sabah, Sarawak, and Brunei Darussalam. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II. West Coast of Sabah and Brunei Darussalam.* Southeast Asian Fisheries Development Center. pp. 224–242.

Chong, V. C. (2006). Importance of coastal habitats in sustaining the fisheries industry. In *Proceedings of 4th National Fisheries Symposium 2006. Chee, P. E., Nair, D. M., Ishak, I. H., Latiff, F. A., Nuruddin, A. A., Ramachandran, S. D., Rahim, M. A. (Eds.).* pp. 113–137. Fisheries Research Institute.

Chung, F. C., & Komilus, C. F. (2012). Possible Spawning Aggregations of Plectropomus leopardus at Lankayan Island, Malaysia. (July), pp9–1313.

Country Garden Pacificview (2014). Detailed Environmental Impact Assessment: The Proposed Forest City Island Reclamation and Mixed Development, Johor. http://case-study.mit.edu/documents/ExecSummary.pdf

D

Danish-Daniel, M., Mohd Nor, M. E., Saari, N. A., Razali, M. A., Mohd Fauzan, M. F., and Yeung, Y. S. (2015). Heavy metals and antibiotics resistance profiling of bacteria isolates from the

Setiu Wetlands. In *Setiu Wetlands Species, Ecosystems and Livelihoods. Faridah, M., Jamilah, M. S., Jarina, M. J., and Rohani, S. (Eds.).* pp. 109–120. Penerbit UMT, Malaysia.

Daud, N., Ali, M, Basir, S, and Arshad, A. H. H. A. (2006). Preliminary study on the distribution and abundance of fish larvae in Sarawak waters using MV SEAFDEC 2. In *Proceedings of 4th National Fisheries Symposium 2006. Chee, P. E., Nair, D. M., Ishak, I. H., Latiff, F. A., Nuruddin, A. A., Ramachandran, S. D., Rahim, M. A. (Eds.).* pp. 466–473. Fisheries Research Institute.

Din, Z. B. (1994). Interpretation of metal pollution data for estuarine and coastal sediments of the Straits of Malacca. In *NRCT-JSPS Joint Seminar on Marine Science, Songkhla (Thailand), 2-3 Dec 1993*. pp. 79–89

F

Faridah, M., Abdul Halim, A. S., Zakariah, N. A., and Baharuddin, N. (2017). Fiddler crab *Uca* sp. abundance and sizes in Setiu Wetlands, Terengganu. In *Invertebrates of Setiu Wetlands. Faridah, M., Ibrahim, Y. S., Baharuddin, N., Azmi, A. A. A. R., and Borkhanuddin, M. H. (Eds.).* Penerbit UMT, Malaysia. pp. 22–27.

Faridah, M., Juli, F. O., Jiksing, C., and Baharuddin, N. (2017). Seven genera of climbing gastropods of Setiu Wetlands. In *Invertebrates of Setiu Wetlands. Faridah, M., Ibrahim, Y. S., Baharuddin, N., Azmi, A. A. A. R., and Borkhanuddin, M. H. (Eds.).* Penerbit UMT, Malaysia. pp. 85–94.

G

Gambang, A. C., Rajali, H., Raja Bidin, R. H., Ali, R., Shiomi, K., Fujiwara, S., Basir, S. (1999). Multi-species fish stock assessment by acoustic method in the South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia.* Southeast Asian Fisheries Development Center. pp. 336–346.

Hashim, N. S., Windupranata, W., Tahar, K. N., & Sulaiman, S. A. H. (2021). Shallow-Water Bathymetry Estimation at Pantai Tok Jembal, Terengganu, Malaysia Using Landsat 8 (OLI). In *IOP Conference Series: Earth and Environmental Science*, 767(1) pp. 012008. IOP Publishing.

I

Ibrahim, Y. S., Ibrahim, N. F., and Idris, I. (2017). Taxonomic study of polychaete community in Setiu Wetlands, Terengganu. In *Invertebrates of Setiu Wetlands. Faridah, M., Ibrahim, Y. S., Baharuddin, N., Azmi, A. A. A. R., and Borkhanuddin, M. H. (Eds.).* Pp. 113–120. Penerbit UMT, Malaysia.

Ikhwanuddin, A. M., Azmie, G., Helmi, M. G., Khor, W. H., Mohd Fazhan, M. H., & Bachok, Z. (2015). Indigenous occurrences of green mud crab, *Scylla paramamosain* (Estampador, 1949) (Crustacea: Decapoda: Portunidae) from Setiu Wetlands, Peninsular Malaysia. In *Setiu Wetlands Species, Ecosystems and Livelihoods. Faridah, M., Jamilah, M. S., Jarina, M. J., and Rohani, S. (Eds.).* pp. 3–17. Penerbit UMT, Malaysia.

Ilias, Z. (2006). Advances in using spicules as sea cucumber identification method: A study on gamat (*Stichopus horrens*) from Pulau Langkawi and Pulau Pangkor. In *Proceedings of 4th National Fisheries Symposium 2006. Chee, P. E., Nair, D. M., Ishak, I. H., Latiff, F. A., Nuruddin, A. A., Ramachandran, S. D., Rahim, M. A. (Eds.).* Fisheries Research Institute. pp. 328–329.

Ilias, Z. (2011). Inventory of sea cucumber in Malaysian waters. In *Malaysia's Marine Biodiversity: Inventory and Current Status. Kamaruddin, I., Mohamed, C. A. R., Rozaimi, M. J., Kee Alfian,*

B. A. A., Fitra, A. Z., and Lee, J. N. (Eds.). pp. 189–197. Department of Marine Park Malaysia, Malaysia.

J

Jabatan Perikanan Malaysia (2009). Laporan kajian awal, status sumber dan habitat di perairan Batuan Tengah dan Tubir Selatan, Johor pada 7 – 8 Ogos 2008. Jabatan Perikanan Malaysia, Pusat Penyelidikan Ekosistem Akuatik Kampung Acheh. pp. 1–24.

Japar Sidek, B. and Muta Harah, Z. (2011). Seagrasses - diversity, values, and why they are declining. In *Malaysia's Marine Biodiversity: Inventory and Current Status. Kamaruddin, I., Mohamed, C. A. R., Rozaimi, M. J., Kee Alfian, B. A. A., Fitra, A. Z., and Lee, J. N. (Eds.).* Department of Marine Park Malaysia, Malaysia. pp. 71–89.

Jutamas Jivaluk (1999). Distribution, abundance, and composition of zooplankton in the South China Sea, Area II: Sabah, Sarawak, and Brunei Darussalam. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II. West Coast of Sabah and Brunei Darussalam.* Southeast Asian Fisheries Development Center. pp. 288 - 309.

K

Kaamin, M., Fadzil, M. A. F. M., Razi, M. A. M., Daud, M. E., Abdullah, N. H., Nor, A. H. M., & Ahmad, N. F. A. (2020). The shoreline bathymetry assessment using unmanned aerial vehicle (UAV) photogrammetry. In *Journal of Physics: Conference Series*, 1529(3), pp. 032109. IOP Publishing.

Ku Kassim, K.Y. (2009). Oceanographic conditions of the Straits of Malacca and their influence on the distribution of pelagic fish. In Abu Talib, A., Alias, M., and Mazalina, A. (Eds.). West Coast of Peninsular Malaysia: Acoustic, Fishery Oceanography, and Bottom Substrate Surveys. Department of Fisheries Malaysia, Ministry of Agriculture and Agro-Based Industry Malaysia. pp. 103-111.

L

Lirdwitayaprasit, T. (1999). Distribution of dinoflagellate cysts in the surface sediment of South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia.* Southeast Asian Fisheries Development Center. pp. 294-309.

Lokman Shamsudin, Abdul Hamid Yasin, Solahudin Abdul Razak, and Mohd Shukri Yusoff. (1999). Microplankton on distribution in the South China Sea, Area II: Sabah, Sarawak, and Brunei Darussalam. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II. West Coast of Sabah and Brunei Darussalam.* Southeast Asian Fisheries Development Center. pp. 197-223.

M

Madin, J. and Koiting, R. F. (2015). Community structure, abundance, and distribution of zooplankton in Mantanani Islands, Sabah, Malaysia. In *Mantanani Island Marine Scientific Expedition 2013. Madin, J., Saleh, E., Hamid, S. B. A., Juli, A. M. B., I smail, N. B., and Chan, A. A. (Eds.).* Department of Marine Park Malaysia, Malaysia. pp. 65–81.

Mahyam M., Abu-Talib, A., and Mansor, M.I. (2001). Population parameters of dominant finfish and cephalopod species caught in the offshore areas of Malaysia. In *Mohd-Taupek, M.-N., Mansor, M.I., and Ahmad-Adnan, N. (eds.). Fisheries Survey in the Exclusive Economic Zone of Malaysia 1997-1999: Biology and Environmental Conditions (Supplementary Volume)*, Department of Fisheries, Ministry of Agriculture Malaysia. pp. 17–50.

Mansor, M.I., Abd Haris Hilmi, A.A., and Samsudin, B. (1999). Distribution, abundance, and biological studies of economically important fishes in the South China Sea, Area I: the Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia.* Southeast Asian Fisheries Development Center. pp. 147–155.

Mansor, M.I., Mohd-Taupek, M.N., and Kamariah, I. (2001). Population structure of some commercially important fish in Malaysian waters. In *Mohd-Taupek, M.-N., Mansor, M.I., and Ahmad-Adnan, N. (eds.). Fisheries Survey in the Exclusive Economic Zone of Malaysia 1997-1999: Biology and Environmental Conditions (Supplementary Volume),* Department of Fisheries, Ministry of Agriculture Malaysia. pp. 53–100.

Mohd Saleh, H. S., Mohd, N. A., Yahya, N., and Bachok, Z. (2017). Filtration rate of mud clam, Polymesoda erosa, subjected to their function on the intertidal flat of Setiu Wetlands, Terengganu. In *Invertebrates of Setiu Wetlands. Faridah, M., Ibrahim, Y. S., Baharuddin, N., Azmi, A. A. A. R., and Borkhanuddin, M. H. (Eds.).* Penerbit UMT, Malaysia. pp. 55-67.

Mohd Saupi Ismail, Khoo Mei Ling, Zainuddin Ilisa, Md Nizam Ismail, Suriyanti Su Nyun Pau, Nur Farah Ain Zainee, Mohammad Rozaimi Jamaludin dan Izarenah Md Repin (2021). Laporan Kajian Penentuan Kawasan Baharu Yang Berpotensi Dijadikan Kawasan Perlindungan Sumber (MPA) di Perairan Perak, Jabatan Perikanan Malaysia, Kementerian Pertanian dan Industri Makanan, Malaysia. pp. 146.

Mohd Tahir, N., Swee, Y. P., and Abdul Rahim, H. M. (2015). Organic geochemistry of core sediments in Setiu Wetlands, Terengganu, Peninsular Malaysia. In *Setiu Wetlands Species, Ecosystems and Livelihoods. Faridah, M., Jamilah, M. S., Jarina, M. J., and Rohani, S. (Eds.).* Penerbit UMT, Malaysia. pp. 121–141.

Mohd. N. A. and Bachok, Z. (201. Taxonomic classification of ark shell, *Scapharca cornea* from the lagoon of Setiu Wetlands, Terengganu. In *Invertebrates of Setiu Wetlands. Faridah, M., Ibrahim, Y. S., Baharuddin, N., Azmi, A. A. A. R., and Borkhanuddin, M. H. (Eds.).* Penerbit UMT, Malaysia. pp. 39–45.

Mohd-Lokman Husain, Harith, M.R., Maurice, J., Rosnan, Y., and Kassim, K.K.Y. (1999). Sedimentological characteristics of the South China Sea sediments, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia.* Southeast Asian Fisheries Development Center. pp. 34-53.

Mohd-Lokman Husain, Harith, M.R., Rosnan, Y., Kassim, K.K.Y. (1999). Sedimentological characteristics of sediments of the South China Sea. Area II: Sabah, Sarawak and Brunei Darussalam. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II. West Coast of Sabah and Brunei Darussalam.* Southeast Asian Fisheries Development Center. pp. 95–110.

Mojiol, A. R., Sompud, J., Saleh, E., and Alip, F. (2015). The preliminary survey of coastal beach vegetation at Mantanani Besar Island. In *Mantanani Island Marine Scientific Expedition 2013. Madin, J., Saleh, E., Hamid, S. B. A., Juli, A. M. B., I smail, N. B., and Chan, A. A. (Eds.).* Department of Marine Park Malaysia, Malaysia. pp. 11–18.

Montira Piamthipmanus. (1999). Temporal changes in the abundance of macrobenthos in the South China Sea, Area II: Sabah, Sarawak, and Brunei Darussalam. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II. West Coast of Sabah and Brunei Darussalam.* Southeast Asian Fisheries Development Center. pp. 323-337.

Musikasung, W., Yusoff, M.S., and Razak, S.A. (1999). Primary production determination in the South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the*

South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia. Southeast Asian Fisheries Development Center. pp. 135-146.

N

Nasir Saadon, Lim Phaik Kin, Anong Snidvongs, and Penjan Rojana-Anawat. (1999). Physical characteristics of water mass in the South China Sea, Area II: Sarawak, Sabah, and Brunei Darussalam Waters. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II. West Coast of Sabah and Brunei Darussalam.* Southeast Asian Fisheries Development Center. pp. 1–22.

Nik-Nurasyikin, N. M. A., Nurulnadia, M. Y., Mohamad Sofi, H., and Jaafar, S. N. (2018). Metals accumulation in cultured tiger grouper, *Epinephelus fuscoguttatus,* with estimated weekly intake levels from the east coast of Peninsular Malaysia. *Journal of Sustainability Science and Management* (Special Issue 5). pp. 47–56.

Noor A.M. Shazili, Mohamed Kamil Abd Rashid, Mohd Lokman Husain, and Rosnan Yaakob. (1999). Trace metals in surface sediment of the South China Sea. Area II: Sabah, Sarawak and Brunei Darussalam. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II. West Coast of Sabah and Brunei Darussalam.* Southeast Asian Fisheries Development Center. pp. 146–155.

Norman, M., Ghazali, N., & Manaf, A. F. M. A. (2012). Shoreline siltation monitoring using remote sensing techniques: Study Area: Tg. Dawai, Kedah, Malaysia. In *2012 IEEE Colloquium on Humanities, Science, and Engineering (CHUSER).* IEEE. pp. 68–73.

O

Odli, Z. S. M., Abdullah, A. L., Saad, F. N. M., & Fadzillah, N. S. A. (2020). The relationship between land use and marine litter at Kuala Perlis coastal area. In *IOP Conference Series: Earth and Environmental Science,* 476(1), pp. 012109. IOP Publishing.

Odli, Z. S. M., Lee, A. J., & Asari, M. A. (2020). Marine Macro-and Microplastic Litter Along the Coastal Area of Kuala Perlis. In *N. Samat, J. Sulong, M. Pourya Asl, P. Keikhosrokiani, Y. Azam, & S. T. K. Leng (Eds.), Innovation and Transformation in Humanities for a Sustainable Tomorrow, vol 89. European Proceedings of Social and Behavioural Sciences*, pp. 303–312. European Publisher.

P

Piamthipmanus, M. (1999). Temporal changes in the abundance of macrobenthos in the South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia.* Southeast Asian Fisheries Development Center. pp. 156–171.

R

Raja Bidin, R.H., Samsudin, B., Sallehudin, J., Siti Azizah, M.N., Abu Talib, A., Osman, M., and Darlina, M.N. (2009). Acoustic and pelagic fish resource survey on the west coast of Peninsular Malaysia. In *Abu Talib, A., Alias, M., and Mazalina, A. (Eds.). West Coast of Peninsular Malaysia: Acoustic, Fishery Oceanography, and Bottom Substrate Surveys.* Department of Fisheries Malaysia, Ministry of Agriculture and Agro-Based Industry Malaysia. pp. 2–28.

Rajali, H. B., Gambang, A. C., Hamid, I. A., Hassan, R. B. B. R., Awang, D., Shiomi, K., & Fujiwara, S. (1999). Stock Assessment by Hydro-Acoustic Method in the South China Sea Area II: Sabah, Sarawak, Brunei Darussalam. In *Proceedings of the Second Technical Seminar on Marine Fishery Resources Survey in the South China Sea, Area II: West Coast of Sabah,*

Sarawak and Brunei Darussalam, 14-15 December 1998, Kuala Lumpur, Malaysia. pp. 338–352. Training Department, Southeast Asian Fisheries Development Center.

Ransangan, J. and Madin, J. (2015). Commercially crucial marine fish and invertebrate species landed by fishermen on Mantanani Island. In *Mantanani Island Marine Scientific Expedition 2013. Madin, J., Saleh, E., Hamid, S. B. A., Juli, A. M. B., I smail, N. B., and Chan, A. A. (Eds.).* Department of Marine Park Malaysia, Malaysia. pp. 107–118.

Rashid, M.K.A. 1999. Polynuclear aromatic hydrocarbon (PAH) and total aliphatic hydrocarbon (TAH) in the bottom sediment of the South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia.* Southeast Asian Fisheries Development Center. pp. 100-104.

Richard Rumpet, Daud Awang, Jamil Musel, and Rooney Biusing. (1999). Distribution, abundance and biological studies of economically important fishes in the South China Sea, Area II: Sabah, Sarawak and Brunei Darussalam. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II. West Coast of Sabah and Brunei Darussalam.* Southeast Asian Fisheries Development Center. pp. 353–361.

Rojana-anawat, P. and Snidvongs. (1999). Dissolved oxygen and carbonate-carbon dioxide in the seawater of the South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia.* Southeast Asian Fisheries Development Center. pp. 6–11.

Rosdi, M.N., Zulkifli, T., Raja Mohammad Noordin, R. O. (2001). Kind, abundance, and distribution of the fish larvae in the Malaysian Exclusive Economic Zone. In *Mohd-Taupek, M.-N., Mansor, M.I., and Ahmad-Adnan, N. (eds.). Fisheries Survey in the Exclusive Economic Zone of Malaysia 1997-1999: Biology and Environmental Conditions (Supplementary Volume).* Department of Fisheries, Ministry of Agriculture Malaysia. pp. 125–150.

S

Saadon, M.N., Rojana-anawat, P., and Snidvongs, A. (1999). Physical characteristics of water mass in the South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia.* pp. 1-5. Southeast Asian Fisheries Development Center

Saleh, E., Daud, N. R., Mustajap, F., and Aung, T. (2015). Underwater acoustic survey of Mantanani Islands, Kota Belud, Sabah. In *Mantanani Island Marine Scientific Expedition 2013. Madin, J., Saleh, E., Hamid, S. B. A., Juli, A. M. B., I smail, N. B., and Chan, A. A. (Eds.).* pp. 19–32. Department of Marine Park Malaysia, Malaysia.

Saleh, E., Hassim, E. H. C., Koiting, R. F., and Mojiol, A. R. (2015). Beach profiles and textural characteristics of Mantanani Besar Island, Kota Belud. In *Mantanani Island Marine Scientific Expedition 2013. Madin, J., Saleh, E., Hamid, S. B. A., Juli, A. M. B., I smail, N. B., and Chan, A. A. (Eds.).* pp. 1–9. Department of Marine Park Malaysia, Malaysia.

Samsudin, B. (2001). Distribution and population biology of cephalopods in the EEZ of Malaysia: Analysis from the survey data in 1997/98. In *Mohd-Taupek, M.-N., Mansor, M.I., and Ahmad-Adnan, N. (eds.). Fisheries Survey in the Exclusive Economic Zone of Malaysia 1997-1999: Biology and Environmental Conditions (Supplementary Volume),* Department of Fisheries, Ministry of Agriculture Malaysia. pp. 103–121.

Shamsudin, L., Yasin, A.H., Razak, S.A., and Yusoff, M.S. (1999). Microplankton (including dinoflagellate and foraminifera) in the South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine*

Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia. pp. 310-335. Southeast Asian Fisheries Development Center.

Shazili, N.A.M., Rashid, M.K.A., Husain, M.K., Nordin, A., and Ali, S. (1999). Trace metals in the South China Sea surface sediment, Area I: the Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia*. pp. 73-85. Southeast Asian Fisheries Development Center.

Sim, Y. K. and Kee Alfian, A. A. (2011). Sea cucumber and sea stars on the reefs and islands of Malaysia. In *Malaysia's Marine Biodiversity: Inventory and Current Status. Kamaruddin, I., Mohamed, C. A. R., Rozaimi, M. J., Kee Alfian, B. A. A., Fitra, A. Z., and Lee, J. N. (Eds.).* pp. 165–187. Department of Marine Park Malaysia, Malaysia.

Snidvongs, A. and Sojisuporn, P. (1999). Numerical simulations of the net current in the Gulf of Thailand under different monsoon regimes. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia.* pp. 54–72. Southeast Asian Fisheries Development Center.

Solahuddin, A.R. and Wan Mohd Lotfi, W.M. (2001). Macrobenthos abundance in Peninsular Malaysia, West Sabah, and Sarawak waters. In *Mohd-Taupek, M.-N., Mansor, M.I., and Ahmad-Adnan, N. (eds.). Fisheries Survey in the Exclusive Economic Zone of Malaysia 1997-1999: Biology and Environmental Conditions (Supplementary Volume)*. pp. 247–267. Department of Fisheries, Ministry of Agriculture Malaysia.

Sopana Boonyapiwat. (1999). Distribution, abundance and species composition of phytoplankton in the South China Sea, Area II: Sabah, Sarawak and Brunei Darussalam. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II. West Coast of Sabah and Brunei Darussalam.* pp. 177-196. Southeast Asian Fisheries Development Center.

Suratman, S., Hussein, A. N. A. R., Mohd. Tahir, N., and Poh, S. C. (2015). Seasonal variation of Si-based nutrient in Setiu Wetlands, Southern South China Sea. In *Setiu Wetlands Species, Ecosystems and Livelihoods. Faridah, M., Jamilah, M. S., Jarina, M. J., and Rohani, S. (Eds.).* pp. 143–157. Penerbit UMT, Malaysia.

Syed Abdullah, S.A.K., Mansor, M.I., and Kamariah, I. (2002). Population structure of some commercially essential fishes in coastal fisheries of the East Coast of Peninsular Malaysia. In *Mansor, M.I. Demersal Fish Resources in Malaysian, Thirteenth Trawl Survey of the Coastal Waters off the East Coast of Peninsular Malaysia (April - June 2001).* pp. 51–81. Department of Fisheries, Ministry of Agriculture Malaysia.

T

Tengki Roziana bt. Tengku Mohamad and Mohd. Shukri b. Yusoff. (1999). Ortho-phosphate in the seawater of the South China Sea. Area II: Sabah, Sarawak and Brunei Darussalam. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II. West Coast of Sabah and Brunei Darussalam.* pp. 32–61. Southeast Asian Fisheries Development Center

Tengku Rozaina, T.M. (2001). Ortho-phosphate distribution in the Exclusive Economic Zone of Malaysia. In *Mohd-Taupek, M.-N., Mansor, M.I., and Ahmad-Adnan, N. (eds.). Fisheries Survey in the Exclusive Economic Zone of Malaysia 1997-1999: Biology and Environmental Conditions (Supplementary Volume).* pp. 185–201. Department of Fisheries, Ministry of Agriculture Malaysia.

Tengku Rozaina, T.M., Faazaz, A.L., and Raja Mohammad Noordin, R.O. (2001). Phytoplankton in Malaysian waters. In *Mohd-Taupek, M.-N., Mansor, M.I. and Ahmad-Adnan, N. (eds.). Fisheries Survey in the Exclusive Economic Zone of Malaysia 1997-1999: Biology and*

Environmental Conditions (Supplementary Volume), Department of Fisheries, Ministry of Agriculture Malaysia. pp. 205–222.

Teoh, V. Y. J. & Woo, S. P. (2021). The diversity of echinoderms in the seagrass meadows of Penang Island, Malaysia*. IOP Conference Series: Earth and Environmental Science* 711, 012012.

Termvidchakorn, A. (1999). Kinds, abundance, and distribution of the fish larvae in the South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia.* pp. 240–255. Southeast Asian Fisheries Development Center.

Thaithaworn Lirdwitayaprasit. (1999). Distribution of dinoflagellate cysts in the surface sediment of South China Sea, Area II: Sabah, Sarawak, and Brunei Darussalam. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II. West Coast of Sabah and Brunei Darussalam.* 310–322. Southeast Asian Fisheries Development Center.

Theparoonrat, Y., Seakow, S., and Seurungreong, S. (1999). Biomass estimation by hydro-acoustic methods in the Gulf of Thailand and Peninsular Malaysia. *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia.* pp. 347–366. Southeast Asian Fisheries Development Center.

U

Utoomprurkporn, W., Hungspreugs, M., Ratanachongkiat, S., and Snidvongs, A. (1999). Biogeochemical implications of dissolved trace metal concentration and distribution in the South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia.* pp. 86–99. Southeast Asian Fisheries Development Center.

V

Valiela, I., & Valiela, I. (1995). Marine ecological processes (Vol. 686). New York: Springer.

Vidthayanon, C. (1999). Species composition and diversity of fishes in the South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia.* pp. 172–240. Southeast Asian Fisheries Development Center.

W

Waheed, Z., Rahman, R. A., and Ariff, A. J. (2011). The status of complex coral diversity in Sabah. In *Malaysia's Marine Biodiversity: Inventory and Current Status. Kamaruddin, I., Mohamed, C. A. R., Rozaimi, M. J., Kee Alfian, B. A. A., Fitra, A. Z., and Lee, J. N. (Eds.).* pp. 1–19. Department of Marine Park Malaysia, Malaysia.

Waleerat Musikasung, Mohd Shuki bin Yusoff, Solahuddin bin Abdul Razak, Anond Snidvongs. (1999). Primary production determination in the South China Sea, Area II: Sabah, Sarawak, and Brunei Darussalam. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II. West Coast of Sabah and Brunei Darussalam.* pp. 165–176. Southeast Asian Fisheries Development Center.

Wan Bayani, W. O. and Zaleha, K. (2015). Biodiversity of mollusks in Setiu Wetlands by using molecular markers for characterization and conservation. In *Setiu Wetlands Species, Ecosystems and Livelihoods. Faridah, M., Jamilah, M. S., Jarina, M. J., and Rohani, S. (Eds.).* pp. 27–37. Penerbit UMT, Malaysia.

Wan-Bayani, W. O., Faridah, M., and Shaza-Shazwani, S. (2017). Shell colors, patterns, and length of hard clams (*Meretrix meretrix*) in Setiu Wetlands. In *Invertebrates of Setiu Wetlands. Faridah, M., Ibrahim, Y. S., Baharuddin, N., Azmi, A. A. A. R., and Borkhanuddin, M. H. (Eds.).* pp. 77–84. Penerbit UMT, Malaysia.

Wilaiwan Utoomprurkporn and Anond Snidvongs. (1999). Trace metal concentrations and distributions in seawater of the South China Sea. Area II: Sabah, Sarawak and Brunei Darussalam. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II. West Coast of Sabah and Brunei Darussalam.* 129–145. Southeast Asian Fisheries Development Center

Wongnapapan, P., Wattayakorn, G., and Snidvongs, A. (1999). Petroleum hydrocarbon in seawater and some sediments of the South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia. In *Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea. The area I: Gulf of Thailand and East Coast of Peninsular Malaysia.* pp. 105–110. Southeast Asian Fisheries Development Center.

Y

Yahya, N., Nurul-Zalizahana, Z., Zakirah, M. T., and Bachok, Z. (2017). Diversity and abundance of Bivalvia (Phylum Mollusca) in lagoon of Setiu Wetlands. In *Invertebrates of Setiu Wetlands. Faridah, M., Ibrahim, Y. S., Baharuddin, N., Azmi, A. A. A. R., and Borkhanuddin, M. H. (Eds.).* pp. 69–76. Penerbit UMT, Malaysia.

Yusof, F., Rani, A., Othman, M. F., Manaf, M. S. A., & Buyong, M. K. (2006). The white spot syndrome virus (WSSV) occurrence in the white shrimp (*Penaeus merguiensis*) population from seven localities on the West Coast of Peninsular Malaysia. In *Proceedings of 4th National Fisheries Symposium 2006. Chee, P. E., Nair, D. M., Ishak, I. H., Latiff, F. A., Nuruddin, A. A., Ramachandran, S. D., Rahim, M. A. (Eds.).* Fisheries Research Institute. pp. 49–52.

Yuttana Theparoonrat (1999). Biomass estimation by hydro-acoustic methods in the South China Sea, Area II: Sabah, Sarawak and Brunei Darussalam. In *Proceedings of the second technical seminar on marine fishery resources survey in the South China Sea. Area II. West Coast of Sabah and Brunei Darussalam.* 362-370. Southeast Asian Fisheries Development Center.

Z

Zainol, Z., & Akhir, M. F. (2016). Coastal upwelling in the vicinity of Tioman Island. In *Journal of Sustainability Science and Management Special Issue Number 1: The International Seminar on the Straits of Malacca and the South China Sea*. pp. 71–80.

Zakirah, M. T., Nurul-Zalizahana, Z., Yahya, N., and Bachok, Z. (2017). Brachyuran crab (Crustacea: Decapoda: Brachyura) from Setiu Lagoon. In *Invertebrates of Setiu Wetlands. Faridah, M., Ibrahim, Y. S., Baharuddin, N., Azmi, A. A. A. R., and Borkhanuddin, M. H. (Eds.).* pp. 11–20. Penerbit UMT, Malaysia.

Zaleha, K., Kamaliah, K., Nurul Huda, A. I., Rozlinda, M. R., Nur Erni Atika, H., and Kamaruzzaman, Y. (2011). Biodiversity of selected marine Arthropoda in Malaysia. In *Malaysia's Marine Biodiversity: Inventory and Current Status. Kamaruddin, I., Mohamed, C. A. R., Rozaimi, M. J., Kee Alfian, B. A. A., Fitra, A. Z., and Lee, J. N. (Eds.).* pp. 99–108. Department of Marine Park Malaysia, Malaysia.

Zilkifli, T., Abd. Haris Hilmi, A.A., and Rosdi, M.N. (2002). Distribution of fish larvae in the coastal area of the East Coast of Peninsular Malaysia. In *Mansor, M.I. Demersal Fish Resources in Malaysian, Thirteenth Trawl Survey of the Coastal Waters off the East Coast of Peninsular Malaysia (April - June 2001). Department of Fisheries, Ministry of Agriculture Malaysia*. pp. 125–138.

JOURNALS

A

Abd Mutalib, A. H., Fadzly, N., Ahmad, A., & Nasir, N. 2015. Understanding nesting ecology and behaviour of green marine turtles at Setiu, Terengganu, Malaysia. *Marine Ecology*, 36(4), 1003 – 1012.

Abdul Kadir, S. R., Abdul Rasid, M. H. F., Kwong, K. O., Wong, L. L., & Arai, T. 2017. Occurrence and the ecological implication of a tropical anguillid eel *Anguilla marmorata* from Peninsular Malaysia*. ZooKeys*. 695, 103 – 110.

Abdullah, A. L., & Dusuki, M. S. A. 2018. Coastal reclamation influence on biological status of coastal waters in Northern Straits of Malacca. *International Journal of Latest Research in Science and Technology*. 7(6), 1 – 7.

Abdullah, A. L., Anscelly, A. A., Mohamed, J., & Yasin, Z. 2016. Conservation of Pulau Payar Marine Park and Optical Remote Sensing Models. *KEMANUSIAAN: The Asian Journal of Humanities*, 23.

Abidin, D. H. Z., Nor, S. A. M., Lavoué, S., Rahim, M. A., Jamaludin, N. A., & Akib, N. A. M. 2021. DNA based taxonomy of a mangrove-associated community of fishes in Southeast Asia. *Scientific Reports 11*, 17800.

Abu Hena, M. K., Kumar, U., Idris, M. H., Karim, N. U., Ismail, J., & Jaafar, N. M. S. N. 2021. Temporal variation in community structure of dragnet (pukat tarik) fishery in relation to ecological variables in an inshore area of Sarawak, Malaysia. *Songklanakarin Journal of Science and Technology*. 43(3), 871 – 880.

Abu Talib, A., Len, R. G., & Nurulhuda, A. F. 2006. Impact of tsunami on demersal fish assemblages off Kedah and Penang Waters. *Malaysia Fisheries Journal*. 5(2), 58 – 73

Adam, N. A. B., & Ishak, N. H. A. 2018. Taxonomic revision of the family Doliolidae Bronn, 1862 (Chordata, Tunicata, Thaliacea, Doliolida) from East Coast of Peninsular Malaysia), with an updated worldwide distribution. *Journal of Sustainability Science and Management*. 13(5), 147 – 177.

Adibah, A. B., Ling, L. P., Tan, S. G., Faridah, Q. Z., & Christianus, A. 2012. Development of single-locus DNA microsatellite markers using 5' anchored ISSR-PCR method for the mangrove horseshoe crab, *Carcinoscorpius rotundicauda* (Latreille, 1802) in Peninsular Malaysia. *Molecular Biology Reports*. 39*(*4), 3815-3820.

Adibah, A. B., Ng, W. L., & Tan, S. G. 2015. The Malay Peninsula as a barrier to gene flow in an Asian horseshoe crab species, *Carcinoscorpius rotundicauda* Latreille. *Biochemical Systematics and Ecology*. 60, 204-210.

Ahmad Adnan, N., Loneragan, N. R., Connolly, R. M. 2002. Variability of, and the influence of environmental factors on, the recruitment of postlarval and juvenile *Penaeus merguiensis* in the Matang mangroves of Malaysia. *Marine Biology*. 141, 241–251.

Ahmad Zubir, A. A., & Mohd Saad, F. N. 2018. Contamination and Pollution Assessment of Heavy Metal in Kuala Perlis Sediment Phase: A Statistical Analysis Approach. *Applied Mathematics and Computational Intelligence*. 7(1), 1-12.

Ahmad, O., Fang, T. P., & Yahya, K. 2011. Distribution of intertidal organisms in the shores of Teluk Aling, Pulau Pinang, Malaysia. *Publication of the Seto Marine Biological Laboratory.* 41, 51 – 61.

Aiman, W. M., Yusoff, F. M., Arshad, A., Kamal, A. H. M., Ismail, J., Idris, M. H., Karim, N. U. & Asif, A. Al. 2020. Distribution of zooplankton community in toli shad (*Tenualosa toli*) habitats, Sarawak, Malaysia. *Biodiversitas*. 21(9), 4022–4033.

Aisyah Alias, S. & Jones, G. 2000. Vertical distribution of marine fungi on *Rhizophora apiculata* at Morib mangrove, Selangor, Malaysia. *Mycoscience*. 41, 431 – 436.

Akbar John, B., Kamaruzzaman, B. Y., Jalal, K. C. A., & Zaleha, K. 2011. Hydrology of the horseshoe crab nesting grounds at Pahang coast, Malaysia. *Oriental Journal of Chemistry.* 27(4), 1475–1483.

Akhir, M. F., Daryabor, F., Husain, M. L., Tangang, F., & Qiao, F. 2015. Evidence of upwelling along Peninsular Malaysia during Southwest Monsoon. *Open Journal of Marine Science*. 5, 273 – 279.

Al-Asif, A., Hamli, H., Kamal, A. H. M., Idris, M. H., Gerusu, G. J., Ismail, J. Bin, & Karim, N. U. 2020. Benthic macrofaunal assemblage in Seagrass-mangrove complex and adjacent ecosystems of Punang-Sari Estuary, Lawas, Sarawak, Malaysia. *Biodiversitas*. 21(10), 4606 – 4615.

Ali, M. A., Halim, M. H. A., Masnan, S. S. K., & Saidin, M. 2021. The biological diversity of Sungai Merbok in fulfill requirement of criteria for natural tourism. Quantum Journal of Social Sciences and Humanities. 2(4), 53 – 66.

Alongi, D. M., Sasekumar, A., Tirendi, F., & Dixon, P. 1998. The influence of stand age on benthic decomposition and recycling of organic matter in managed mangrove forests of Malaysia. *Journal of Experimental Marine Biology and Ecology*. 225(2), 197 – 218.

Amelia, T. S. M., Khalik, W. M. A. W. M., Ong, M. C., Shao, Y. T., Pan, H. J., & Bhubalan, K. 2021. Marine microplastics as vectors of major ocean pollutants and its hazards to the marine ecosystem and humans. *Progress in Earth and Planetary Science*. 8(1), 1 – 26.

Amira, F. S., Rahman, M. M., Kamaruzzaman, B. Y., Jalal, K. C. A., Hossain, M. Y., & Khan, N. S. 2016. Relative abundance and growth of male and female *Nemipterus furcosus* population. *Sains Malaysiana*. 45(1), 79 – 86.

Ara, R., Arshad, A., Musa, L., Amin, S. M. N., & Kuppan, P. 2011. Feeding habits of larval fishes of the Family Clupeidae (Actinopterygii: Clupeiformes) in the estuary of river Pendas, Johor, Malaysia. *Journal of Fisheries and Aquatic Science*. 6(7), 816 – 821.

Ara, R., Amin S. M. N., Yusoff, F. Md., Arshad, A., & Romano, N. 2020. Larval fish assemblage, diversity and habitat ecology in the Matang Mangrove Ecosystem, Perak, Malaysia. *Journal of Environmental Biology*. 41, 1316 – 1325.

Ara, R., Arshad, A., Nurul Amin, S. M., and Ghaffar, M. A. 2015. Fish larval occurrence and distribution in the seagrass-mangrove ecosystems of the Johor Straits. *Malayan Nature Journal*. 66(1-2), 182 – 201.

Ara, R., Arshad, A., Nurul Amin, S. M., Daud, S. K., & Ghaffar, M. A. 2011. Environment and diversity of ichthyoplankton in the seagrass beds of Sungai Pulai estuary, Johor, Peninsular Malaysia. *Journal of Food, Agriculture and Environment*. 9(3 – 4), 733 – 738.

Ara, R., Arshad, A., Nurul Amin, S. M., Daud, S. K., Bujang, J. S., & Ghaffar, M. A. 2010. Feeding habits of larval fishes of the family Gobiidae (Actinopterygii: Perciformes) in seagrass beds of Sungai Pulai estuary, Johor Strait, Malaysia. *Coastal Marine Science*. 34(1), 123 – 128.

Arai, T. 2014. First record of a tropical mottled eel, *Anguilla bengalensis bengalensis* (Actinopterygii: Anguillidae) from the Langkawi Islands, Peninsular Malaysia, Malaysia. *Marine Biodiversity Records*, 7.

Arai, T., & Abdul Kadir, S. R. 2017. Opportunistic spawning of tropical anguillid eels *Anguilla bicolor bicolor* and A. *bengalensis bengalensis*. *Scientific Reports*, 7. 1 – 17.

Ariffin, E. H., Mathew, M. J., Yaacob, R., Akhir, M. F., Shaari, H., Zulfakar, M. S. Z., Sedrati, M., and Awang, N. A. 2018. Beach morphodynamic classification in different monsoon seasons at Terengganu beaches, Malaysia. *Journal of Sustainability Science and Management (Special Issue 5).* 65 – 74.

Arsad, N. A., Othman, R., Shaleh, S. R. M., Abdullah, F. C., & Matsumoto, M. M. 2020. Effects of physicochemical parameters on the reproductive pattern of sea cucumber *Holothuria scabra* in Sabah. *Songklanakarin Journal of Science & Technology*. 42(1).

Arshad, A. B., Ara, R., Nurul Amin, S. M., Daud, S. K., & Ghaffar, M. A. 2012. Larval fish composition and spatio-temporal variation in the estuary of Pendas River, southwestern Johor, Peninsular Malaysia. *Coastal Marine Science*. 35(1), 96 – 102.

Arshad, A., Amani, A.A., Nurul Amin, S.M., Yusoff, F.M. 2016. Sex ration, spawning season and the size at maturity of *Parapenaeopsis sculptilis* (Heller 1862) in the coastal water of Perak, Peninsular Malaysia. *Journal of Environmental Biology*. 37, 709 – 713.

Arshad, A., Ara, R., Amin, S. M. N., Effendi, M., Zaidi, C. C., & Mazlan, A. G. 2011. Influence of environmental parameters on shrimp post-larvae in the Sungai Pulai seagrass beds of Johor Strait, Peninsular Malaysia. *Scientific Research and Essays*. 6(26), 5501 – 5506.

Awang, N. A., Jusoh, W. H. W., & Hamid, M. R. A. 2014. Coastal Erosion at Tanjong Piai, Johor, Malaysia. *Journal of Coastal Research*. 71(10071), 122 – 130.

Azim, M. M. K., Amin, S. M. N., Mazumder, D., Arshad, A., & Yusoff, F. M. 2020. Feeding Habits of Five Dominant Fish Species from Matang Mangrove Estuaries, Malaysia, Based on Stomach Content and Stable Isotope Analyses. *Bulletin of Marine Science*. 96(3), 550.

Aziz, A., Bujang, J. S., Zakaria, M. H., Suryana, Y., & Ghaffar, M. A. 2006. Fish communities from seagrass bed of Merchang Lagoon, Terengganu, Peninsular Malaysia. *Coastal Marine Science*. 30(1), 268 – 275.

Azlan, A., Mohamad Nasir, N. N., Shamsudin, N., Rahman, H. A., Khoo, H. E., & Razman, M. R. 2015. PCDD and PCDF exposures among fishing community through intake of fish and shellfish from the Straits of Malacca. *BMC Public Health*. 15(1), 1 – 13.

Azman, B. A. R., & Othman, B. H. R. 2013. Shallow water marine gammaridean amphipods of Pulau Tioman, Malaysia, with the description of a new species. *ZooKeys*. 335, 1 – 31.

Azrina, M. Z., Yap, C. K., Ismail, A. R., Ismail, A., & Tan, S. G. 2006. Anthropogenic impacts on the distribution and biodiversity of benthic macroinvertebrates and water quality of the Langat River, Peninsular Malaysia. *Ecotoxicology and environmental safety*. 64(3), 337 – 347.

Azwady, A. N., & Mazlan, A. G. 2009. Feeding habits and temporal variation of diet composition of fish larvae (Osteichthyes: Sparidae) in the Sungai Pulai seagrass bed, Johore, Peninsular Malaysia. *Journal of Biological* Sciences. 9(5), 445 – 451.

B

Babatunde, T. A., Amin, S. M. N., Romano, N., Yusoff, F. M., Arshad, A., Esa, Y. B., & Ebrahimi, M. 2018. Gonad maturation and spawning of cobia, *Rachycentron canadum* (Linnaeus, 1766) off the Dungun coast, Malaysia. *Journal of Applied Ichthyology*. 34(3), 638 – 645.

Babatunde, T. A., Amin, S. M. N., Yusoff, F. M., Romano, N., Arshad, A., Esa, Y. B., & Ebrahimi, M. 2020. Influence of season and feeding intensity on fatty acid composition of wild cobia (*Rachycentron canadum*, Linnaeus, 1766) in the Dungun coast, Malaysia. *Journal of Environmental Biology*. 41(5), 1309 – 1315.

Baharuddin, N. & Zakaria, N. A. 2018. The biodiversity and conservation status of the marine gastropod (Mollusca; Gastropoda) in Pulau Bidong, Terengganu, Malaysia. *AACL Bioflux*. 11(4), 988 – 1000.

Baharuddin, N., Basir, N. H. M., & Zainuddin, S. N. H. 2019. Tropical intertidal gastropods: Insights on diversity, abundance, distribution and shell morphometrics of Pulau Bidong, Malaysia. *AACL Bioflux*. 12(4), 1375 – 1387.

Balok, P., & Belangkas, S. 2019. Spermiogram of Wild and Captive Malaysian Horseshoe Crab (*Tachypleus gigas*). 48(2), 325 – 328.

Berry, A. J. 1986. Semi-lunar and lunar spawning periodicity in some tropical littorinid gastropods. *Journal of Molluscan Studies*. 52(2), 144 – 149.

Bin, C. Y., Hong, L. S., Ibrahim, Y. S., Bachok, Z., Tuan Anuar, S. 2021. Dynamic fatty acid profiles of asian sea bass (*Lates calcarifer*) from Setiu Wetlands, East Coast of Peninsular Malaysia. *Malaysian Journal of Analytical Sciences*. 25(1), 53 – 61.

Bujang, J. S., Zakaria, M. H., & Arshad, A. 2006. Distribution and significance of seagrass ecosystems in Malaysia. *Aquatic Ecosystem Health and Management*. 9(2), 3 – 14.

C

Chai, X., Li, X., Hii, K. S., Zhang, Q., Deng, Q., Wan, L., Zheng, L., Lim, P. T., Tan, S. N., Mohd-Din, M., Song, C., Song., L., Zhou, Y. & Cao, X. 2021. Blooms of diatom and dinoflagellate associated with nutrient imbalance driven by cycling of nitrogen and phosphorus in anaerobic sediments in Johor Strait (Malaysia). *Marine Environmental Research*. 169, 105398.

Chang, H. W. J., Francis, A. S., Dayou, J., Sentian, J., & Chee, F. P. 2018. Upwelling event characteristics of chlorophyll-a concentration in the surface layer of Sabah waters. *Indian Journal of Geo Marine Sciences*. 47(12), 2532 – 2540.

Chelliah, A., Amar, H. Bin, Hyde, J., Yewdall, K., Steinberg, P. D., & Guest, J. R. 2015. First record of multi-species synchronous coral spawning from Malaysia. *PeerJ*. 2015(2), 1 – 8.

Chen, C. A., & Long, S. M. 2015. A new marine nematode species, *Metalinhomoeus ramsarensis* (Linhomoeidae Filipjev, 1922) from Kuching Wetland National Park, Sarawak, Malaysia. *Borneo Journal of Resource Science and Technology*. 5(1), 11 – 15.

Chen, C. A., Mohd Long, S., & Rosli, N. M. 1970. An Ecological Study of Free-living Marine Nematodes in Teluk Awar, Sarawak, Malaysia. *Borneo Journal of Resource Science and Technology*. 2(1), 1 – 10.

Chen, C. A., Soo, C. L., Balsamo, M., & Semprucci, F. 2018. An approach based on nematode descriptors for the classification of ecological quality (EcoQ) of the Malaysian coasts. *Marine Biodiversity*. 48(1), 117 – 126.

Chong, V. C., & Sasekumar, A. 1981. Food and feeding habits of the white prawn *Penaeus merguiensis*. *Marine Ecology Progress Series*. 5(20), 185 – 191.

Chong, V. C., Jamizan, A. R., Mohamad Yazid, Z., Rizman-Idid, M., Muhammad Ali, S. H., & Natin, P. 2010. Diversity and Abundance of Fish and Invertebrates of Semerak Estuary and Adjacent Inshore Waters, Kelantan. *Malaysian Journal of Science 29 (Special Issue)*. 95 – 110.

Chong, V. C., Lee, P. K. Y., & Lau, C. M. 2010. Diversity, Extinction Risk and Conservation of Malaysian fishes. *Journal of Fish Biology*. 76, 2009 – 2066.

Chong, V. C., Sasekumar, A., Leh, M. U. C., & D'Cruz, R. (1990). The fish and prawn communities of a Malaysian coastal mangrove system, with comparisons to adjacent mud flats and inshore waters. *Estuarine, Coastal and Shelf Science*. 31(5), 703 – 722.

Chu, C., Chew, L. L., Chong, V. C., Ng, C. C., Ooi, A. L., & Loh, K. H. 2021. Effect of coastal development on larval fish abundance in Klang Strait (Malaysia). *Regional Studies in Marine Science*. 46, 101889.

Chuan, C. H., Maran, B. A. V., Yap, T. K., Cheong, K. C., Hussein, M. A. S., Saleh, E., & Tan, S. H. 2020. First record of jellyfish *Anomalorhiza shawi* Light, 1921 (Cnidaria: Scyphozoa) and its associated organisms in Sabah, Malaysia. *Regional Studies in Marine Science*. *35*, 101232.

Cob, Z. C., Arshad, A., Japar Sidik, B., Nurul-Husna, W. H. W., and Mazlan, A. G. 2014. Feeding behaviour and stomach content analysis of *Leivistrombus canarium* (Linnaeus, 1758) from the Merambong Shoal, Johor, Malaysia. *Malayan Nature Journal*. 66(1-2), 184 – 197.

Cob, Z. C., Arshad, A., Wan-Lotfi, W. M., & Ghaffar, M. A. 2008. Gastropod and bivalve molluscs associated with the seagrass bed at Merambong Shoal, Johor Straits, Malaysia. *Siri Penyelidikan & Maklumat Perairan Malaysia*. 2, 89 – 99.

D

Daud, N. R., Akhir, M. F., & Muslim, A. M. 2019. Dynamic of ENSO towards upwelling and thermal front zone in the east coast of Peninsular Malaysia. *Acta Oceanologica Sinica*, 38(1), 48 – 60.

Daya, S. M. B. 2019. Distribution of nutrients concentration in the upwelling area off the east coast of Peninsular Malaysia during the Southwest Monsoon. *Malaysian Journal of Analytical Sciences*. 23(6), 1030 – 1043.

E

Eckert, S. A., Dolar, L. L., Kooyman, G. L., Perrin, W., & Rahman, R. A. 2002. Movements of whale sharks (*Rhincodon typus*) in South-east Asian waters as determined by satellite telemetry. *Journal of Zoology*. 257(1), 111 – 115.

Elias, M. S., Ibrahim, S., Samuding, K., Rahman, S. A., & Hashim, A. 2018. The sources and ecological risk assessment of elemental pollution in sediment of Linggi estuary, Malaysia. *Marine Pollution Bulletin*. 137, 646 – 655.

F

Fairuz-Fozi, N., Satyanarayana, B., Mat Zauki, N. A., Muslim, A. M., Husain, M. L., Ibrahim, S., & Nelson, B. R. 2018. *Carcinoscorpius rotundicauda* (Latreille, 1802) population status and spawning behaviour at Pendas coast, Peninsular Malaysia. *Global Ecology and Conservation*. 15, 00422.

Fairuz-Fozi, N., Triest, L., Mat Zauki, N. A., Kaben, A. M., Nelson, B. R., Chatterji, A., Akhir, M.F., Satyanarayana, B. & Dahdouh-Guebas, F. 2021. Mangrove horseshoe crab (*Carcinoscorpius otundicauda* Latreille, 1802) populations reveal genetic break in Strait of Malacca, with connectivity along southern coasts of Peninsular Malaysia. *Aquatic Conservation: Marine and Freshwater Ecosystems*. 31(7), 1559 – 1569.

Freeman, A. S., Short, F. T., Isnain, I., Razak, F. A., & Coles, R. G. 2008. Seagrass on the edge: land-use practices threaten coastal seagrass communities in Sabah, Malaysia. Biological Conservation. 141(12), 2993 – 3005.

G

Gambang, A. C. 1997. Status report: pelagic fish stock in Sarawak, Malaysia. The third regional workshop of shared stocks in the South China Sea area.

Gan, S. H., Waheed, Z., Chung, F. C., Spiji, D. A., Sikim, L., Saleh, E., & Tan, C. H. 2021. In situ observations of coral spawning and spawn slick at Lankayan Island, Sabah, Malaysia. *Marine Biodiversity*, 51(1).

Gholizadeh, M., Yahya, K., Talib, A., & Ahmad, O. 2012. Effects of environmental factors on polychaete assemblage in Penang National Park, Malaysia. *World Academy of Science, Engineering and Technology*. 72, 669 – 672.

Goessens, A., Satyanarayana, B., Van der Stocken, T., Quispe Zuniga, M., Mohd-Lokman, H., Sulong, I., & Dahdouh-Guebas, F. 2014. Is Matang Mangrove Forest in Malaysia sustainably rejuvenating after more than a century of conservation and harvesting management? *PloS ONE*. 9(8), 105069.

Guan, W. S., Lee, D. M., Ghaffar, M. A., Ali, M. D. & Cob, Z. C. 2014. Macrobenthos composition, distribution and abundance within Sungai Pulai estuary, Johor, Malaysia. *AIP Conference Proceedings*. 1614, 591 – 596.

H

Hajisamae, S., & Chou, L. M. 2003. Do shallow water habitats of an impacted coastal strait serve as nursery grounds for fish? *Estuarine, Coastal and Shelf Science*. 56 (2), 281 – 290.

Hall, L. S., Krausman, P. R., & Morrison, M. L. 1997. The habitat concept and a plea for standard terminology. *Wildlife Society Bulletin*. 173 – 182.

Hamdan, N. A., Hassan, M. S. A., Noor, N. M., Hamid, S. A., & Bunnori, N. M. 2017. Dinoflagellates: Ecological Approaches and Spatial Distributions in Malaysia Waters. *Journal of Oceanography and Marine Research*. 5(164), 2.

Hamli, H., Idris, M. H., Abu Hena, M. K., Wong, S. K., & Arshad, A. 2013. Checklist and Habitat Descriptions of Edible Gastropods from Sarawak, Malaysia. *Journal of Fisheries and Aquatic Science*. 8(2), 412 – 418.

Hamli, H., Idris, M. H., Rajaee, A. H., & Kamal, A. H. M. 2015. Reproductive cycle of hard clam, *Meretrix lyrata* Sowerby, 1851 (Bivalvia: Veneridae) from Sarawak, Malaysia. *Tropical Life Sciences Research*. 26(2), 59 – 72.

Hamzah, F. M., Jaafar, O., Jani, W. N. F. A., & Abdullah, S. M. S. 2016. Multivariate analysis of physical and chemical parameters of marine water quality in the straits of Johor, Malaysia. *Journal of Environmental Science and Technology*. 9(6), 427 – 436.

Harith, H., Husain, M. L., & Mohd Akhir, M. F. 2016. Coastal oceanographic processes associated with blood cockle (*Anadara granosa*) induce spawning season in Kapar, Selangor, Malaysia. *Journal of Ocean Engineering and Science*. 1(4), 289 – 299.

Harith, M. N., Md Desa, M. H. I., & Ilias, Z. 2018. *Holothuria leucospilota* population in Satang Besar Island, Sarawak, Malaysia. *International Journal of Zoology*, 1 – 6.

Hii, K. S., Mohd-Din, M., Luo, Z., Tan, S. N., Lim, Z. F., Lee, L. K., Leong, S. C. Y., Teng, S. T., Gu, H., Cao, X., Lim, P. T. & Leaw, C. P. 2021. Diverse harmful microalgal community assemblages in the Johor Strait and the environmental effects on its community dynamics. *Harmful Algae*. 107, 102077.

Ho, D. J., Maryam, D. S., Jafar-Sidik, M., & Aung, T. 2013. Influence of weather condition on pelagic fish landings in Kota Kinabalu, Sabah, Malaysia. *Journal of Tropical Biology and Conservation*. 10, 11 – 21.

Hookham, B., Shau-Hwai, A. T., Dayrat, B., & Hintz, W. 2014. A baseline measure of tree and gastropod biodiversity in replanted and natural mangrove strands in Malaysia: Langkawi Island and Sungai Merbok. *Tropical Life Sciences Research*. 25(1), 1 – 12.

Hoque, M. M., Mustafa Kamal, A. H., Idris, M. H., Ahmed, O. H., Saifullah, A. S. M., & Billah, M. M. 2015. Status of some fishery resources in a tropical mangrove estuary of Sarawak, Malaysia. *Marine Biology Research*. 11(8), 834 – 846.

Hossain, M. S., Bujang, J. S., Zakaria, M. H., & Hashim, M. 2016. Marine and human habitat mapping for the Coral Triangle Initiative region of Sabah using Landsat and Google Earth imagery. *Marine Policy*. 72, 176 – 191.

Hossain, M. S., Hashim, M., Bujang, J. S., Zakaria, M. H., & Muslim, A. M. 2019. Assessment of the impact of coastal reclamation activities on seagrass meadows in Sungai Pulai estuary, Malaysia, using Landsat data (1994–2017). *International Journal of Remote Sensing*. 40(9), 3571 – 3605.

Husain, M. L., Yaakob, R., & Saad, S. 1995. Beach erosion variability during a northeast monsoon: The Kuala Setiu coastline, Terengganu, Malaysia. *Pertanika Journal of Science and Technology*. 3(2), 337 – 348.

Hussin, W. M. R. W. 2014. Marine fish farming in Bidong Island, Malaysia and its implications on benthic community structure and functional diversity. *Aquaculture, Aquarium, Conservation & Legislation*. 7(6), 431 – 440.

I

Ibharim, N. A., Mustapha, M. A., Lihan, T., & Mazlan, A. G. 2015. Mapping mangrove changes in the Matang Mangrove Forest using multi temporal satellite imageries. *Ocean & Coastal Management*. 114, 64 – 76.

Ibrahim, N. E., Wan Omar, W. B., and Faridah, M. 2018. Population density and size of blood cockle, Anadara cornea in Setiu Wetlands, Terengganu during Northeast monsoon season. *Journal of Sustainability Science and Management (Special Issue 5)*, 113 – 123.

Ibrahim, S., Hussin, W. M. R. W, Kassim, Z., Joni, Z. M., Zakaria, M. Z., & Hajisamae, S. 2006. Seasonal abundance of benthic communities in coral areas of Karah Island, Terengganu, Malaysia. *Turkish Journal of Fisheries and Aquatic Sciences*. 6, 129 – 136.

Ibrahim, Y. S., Hamzah, S. R., Khalik, W. M. A. W. M., Yusof, K. M. K. K., & Anuar, S. T. 2021. Spatiotemporal microplastic occurrence study of Setiu Wetland, South China Sea. *Science of The Total Environment*. 788, 147809.

Ibrahim, Y. S., Rathman, R. Anuar, S. T. and Khalik, W. M. A. W. M. 2017. Isolation and characterisation of microplastic abundance in *Lates calcarifer* from Setiu Wetlands, Malaysia. *Malaysian Journal of Analytical Sciences*. 21(5), 1054 – 1064.

Idrus, F. A., Aziz, F., & Lee, A. C. 2021. Length-Weight Relationship, Condition Factor and Feeding Habit of Fishes from Mangrove of Santubong Estuary, Sarawak, Malaysia. *Borneo Journal of Resource Science and Technology*. 11(2), 10 – 18.

Ikhwanuddin, M., Liyana, A. N., Azra, M. N., Bachok, Z., & Abol-Munafi, A. B. 2014. Natural diet of blue swimming crab, *Portunus pelagicus* at Strait of Tebrau, Johor, Malaysia. *Sains Malaysiana*. 43(1), 37 – 44.

Ilias, Z. 2015. *Holothuria scraba* (sandfish) habitat and distribution in Peninsular Malaysia. *Malaysia Fisheries Journal.* 14, 21 – 28.

Island, S., Saleh, E., Kiat, Y. T., Geng, C. N., & Masidi, A. M. 2020. Inventory of marine fauna on reef balls structures of Selingan Island, Sandakan, Sabah, Malaysia. *Journal of Tropical Biology and Conservation.* 17, 203 – 216.

Ismail, A., Yusof, S., and Rahman, F. 2014. Notes on the occurrence of medaka (m.l.c.) fish in South Johor, Malaysia. *Malayan Nature Journal.* 66(1- 2), 36 – 40.

Ismail, J., Kamal, A. H. M., Idris, M. H., Nurul Amin, S. M., Hamli, H., Sien, L. S., Al-Asif, A., & Abualreesh, M. H. 2021. Zooplankton species composition and diversity in the seagrass habitat of Lawas, Sarawak, Malaysia. *Biodiversity Data Journal*. 9, 67449.

Ismail, N., Jolly, J. J., Dzulkiply, S. K., Mustakin, M. M., Hafiz, A. N. M., Huda, A. I., Faezah, S. S. & Chatterji, A. 2011. Carapace Width and Total Body Weight Relationship of Horseshoe crab *Tachypleus gigas* from Chendor and Cherating, Pahang, Malaysia. *Empowering Science, Technology and Innovation Towards a Better Tomorrow, LSP46*, 440 – 444.

J

Jaafar, N., Azfaralariff, A., Musa, S. M., Mohamed, M., Yusoff, A. H., & Lazim, A. M. 2021. Occurrence, distribution and characteristics of microplastics in gastrointestinal tract and gills of commercial marine fish from Malaysia. *Science of the Total Environment*. 799, 149457.

Jaafar, T. N. A. M., Lee, J. N., Abd Ghaffar, M., Kadir, S. T. S. A., & Seah, Y. G. 2019. *Opistognathus nigromarginatus* Rüppell, 1830 (Perciformes, Opistognathidae), Bridled Jawfish: a first record from Malaysia. *Check List*. 15(5).

Jaaman, S. A. & Mohamed, C. A. R. 2014. Marine Mammals in the Waters of East Coast Johor, Malaysia. *ASM Science Journal*. 8(2), 143 – 149.

Jaaman, S. A., Najib, R., Syuhaime, A. A., & Yuhana, U. L. A. 2002. Records of marine mammals in Peninsular Malaysia: A review. In *Tropical Marine Environment: Charting Strategies for the Millennium. F. M. Yusoff, M. Shariff, H. M. Ibrahim, S. G. Tan & S. Y. Tai (eds.), Malacca Straits Research and Development Centre (MASDEC),* Universiti Putra Malaysia, Serdang, Malaysia. 499 – 515.

Jalal, K. C. A., Ahmad Azfar, M., Akhbar John, B., Kamaruzzaman, Y. B., & Shahbudin, S. 2012. Diversity and community composition of fishes in tropical estuary Pahang Malaysia. *Pakistan Journal of Zoology*. 44 (1), 181 – 187.

Jalal, K. C. A., Kamaruzzaman, B. Y., Arshad, A., Ara, R., & Rahman, M.F. 2012. Diversity and distribution of fishes in tropical estuary Kuantan, Pahang, Malaysia. *Pakistan Journal of Biological Sciences*. 15(12), 576 – 582.

Jamizan, A. R., & Chong, V. C. 2017. Demersal fish and shrimp abundance in relation to mangrove hydrogeomorphological metrics. *Sains Malaysiana*. 46(1), 9 – 19.

Jamon, S., Faizal, E. M., & Basir, S. 2016. Fishery, biology and population characteristics of Kawakawa in Perlis the West Coast of Peninsular Malaysia. *Indian Ocean Tuna Commission IOTC-2016-Working Party on Neritic Tuna*, 06 – 15.

Jawahir, A. R. N., Samsur, M., Shabdin, M. L., & Adha, A. R. K. 2017. Distribution of two species of Asian horseshoe crabs at west coast of Sarawak's Waters, East Malaysia. *The Egyptian Journal of Aquatic Research*. 43(2), 135 – 140.

Jipanim, S. J., Shaleh, S. R. M., Lim, P. T., Leaw, C. P., & Mustapha, S. (2019). The monitoring of harmful algae blooms in Sabah, Malaysia. *Journal of Physics: Conference Series*, 1358.

Jivaluk, J. 1999. Distribution, abundance and composition of zooplankton in the South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia Fisheries Research, 256 – 284.

Johan, I., Abu Hena, M. K., Idris, M. H., Amin, S. M. N., Denil, N. A., & Karim, N. U. 2020. Species composition and diversity of fishes from the seagrass habitat of Lawas, Sarawak, Malaysia. *Journal of Environmental Biology*. 41, 1382 – 1389.

Johari, A., Akhir, M. F., Satar, M. N., Zainol, Z., & Jingsong, G. 2021. Inter-annual Changes of Water Temperature in the Southern South China Sea's Continental Shelf: The Influence of Enso on Malaysian Waters. *Journal of Marine Science and Technology*, 29(4), 12.

John, B. A., Jalal, K. C. A., & Kamaruzzaman, B. Y. 2013. Macrobenthic Diversity in Horseshoe Crab Nesting Ground-Balok Station, Pahang, Malaysia. *Oriental Journal of Chemistry*. 29(4), 1311 – 1318.

John, B. A., Sihin, S., Kamaruzzaman, B. Y., Jalal, K. C. A., & Zaleha, K. 2012. Sediment profiling of the nesting grounds of horseshoe crabs at East Peninsular Malaysia. *International Journal of Biology*. 4(2), 159.

Joseph, J., Nishizawa, H., Arshaad, W. M., Kadir, S. A. S., Jaaman, S. A., Bali, J., Jamaludin, N. A. & Katoh, M. 2016. Genetic stock compositions and natal origin of green turtle (*Chelonia mydas*) foraging at Brunei Bay. *Global Ecology and Conservation*. 6, 16 – 24.

Juen, L. L., Aris, A. Z., and Yusoff, F. M. 2014. Metal concentration (CO, Ni, Pb, Zn) in the estuarine and coastal waters from western parts of the Johor Straits. *Malayan Nature Journal*. 66(1-2), 94 – 107.

Jusoff, K. 2013. Malaysian Mangrove Forests and their Significance to the Coastal Marine Environment. *Polish Journal of Environmental Studies*. 22(4).

K

Kadir, S. T. S. A., Manaf, N. A., Ali, A. N., Wail, N. F. C., Bidai, J. A., Ahmad, H., Abdullah, C. M. K. A. C., Mohamad, M. N., Ahmad, M. F., Ahmad, A., Bachok, Z., Motomura, H., Husain, M. L., Ambak, M. A. & Ghaffar, M. A. 2020. Physical-chemical parameters in relation to fish assemblages in the east coast of peninsular Malaysia. *Malaysian Applied Biology*. 49(4), 193 – 199.

Kamarudin, K. R., Rehan, M. M., & Bahaman, N. 2017. Morphological and molecular identifcation of sea cucumber species *Holothuria scabra*, *Stichopus horrens* and *Stichopus ocellatus* from Kudat, Sabah, Malaysia. *Pertanika Journal of Tropical Agricultural Science*. 40(1), 161 – 172

Kamaruzzaman, B. Y., & Ong, M. C. 2008. Recent sedimentation rate and sediment ages determination of Kemaman-Chukai Mangrove Forest, Terengganu, Malaysia. *American Journal of Agricultural and Biological Sciences*. 3(3), 522 – 525.

Kamaruzzaman, B. Y., & Ong, M. C. 2010. The determination of 210Pb in the sediments: Sedimentation rates from the Terengganu coastal waters, Malaysia. *Current World Environment*. 5(1), 9.

Kamaruzzaman, Y. N., Mustapha, M. A., & Abd Ghaffar, M. 2021. Determination of fishing grounds distribution of the Indian Mackerel in Malaysia's Exclusive Economic Zone off South China

Sea using boosted regression trees model. *Thalassas: An International Journal of Marine Sciences*. 37(1), 147 – 161.

Kamaruzzan, A. S., & Jaaman, S. A. 2013. Interactions between Indo-Pacific humpback and Irrawaddy dolphins in Cowie Bay, Sabah, Malaysia. *Malayan Nature Journal*. 64(4), 185 – 191.

Karbalaei, S., Golieskardi, A., Hamzah, H. B., Abdulwahid, S., Hanachi, P., Walker, T. R., & Karami, A. 2019. Abundance and characteristics of microplastics in commercial marine fish from Malaysia. *Marine Pollution Bulletin*. 148, 5 – 15.

Kassim, Z. 2019. Feeding mechanisms of adult tropical horseshoe crab, *Tachypleus gigas* toward Feeds' conditions. *ASM Science Journal*. 11(2), 76 – 85.

Kassim, Z., Ahmad, Z., & Ismail, N. 2018. Diversity of Bivalves in Mangrove Forest, Tok Bali Kelantan, Malaysia. Science Heritage Journal. 2(2), 4 – 9.

Kassim, Z., Murni, W. N. A. W., Razak, M. R., & Adam, S. B. 2018. Chitosan isolated from horseshoe crab *Tachypleus gigas* from the Malay Peninsula. *Oriental Journal of Chemistry*. 34(2), 928.

Khalit, S. I., Samsudin, M. S., Azid, A., Yunus, K., Zaudi, M. A., Sharip, Z., Sharifuddin, S. S., Husin, T. M. 2017. A preliminary study of marine water quality status using principal component analysis at three selected mangrove estuaries in East Coast Peninsular Malaysia. *Malaysian Journal of Fundamental and Applied Sciences*. 13(4), 764 – 768.

Khodzori, F. A., Saad, S., & Mohammad-Noor, N. 2019. Coral Community Structure in Payar Island Marine Park, Malaysia. *Journal of Sustainability Science and Management*. 14(1), 29 – 39.

Kimoto, H., & Johari, I. 1996. The stock status and management scheme of kerisi (*Nemipterus peronii*) on the East Coast of Peninsular Malaysia. Marine Fishery Resources Development and Management Department Of SEAFDEC, Kuala Terengganu, Malaysia.

Kok, P. H., Akhir, M. F., & Qiao, F. 2019. Distinctive characteristics of upwelling along the Peninsular Malaysia's east coast during 2009/10 and 2015/16 El Niños. *Continental Shelf Research*. 184, 10 – 20.

Kok, P. H., Mohd Akhir, M. F., Tangang, F., & Husain, M. L. 2017. Spatiotemporal trends in the southwest monsoon wind-driven upwelling in the southwestern part of the South China Sea. *PloS ONE.* 12(2), 0171979.

Kuit, S. H., Ponnampalam, L. S., Ng, J. E., Chong, V. C., & Then, A. Y. 2019. Distribution and habitat characteristics of three sympatric cetacean species in the coastal waters of Matang, Perak, Peninsular Malaysia. *Aquatic Conservation: Marine and Freshwater Ecosystems*. 29(10), 1681 – 1696.

L

Lau, Y. W., & Reimer, J. D. 2019. A first phylogenetic study on stoloniferous octocorals off the coast of Kota Kinabalu, Sabah, Malaysia, with the description of two new genera and five new species. *ZooKeys*. 872, 127.

Lee, S. L., Chong, V. C., & Yurimoto, T. 2016. Ichthyofauna on a Tropical Mudflat: Implications of Spatial and Temporal Variability in Assemblage Structure and Abundance. *Estuaries and Coasts*. 39(5), 1543 – 1560.

Lee. H. L., Tangang, F., Yusoff, F. M., Ibrahim, Z. Z., Kasim, M. F., & Afzaihelmi, M. 2016. A Baseline study of tropical phytoplankton abundance and its relationships to the environmental variables in the Terengganu River Estuary, Malaysia. *Malaysian Journal of Civil Engineering.* 28(1), 35 – 49.

Leong, T. S. & Wong, S. Y. 1988. A comparative study of the parasite fauna of wild and cultured grouper (*Epinephelus malabaricus* Bloch et Schneider) in Malaysia. *Aquaculture*. 68(3), 203 – 207.

Lias, K., Jamil, T., and Nor Aliaa, S. 2013. A preliminary study on heavy metal concentration in the marine bivalves *Marcia marmorata* species and sediments collected from the coastal area of Kuala Perlis, North of Malaysia. *IOSR Journal of Applied Chemistry*. 4(1), 48 – 54.

Lim, H. C., Teng, S. T., Leaw, C. P., Iwataki, M., and Lim, P. T. 2014. Phytoplankton assemblage of the Merambong Shoal, Tebrau Straits with note on potentially harmful species. *Malayan Nature Journal*. 66(1-2), 1 – 14.

Lim, J. H., Azman, B. A. R., & Othman, B. R. 2019. A new species of Aciconula (Amphipoda, Senticauda, Caprellidae) from Sultan Iskandar Marine Park, Malaysia. *ZooKeys*. 859, 17.

Lim, J. H., Lee, C. W., & Bong, C. W. 2021. Investigating factors driving phytoplankton growth and grazing loss rates in waters around Peninsular Malaysia. *Journal of Oceanology and Limnology*. 3(1), 148 – 159.

Lim, J. H., Lee, C. W., & Kudo, I. 2015. Temporal variation of phytoplankton growth and grazing loss in the west coast of Peninsular Malaysia. *Environmental Monitoring and Assessment*, 18(5).

Lim, J. H., Lee, C. W., Bong, C. W., & Kudo, I. 2021. The impact of eutrophication towards selected bacterial process rates in tropical coastal waters. *Marine Pollution Bulletin*. 169, 112524.

Lim, K. K., Hussein, M. A. S., & Palaniappan, P. 2020. Abundance, placement and sexual identity of the epizoic barnacle *Chelonibia testudinaria* relative to the size and species of host turtles in Mabul Island, Malaysia. *Journal of the Marine Biological Association of the United Kingdom*. 100(8), 1299 – 1309.

Liow, G. R., Lau, W. L. S., Law, K., Hii, K. S., Noor, N. M., Leaw, C. P., & Lim, P. T. 2019. Phytoplankton community changes in Kuantan Port (Malaysia), with emphasis on the paralytic-shellfish toxin-producing dinoflagellate *Alexandrium tamiyavanichii*. *Regional Studies in Marine Science*. 26, 100504.

Lo, S. L., Yap, T. K., Chen, C. A., & Yoshida, T. 2020. Zooplankton in seagrass and adjacent non-seagrass habitats in Tun Mustapha Park, Sabah, Malaysia. *Borneo Journal of Marine Science and Aquaculture*. 4, 6 – 13.

Lola, M. S., & Kamil, A. A. 2021. Estimating discharge of nitrogen in zero water Exchange at I-Sharp Setiu, Terengganu, Malaysia, based on system dynamic approach. *Nature Environment and Pollution Technology*. 20(1), 297 – 303.

M

Madin, J., Ho, S., & Maran, B. V. 2021. Gastropods in the Intertidal Shore of Kota Kinabalu, Sabah (Malaysian Borneo). *Borneo Journal of Resource Science and Technology*. 11(1), 9 – 23.

Maghsoudlou, E., Yahya, K., Ghaedi, A., & Sitiazizah, M. N. 2017. Reproductive biology of the jellyfish (*Chrysaora* sp.) in the north-western coastal waters of Malaysia (Penang Island). *Indian Journal of Geo Marine Sciences*. 46(04), 822 – 829.

Mahadi, M., Sazlina, S., Aileen, T. S. H., and Zulfigar, Y. 2014. Benthic harpacticoid copepod assemblages in Merambong shoal, Johor. *Malayan Nature Journal*. 66(1-2), 54 – 62.

Manca, A., Mohamad, F., Nelson, B. R., Mohd Sofa, M. F. A., Alia'm, A. A. & Noraznawati Ismail. 2016. Trailing the spawning horseshoe crab *Tachypleus gigas* (Müller, 1785) at designated natal beaches on the East Coast of Peninsular Malaysia. *Cell & Developmental Biology*, 5(01).

Mandal, S., Behera, N., Gangopadhyay, A., Susanto, R. D., & Pandey, P. C. 2021. Evidence of a chlorophyll "tongue" in the Malacca Strait from satellite observations. *Journal of Marine Systems*. 223, 103610.

Mat Zauki, N. A., Satyanarayana, B., Fairuz-Fozi, N., Nelson, B. R., Martin, M. B., Akbar-John, B., & Chowdhury, A. J. K. 2019. Citizen science frontiers horseshoe crab population regain at their spawning beach in East Peninsular Malaysia. *Journal of Environmental Management*. 232, 1012 – 1020.

Matias-Peralta, H. M. and Yusoff. 2014. Seasonal environmental quality variations in a tropical seagrass ecosystem at the Straits of Malacca. *Malayan Nature Journal*. 66(1-2), 63 – 80.

Matias-Peralta, H. M., & Yusoff, F. M. 2015. Status of Planktonic Copepod Diversity in the Merambong Seagrass Meadow, Johor, Peninsular Malaysia. *International Journal of Ecosystem*. 5(2), 39 – 43.

Matsuoka, K., Yurimoto, T., Chong, V. C., & Man, A. 2017. Marine palynomorphs dominated by heterotrophic organism remains in the tropical coastal shallow-water sediment; the case of Selangor coast and the estuary of the Manjung River in Malaysia. *Paleontological Research*. 21(1), 14 – 26.

Mazlan, A. G., Abdullah, S., Shariman, M. G., & Arshad, A. 2008. On the biology and bioacoustic characteristic of spotted catfish *Arius maculatus* (Thunberg 1792) from the Malaysian Estuary. *Research Journal of Fisheries and Hydrobiology*. 3(2), 63 – 70.

Mazlan, A. G., Zaidi, C. C., Wan-Lotfi, W. M., & Othman, B. H. R. 2005. On the current status of coastal marine biodiversity in Malaysia. *Indian Journal of Marine Sciences*. 34(1), 76 – 87.

Mazlan, B. A. G., & Rohaya, M. 2008. Size, growth and reproductive biology of the giant mudskipper, *Periophthalmodon schlosseri* (Pallas, 1770), in Malaysian waters. *Journal of Applied Ichthyology*. 24(3), 290 – 296.

Md Razak, M. R., Kassim, Z., Abd Wahab, R., & Hazahari, N. Y. 2022. Horseshoe Crab and Its Spawning Ground Condition in Johor Lama, Johor. *Malaysian Journal of Science*. 41(1), 1 – 22.

Milton, D. A., Chenery, S. R., Farmer, M. J., & Blaber, S. J. M. 1997. Identifying the spawning estuaries of the tropical shad, terubok *Tenualosa toli*, using otolith microchemistry. *Marine Ecology Progress Series*. 153(1–3), 283 – 291.

Minton, G., Peter, C., & Tuen, A. A. 2011. Distribution of small cetaceans in the nearshore waters of Sarawak, East Malaysia. *Raffles Bulletin of Zoology*, 59(1).

Mohamad Saupi, I. & Goeden, G. B. 2020. Assessment of coral reefs community health in Pulau Berhala, Pahang, Malaysia. *Journal of PeerScientist*. 2(1), 1000017.

Mohamad Saupi, I. & Khoo, M. L. 2018. Occurrence and distribution of seagrass in waters of Pulau Setindan, Johor. *Malaysian Fisheries Journal*. 17, 12 – 18.

Mohamad Saupi, I., Khoo, M. L., Masazurah, A. R., Dzulfikkar, B. M., & Hadzley, H. 2017. Checklist and Distribution of Jellyfish in the Coastal Waters of Penisular Malaysia. *Malaysia Fisheries Journal*. 16, 9 – 18.

Mohamad, F., Manca, A., Ahmad, A., Fawwaz, M., Sofa, A. M., Asyraf, A., & Noraznawati, I. 2016. Width-weight and length-weight relationships of the Tri-spine Horseshoe Crab, *Tachypleus tridentatus* (Leach 1819) from two populations in Sabah, Malaysia: implications for population management. *Journal of Sustainability Science and Management*. 11(1), 1 – 13.

Mohamat-Yusuff, F., Sien, K. W., Johari, W. L. W., Ismail, A., Zulkifli, S. Z., and Mustafa, M. 2014. Potential tributyl-tin (TBT) biodegradation agent in contaminated sediment. *Malayan Nature Journal*. 66(1-2), 81 – 93.

Mohamed Rashidi, A. H., Jamal, M. H., Hassan, M. Z., Mohd Sendek, S. S., Mohd Sopie, S. L., & Abd Hamid, M. R. 2021. Coastal structures as beach erosion control and sea level rise adaptation in Malaysia: A review. *Water*. 13(13), 1741.

Mohd Hanapiah, M. F., Saad, S., & Ahmad, Z. 2020. Dispersal Pattern of Coral Larvae in Kuantan Coastal Waters, Malaysia. *Science Heritage Journal*, 4(1), 13 – 18.

Mohd Hanapiah, M. F., Saad, S., Ahmad, Z., Yusof, M. H., Khodzori, M. F. A., & Rosli, M. K. 2020. Broadcast Spawning Pattern and Pelagic Larvae Duration of *Acropora Cytherea* and *A. Clathrata* From Inshore Reef Area in Kuantan Coastal Region. *Science Heritage Journal*. 4(2), 51 – 55.

Mohd Kasihmuddin, M. S., & Cob, Z. C. 2021. Ecological roles of benthic community in seafloor northwards of Pulau Indah, Klang, Malaysia. *Pertanika Journal of Science & Technology*, 29(2).

Mohd Rafi, N. I. F., Ishak, I. M., Rahim, F., Ahmad, R., Mohamed, M. S., Wahab, M. A. I. A., & Ngadi, E. 2020. Diversity of sea shore invertebrates at West Coast Peninsular Malaysia. In *Conference Proceeding Insan Junior Researcher Conference*, 42 – 47.

Mokhtari, M., Ghaffar, M. A., Usup, G., & Cob, Z. C. 2015. Determination of key environmental factors responsible for distribution patterns of fiddler crabs in a tropical mangrove ecosystem. *PLoS ONE*. 10(1), 1 – 17.

Montagne, A., Naim, O., Tourrand, C., Pierson, B., & Menier, D. 2013. Status of coral reef communities on two carbonate platforms (Tun Sakaran Marine Park, East Sabah, Malaysia). *Journal of Ecosystems*, 1 – 15.

Muhamad Darif, N. A., Abdul Samad, N. S., Salleh, S., Mohammad, M., Ahmad Nordin, N. A., Mohamed Javeed, A. M., Jonik, M. G. G., & Mohd Zainudin, M. H. 2016. The abundance and spatial distribution of soft sediment communities in Tanjung Bungah, Malaysia: A preliminary study. *Tropical Life Sciences Research*. 27(1), 71 – 77.

Muhammad Amirullah Al Amin, A., Ahmad, A., Nadia, H., Mohd Saki, N., Nor Azman, Z., Mohd Sukri, M., & Wahab, D. 2020. Study on biomass, value and biodiversity of fishes by underwater videography at selected artificial reefs in Peninsular Malaysia. Institut Sumber Marin Asia Tenggara, Jabatan Perikanan Malaysia. pp. 49 – 51. SEAFDEC/MFRDMD/SP.

Musel, J., Anuar, A., Hassan, M. H., Rajali, H., Yusof, S., & Anuar, A. 2018. Stick Held Cast Net Artificial Light Fishing Effect towards Pelagic Resources in EEZ, Sarawak. *Malaysia Fisheries Journal*. 17, 28 – 38.

Musel, J., Anuar, A., Mohamad, S., Mustapa, N., Hassan, M. H., Rajali, H., & Anuar, A. 2019. Morphometric relationship and the spawning season of *Acetes intermedius* from the coast of Miri Sarawak, Northwestern Borneo. *AACL Bioflux*. 12(2), 457 – 471.

Mustaffa, A., Ahmad, O., Vongpanich, V., Talib, A., & Yahya, K. 2013. Benthic mollusc assemblages in subtidal coastal waters of Penang National Park, Malaysia. In *Proceedings of the 3rd Annual International Conference Syiah Kuala University (AIC Unsyiah) in Conjunction with the 2nd International Conference on Multidisciplinary Research (ICMR),* 144 – 150.

Mustajap, F., Saleh, E., Madin, J., & Hamid, S. A. 2015. Marine habitat mapping at Labuan Marine Park, Federal Territory of Labuan, Malaysia. *Ocean Science Journal*. 50(2), 291 – 298.

Muta Harah, Z. & Sidik, B. J. 2013. Occurrence and Distribution of Seagrasses in Waters of Perhentian Island Archipelago, Malaysia. *Journal of Fisheries and Aquatic Science*. 8(3), 441 – 451.

Muthurajah, S. D., Leong, S. C. Y., Kuwahara, V. S., Moh, P. Y., Ross, O. B. H., & Yoshida, T. 2021. Monsoonal and spatial influence on zooplankton variation in a tropical bay, North Borneo, Malaysia. *Regional Studies in Marine Science*. 47, 101952.

N

Nakajima, R., Yoshida, T., Fuchinoue, Y., Okashita, T., Maekawa, T., Kushairi, M. R. M., Othman, B. H. R. & Toda, T. 2013. Sedimentation impacts on the growth rates of the scleractinian coral *Acropora formosa* from fringing reefs of Tioman Island, Malaysia. *Sains Malaysiana.* 42(9), 1201 – 1205.

Nakajima, R., Yoshida, T., Ross, O. & Toda, T. 2013. First record of a blue-pigmented acartiid copepod in the tropical coral reef waters of Malaysia. *Galaxea, Journal of Coral Reef Studies*. 15, 27 – 28.

Narumon Thapthim. 2002. Abundance and Distribution of Cephalopod Paralarvae in the South China Sea: Sabah, Sarawak (Malaysia) and Brunei Darussalam Waters. Training Department Southeast Asian Fisheries Development Center.

Nasher, E., Heng, L. Y., Zakaria, Z., & Surif, S. 2013. Assessing the ecological risk of polycyclic aromatic hydrocarbons in sediments at Langkawi Island, Malaysia. *The Scientific World Journal*, 1 – 13.

Nasir, N. N. M., Azlan, A., Razman, M. R., Ramli, N. A., & Latiff, A. A. 2011. Dioxins and furans in demersal fish and shellfish from regions in west coast Peninsular Malaysia. *Journal of Food, Agriculture & Environment*. 9(2), 72 – 78.

Nelson, B. R., Satyanarayana, B., Moh, J. H. Z. and Shaharom, F. 2017. Does human infringement at the spawning grounds challenge horseshoe crab eggs and their embryogenesis? *Journal of Sustainability Science and Management Special Issue Number 1: The International Seminar on the Straits of Malacca and the South China Sea 2016*, 1 – 10

Nelson, B. R., Zhong, J. M. H., Zauki, N. A. M., Satyanarayana, B. E. H. A. R. A., & Chowdhury, A. J. K. 2019. Effects of shore sedimentation to *Tachypleus gigas* (Müller, 1785) spawning activity from Malaysian waters. *Journal of Sustainability Science and Management.* 14(1), 41 – 60.

Newell, R. I. E., Marshall, N., Sasekumar, A., & Chong, V. C. 1995. Relative importance of benthic microalgae, phytoplankton, and mangroves as sources of nutrition for penaeid prawns and other coastal invertebrates from Malaysia. *Marine Biology.* 123(3), 595 – 606.

Ng, Y. H., Mohamed, M., Othman, M. N. A., & Tokiman, L. 2019. Diversity and behaviour of mudskippers of Tanjung Piai, Pontian, Johor. *IOP Conference Series: Earth and Environmental Science.* 269, 012037.

Nik-Nurasyikin, N. M. A., Nurulnadia, M. Y., Mohamad Sofi, H., and Jaafar, S. N. 2018. Metals accumulation in cultured tiger grouper, *Epinephelus fuscoguttatus* with estimated weekly intake levels from east coast of Peninsular Malaysia. *Journal of Sustainability Science and Management (Special Issue 5),* 47 – 56.

Nurshazwan, J., Ahmad-Zaki, A. B., & Azman, B. A. R. 2020. A new species of *Cerapus* (Amphipoda: Senticaudata: Ischyroceridae) from Pulau Bum Bum, Sabah, Malaysia, with an identification key to Cerapus species. *Zootaxa*. 4802(3), 519 – 533.

Nurulhuda, A.F., Abu Talib, A., Stobutzki, I. C., & Garces, L.R. 2014. The fisheries resources of the east coast of Peninsular Malaysia dramatic historical declines. *Malaysia Fisheries Journal*. 13, 50 – 70.

Nyanti, L., Ling, T. Y., & Jongkar, G. 2012. Fish and crustacean communities and fish length-weight relationship of Lutong River, Miri, Sarawak, Malaysia. *World Journal of Fish and Marine Sciences*. 4(1), 102 – 110.

Nyanti, L., Nur'Asikin, R., Ling, T.Y. & Grinang, J. 2012. Fish diversity and water quality during flood mitigation works at Semariang mangrove area, Kuching, Sarawak, Malaysia. *Sains Malaysiana*. 41, 1517 – 1525.

O

Okamoto, J., Kadir, S. T. S. A., Motomura, H., Jaafar, T. N. A. M., & Seah, Y. G. 2019. First records of the sole, *Aseraggodes kobensis* (Steindachner, 1896) (Pleuronectiformes, Soleidae), from Malaysia. *Check List*. 15, 991.

Omar, T. F. T., Aris, A. Z., Yusoff, F. M., & Mustafa, S. 2019. Occurrence and level of emerging organic contaminant in fish and mollusk from Klang River estuary, Malaysia and assessment on human health risk. *Environmental Pollution*. 248, 763 – 773.

Ong, M. C., Aziz, N. A., Shazili, N. A. M., and Kamaruzzaman, Y. 2018. Selected heavy metals content in commercial fishes at different season landed at Fisheries Development Authority of Malaysia Complex, Kuala Terengganu, Malaysia. *Journal of Sustainability Science and Management (Special Issue 5)*, 29 – 38.

Ooi, A. L. & Chong, V. C. 2011. Larval fish assemblages in a tropical mangrove estuary and adjacent coastal waters: Offshore-inshore flux of marine and estuarine species. *Continental Shelf Research*, 31, 1599 – 1610.

Ooi, J. L. S., Van Niel, K. P., Kendrick, G. A., & Holmes, K. W. 2014. Spatial structure of seagrass suggests that size-dependent plant traits have a strong influence on the distribution and maintenance of tropical multispecies meadows. *PLoS ONE*, 9(1).

Osman, F., Jaswir, I., Khaza'ai, H., & Hashim, R. 2007. Fatty acid profiles of fin fish in Langkawi Island, Malaysia. *Journal of Oleo Science*, 56(3), 107 – 113.

P

Pang, K., Sharuddin, S. S., Alias, S. A., Nor, N. A. M., & Awaluddin, H. H. 2010. Diversity and abundance of lignicolous marine fungi from the east and west coasts of Peninsular Malaysia and Sabah (Borneo Island). *Botanica Marina*. 53, 515 – 523.

Phang, S., Yeong, H. Y., Ganzon-Fortes, E. T., Lewmanomont, K., Prathrep, A., Hau, L. N, Gerung, G. S. & Tan, K. S. 2016. Marine algae of the South China Sea bordered by Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam. *Raffles Bulletin of Zoology*. 34, 13 – 59.

Piah, R. M., Kamaruddin, S. A., Jamaluddin, M. S., Faizol, N. S., Bokhri, S. N., Jaafar, T. N. A. M., Tan, M. P., & Man, A. 2018. Length-frequency Distribution and Age Composition of Groupers (Serranidae) of Exclusive Economic Zone (EEZ) East Coast of Peninsular Malaysia implication to Fisheries Management. *Malaysia Fisheries Journal*. 17, 19 – 27.

Pinn, W. S., Fang, A. N. P., Razalli, N. M., Nilamani, N., Peng, T. C., Yasin, Z., Tan, S. H., & Fujita, T. 2014. New records of sea stars (Echinodermata: Asteroidea) from Malaysia with notes on their association with seagrass beds. *Biodiversity Journal*. 5(4), 453 – 458.

Ponnampalam, L. S. 2012. Opportunistic observations on the distribution of cetaceans in the Malaysian South China, Sulu and Sulawesi Seas and an updated checklist of marine mammals in Malaysia. *The Raffles Bulletin of Zoology*. 60(1), 221 – 231.

Ponnusami, J. & Aziz, F. 2017. Checklist of Molluscs (Gastropoda and Bivalvia) of Malaysia Exclusive Economic Zone (EEZ) in Sarawak Waters. *Borneo Journal of Resource Science and Technology*. 7(2), 111 – 117.

R

Rahman, R. A., Wong, E. P., Joseph, J., Salleh, S. M., Khoo, S. N., Ismail, M. S., Rahim, M. A., Ramli, R., Ang, T. L., Lee, B. H., Chan, Z. S. & Long, S. L. 2021. First Record of a Stranded Loggerhead Turtle (*Caretta caretta*) in a Ghost Net off Penang, Malaysia. *Marine Turtle Newsletter*. 162, 22 – 24.

Rajali, H. B., Nayan, M. Z. Z., Saidin, M. S., & Salus, D. 2016. The first prawn resource assessment of Lawas District of Sarawak, Federal Territory (FT) Labuan and Sabah Coastal Waters (8th January - 23rd May 2015). *Malaysian Fisheries Journal*. 15, 12 – 64.

Ramarn, T., Chong, V., & Hanamura, Y. 2012. Population Structure and Reproduction of the Mysid Shrimp *Acanthomysis thailandica* (Crustacea: Mysidae) in a Tropical Mangrove Estuary, Malaysia. *Zoological Studies*. 51(6), 768 – 782.

Ransangan, J. & Soon, T. K. 2018. Occurrence and Distribution of Marsh Clam, Polymesoda spp. in Marudu Bay, Sabah, Malaysia. *Open Journal of Marine Science.* 8, 314 – 322.

Rauff, K. O., Abir, I. A., & Qadir, A. 2020. Effect of land reclamation on water using remote sensing techniques, Penang Island. *Indian Journal of Ecology*. 47(2), 290 – 294.

Raveen, B., Satyanarayana, B., Moh, J., & Zhong, H. 2015. Episodic human activities and seasonal impacts on the *Tachypleus gigas* (Müller, 1785) population at Tanjung Selangor in Peninsular Malaysia. *Estuarine, Coastal and Shelf Science*. 164, 313 – 323.

Razak, M. R., & Kassim, Z. 2018. Comparison of horseshoe crabs (*Tachypleus gigas*) morphometry between different populations using allometric analysis. *Aquaculture, Aquarium, Conservation & Legislation*. 11(1), 143 – 157.

Redzuan, N. S. 2021. Monthly Chaetocerotales diversity and abundance, and its relationship with water physicochemical parameters and phytoplankton diversity in Carey Island mangrove ecosystem, Malaysia. *Biodiversitas Journal of Biological Diversity*, 22(7).

Rezagholinejad, S., Arshad, A., Nurul Amin, S. M., & Ara, R. 2016. Composition and diversity of larval fish in the mangrove estuarine area of Marudu Bay, Sabah, Malaysia. *Journal of Environmental Biology 37 (Special Issue)*, 697 – 703.

Rinyod, A. M. R., & Rahim, S. A. K. A. 2011. Reproductive cycle of the razor clam *Solen regularis* Dunker, 1862 in the western part of Sarawak, Malaysia, based on gonadal condition index. *Journal of Sustainability Science and Management*. 6(1), 10 – 18.

Robert, R., Muhammad Ali, S. H., & Amelia-Ng, P. F. 2014. Demographics of Horseshoe Crab Populations in Kota Kinabalu, Sabah, Malaysia with Emphasis on *Carcinoscorpius rotundicauda* and Some Aspects of its Mating Behaviour. *Pertanika Journal of Tropical Agricultural Science*, 37(3).

Rosle, S., & Ibrahim, S. 2017. Habitat preferences of shrimp (*Penaeus monodon*) in Kelantan Delta, Malaysia. *International Journal of Fisheries and Aquatic Studies*. 5(6), 326 – 330.

Rosli, N. S., Yahya, N., Idris, I. and Bachok, Z. 2018. Polychaetous annelid community structure in relation to soft bottom sediment characteristics in continental shelf of the Southern South China Sea. *Journal of Sustainability Science and Management*. 13(5), 125 – 145.

Rosman, N., Taufik, A., & Abir, I. A. 2020. The effect of land reclamation on water clarity in Tanjung Tokong using remote sensing. *Warta Geologi*. 46(2), 82 – 87.

Roziawati, M. R., Hadzley, H., & Ku Kassim, K. Y. 2018. Fitoplankton di kawasan ternakan kerang, Kuala Selangor. *Malaysia Fisheries Journal.* 17, 51 – 60.

Rozihan, M., & Ismail, E. 2012. Impact of Malaysian continental drift on the genetic diversity of horseshoe crab inferred through mtDNA sequence analysis. *International Journal of Biology*. 4(1), 104.

Rumeaida, M. P., Daud, S. M. M., & Badri, F. M. I. 2014. Fish diversity and abundance in Bidong Island, South China Sea, Malaysia. *AACL Bioflux*. 7(3), 176 – 183.

Rumpet, R., Awang, D., Musel, J., & Biusing, R. 1987. Distribution, Abundance and Biological Studies of Economically Important Fishes in the South China Sea, Area II: Sarawak, Sabah and Brunei Darussalam Waters. *Fisheries Research*, 353 – 361.

S

Saad, S. & Khodzori, M. F. A. 2017. Species diversity and abundance of Euphylliidae (Cnidaria: Anthozoa: Scleractinia) corals in Tioman, Redang and Payar Islands, Peninsular Malaysia. *Borneo Journal of Marine Science and Aquaculture.* 1, 51 – 56.

Saadu, H., Sutra, J., Hashim, A. M., Ismail, A., Zulkifli, S. Z., & Amal, M. N. A. 2021. Diversity, composition, taxa biomarkers, and functional genes of fish gut microbes in peat swamp forests and its converted areas in North Selangor, Malaysia. *Pertanika Journal of Tropical Agricultural Science*, 44(3).

Safuan, C. D. M., Ismail, K., Khalil, I., Ali, A., Chong, W. S., Chan, A. A., Ismail, M. N., Repin, I. M., Bachok, Z. 2018. Quantification of coral reef benthos for coral health assessment in Labuan Marine Park Malaysia. *Journal of Sustainability Science and Management (Special Issue 5)*, 101 – 112.

Said, N. M., Mahmud, M. R., & Hasan, R. C. 2017. Satellite-derived bathymetry: Accuracy assessment on depths derivation algorithm for shallow water area. *International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences*, 42.

Salleh, S. M., Nishizawa, H., Ishihara, T., Sah, S. A. M., & Chowdhury, A. J. K. 2018. Importance of Sand Particle Size and Temperature for Nesting Success of Green Turtles in Penang Island, Malaysia. *Chelonian Conservation and Biology*. 17(1), 116 – 122.

Salleh, S. M., Sah, S. A. M., & Chowdhury, A. J. K. 2019. Green turtle nesting activity in Penang Island from 2010 to 2016. *Journal of Sustainability Science and Management*. 14(5), 26 – 42.

Sany, S. B. T., Rezayi, M., Hashim, R., Salleh, A., & Safari, O. 2014. Diversity and distribution of benthic invertebrates in the West Port, Malaysia. *International Journal of Environmental and Ecological Engineering*. 8(7), 493-496.

Sany, S. B. T., Salleh, A., Rezayi, M., Saadati, N., Narimany, L., & Tehrani, G. M. 2013. Distribution and contamination of heavy metal in the coastal sediments of Port Klang, Selangor, Malaysia. *Water, Air, & Soil Pollution*. 224(4), 1476 – 1493.

Sany, S. B. T., Salleh, A., Sulaiman, A. H., Sasekumar, A., Rezayi, M., & Tehrani, G. M. 2013. Heavy metal contamination in water and sediment of the Port Klang coastal area, Selangor, Malaysia. *Environmental Earth Sciences*, 69(6).

Satar, M. N., Akhir, M. F., Kok, P. H., & Daud, N. R. 2020. Upwelling in the northwest Sabah during the northeast monsoon and its relation with El–Niño. *Research in Marine Science*. 5(2), 681 – 698.

Shaari, H., Mohd Nasir, Q., Pan, H. J., Mohamed, C. A. R., Yusoff, A. H., Wan Mohd Khalik, W. M. A., Naim, E., Setiawan, R. Y., & Anthony, E. J. 2020. Sedimentation and sediment geochemistry in a tropical mangrove channel meander, Sungai Kerteh, Peninsular Malaysia. *Progress in Earth and Planetary Science*. 7(1), 1 – 11.

Shah, K., Mustafa Kamal, A. H., Rosli, Z., Hakeem, K. R., & Hoque, M. M. 2016. Composition and diversity of plants in Sibuti mangrove forest, Sarawak, Malaysia. *Forest Science and Technology*. 12(2), 70 – 76.

Shahbudin, S., Hafifi Hafiz, Z., Akhbar John, B., Kamaruzzaman, B. Y., & Jalal, K. C. A. 2011. Distribution and diversity of corals on artificial reefs at Pasir Akar and Teluk Kalong, Redang Island, Malaysia. *Journal of Applied Sciences*. 11(2), 379 – 383.

Shahbudin, S., Jalal, K. C. A., Kamaruzzaman, Y., Mohammad-Noor, N., Chit Dah, T., Akhbar John, B. 2011. Artificial Seagrass: A Habitat for Marine Fishes. *Journal of Fisheries and Aquatic Science*. 8(1), 85 – 92.

Sharum, Y. 2002. Demersal fish stock assessment in the inshore area of the East Coast of Peninsular Malaysia. In *Mansor, M.I. Demersal Fish Resources in Malaysian, Thirteeth Trawl Survey of the Coastal Waters off the East Coast of Peninsular Malaysia (April - June 2001).* pp. 15 - 50. Department of Fisheries, Ministry of Agriculture Malaysia.

Shazili, N. A. M., Yunus, K., Ahmad, A. S., Abdullah, N., & Rashid, M. K. A. 2006. Heavy metal pollution status in the Malaysian aquatic environment. *Aquatic Ecosystem Health & Management*. 9(2), 137 – 145.

Shi, G. W., Ghaffar, M. A., Ali, M. M., and Cob, Z. C. 2014. The polychaeta (Annelida) communities of the Merambong and Tanjung Adang Shoals, Malaysia, and its relationship with the environmental variables. *Malayan Nature Journal*. 66(1 – 2), 168 – 183.

Short, F. T., Polidoro, B., Livingstone, S. R., Carpenter, K. E., Bandeira, S., Bujang, J. S., Calumpong, H. P., Carruthers, T. J. B., Coles, R. G., Dennison, W. C., Erftemeijer, P. L. A., Fortes, M. D., Freeman, A. S., Jagtap, T. G., Kamal, A. H. M., Kendrick, G. A., Kenworthy, W. J., La Nafie, Y. A., Nasution, I. M., Orth, R. J., Prathep, A., Sanciango, J. C., van Tussenbroek, B., Vergara, S. G., Waycott, M. & Zieman, J. C. 2011. Extinction risk assessment of the world's seagrass species. *Biological Conservation*. 144(7), 1961 – 1971.

Shuaib, N., Mohammad, M., Peralta, H. M. M.-, Rusiman, M. S., & Sanusi, S. B. 2018. Preliminary Observations of Zooplankton in Pulau Tinggi, Marine Park, Johor, Malaysia. *International Journal of Engineering & Technology*. 7(4.30), 94 – 95.

Sigwart, J. D., Wong, N. L. W., & Esa, Y. 2021. Global controversy in oyster systematics and a newly described species from SE Asia (Bivalvia: Ostreidae: Crassostreinae). *Marine Biodiversity*. 51(5), 1 – 16.

Singh, H. R. & Sasekumar, A. 1994. Distribution and abundance of marine wood borers on the west coast of Peninsular Malaysia. Hydrobiologia. 285, 111 – 121.

Siow, R., Nurridan, A. H., Hadil, R. and Richard, R. 2019. The establishment of fisheries refugia as a new approach to sustainable management of fisheries in Malaysian waters. *IOP Conference Series: Earth and Environmental Science,* 414.

Siti-Balkhis, A. B., Yaman, I. C., Siti-Hasmah, I., Khalil, M. Z., Muhammad-Shukri, M. Y., Zulfigar, Y., & Aileen-Tan, S. H. 2014. A Survey of the Marine Intertidal Macrogastropoda in the Northern Straits of Malacca. *ASM Science Journal*. 8(2), 159 – 164.

Somerfield, P. J., Gee, J. M., & Aryuthaka, C. 1998. Meiofaunal communities in a Malaysian mangrove forest. *Journal of the marine biological Association of the United Kingdom*. 78(3), 717 – 732.

Srijaya, T. C., Pradeep, P. J., Mithun, S., Hassan, A., Shaharom, F., Chatterji, A. 2010. A new record on variability in different body measurements of the horseshoe crab, *Carcinoscorpius rotundicauda* (Latreille) collected from Setiu and Gelang Patah habitats in Peninsular Malaysia. *Journal of the Bombay Natural History Society*. 107(2), 130 – 135

Su Yin, C. & Yee Kwang, S. 2016. Coastal macroinvertebrate study in Penang Island, Malaysia. *Tropical Life Sciences Research*. 27(1), 39 – 44.

Syahrizan, H. K., & Bachok, Z. 2018. Effect of monsoonal fluctuations on micro-phytoplankton and chlorophyll-a relationship in reefs ecosystems of South China Sea. *Journal of Sustainability Science and Management*. 5, 191 – 201.

Syazwan, W. M., Low, L. B., & Rizman-Idid, M. 2020. First record in Peninsular Malaysia and morphological redescription of *Lychnorhiza malayensis* (Scyphozoa: Rhizostomeae: Lychnorhizidae). *Raffles Bulletin of Zoology*, 68.

Syuhaida, N., Rozihan, M., Akbar, J., Akmal, M., & Joni, H. 2019. Allometry relationship of mangrove horseshoe crab, *Carcinoscorpius rotundicauda* from the West Coast of Peninsular Malaysia. *International Journal of Fisheries and Aquatic Studies*. 7(2), 223 – 228.

T

Taha, Z. D., Amin, R. M., Anuar, S. T., Nasser, A. A. A., & Sohaimi, E. S. 2021. Microplastics in seawater and zooplankton: A case study from Terengganu estuary and offshore waters, Malaysia. *Science of The Total Environment*. 786, 147466.

Tan C. H., Mohd Safuan, C. D., Idris, I., Mohd Noor, M. R. H., Samshuri, M. A., Kamarrudin, N., Zaidi, P. N., Jaafar, S. N. T., & Andrew H. B. 2020. Multispecific synchronous coral spawning on Pulau Bidong, Malaysia. *Bulletin of Marine Science*. 96, 193 – 194.

Tan, A. N., Christianus, A., & Satar, M. A. 2011. Epibiont infestation on horseshoe crab *Tachypleus gigas* (Müller) at Pantai Balok in Peninsular Malaysia. *Our Nature*. 9(1), 9 – 15.

Tan, H. S. & Rahim, A. A. 2018. Diversity of coastal mysids from Pulau Tinggi, Sultan Iskandar Marine Park, Malaysia. *Nauplius: The Journal of The Brazilian Crustacean Society*. 26, 2018037.

Tan, I. V., & Arai, T. 2019. Reproductive characteristics of coral-reef fishes, Pomacentridae, Monodactylidae and Chaetodontidae, in the east coast of Peninsula Malaysia. *Tropical Ecology.* 60(4), 532 – 538.

Tan, K. S., & Ransangan, J. 2017. Effects of nutrients and zooplankton on the phytoplankton community structure in Marudu Bay. *Estuarine, Coastal and Shelf Science*. 194, 16 – 29.

Tan, T. H., Lim, P. T., Mujahid, A., Usup, G., & Leaw, C. P. 2013. Benthic harmful dinoflagellate assemblages in a fringing reef of Sampadi Island, Sarawak, Malaysia. *Marine Research in Indonesia*. 38(2), 11 – 21.

Tang, K. K. W., & Mahmud, M. R. 2018. Imagery-derived bathymetry in Strait of Johor's turbid waters using multispectral images. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*. 42, 139 – 145.

Tang, K. K. W., & Mahmud, M. R. 2021. The Accuracy of Satellite Derived Bathymetry in Coastal and Shallow Water Zone. *International Journal of Built Environment and Sustainability*. 8(3), 1 – 8.

Teh, C. P., Nithiyaa, N., Amelia Ng, P. F., Woo, S. P., Norhanis, M. R., Zulfigar, Y., Aileen, Tan, S. H. 2014. The diversity of the marine macrogastropods on the seagrass meadows in Merambong Shoal, Johore. *Malayan Nature Journal*. 66 (1–2), 149 – 158.

Teoh, V. Y. J. & Woo, S. P. 2021. The diversity of echinoderms in the seagrass meadows of Penang Island, Malaysia. *IOP Conference Series: Earth and Environmental Science*. 711, 012012.

Thornberg, H. M., Culver, S. J., Corbett, D. R., Mallinson, D. J., Buzas, M. A., & Shazili, N. A. M. 2014. The influence of aquaculture on modern foraminifera and sediments in the Setiu estuary and Lagoon, Terengganu, Malaysia: A temporal investigation. *Journal of Foraminiferal Research*. 44(4), 365 – 389.

Toda, T., Okashita, T., Maekawa, T., Alfian, B. A. A. K., Rajuddin, M. K. M., Nakajima, R., Chen, W., Takahashi, K. T., Othman, B. H. R., & Terazaki, M. 2007. Community structures of coral reefs around Peninsular Malaysia. *Journal of Oceanography*. 63, 113 – 123.

Tongkul, F., Roslee, R., & Daud, A. K. T. M. 2020. Assessment of tsunami hazard in Sabah-Level of threat, constraints and future work. *Bulletin of the Geological Society of Malaysia*, 70.

Tzuen Kiat, Y. 2018. The occurrence of boring bivalve (Genus: Zachsia), in a tropical seagrass meadow in Gaya Island (Sabah, Malaysia) and its possible ecological implications. *Borneo Journal of Marine Science and Aquaculture*. 2, 48 – 53.

U

Uning, R., Suratman, S., Nasir, F. A. M., & Latif, M. T. 2021. Spatial and temporal variations in nutrients during upwelling season off the East Coast of Peninsular Malaysia. *Bulletin of Environmental Contamination and Toxicology*, 1 – 6.

V

Vaezzadeh, V., Thomes, M. W., Kunisue, T., Tue, N. M., Zhang, G., Zakaria, M. P., Affendi, Y. A., Yap, F. C., Chew, L. L., Teoh, H. W., Lee, C. W. & Bong, C. W. 2021. Examination of barnacles' potential to be used as bioindicators of persistent organic pollutants in coastal ecosystem: A Malaysia case study. *Chemosphere*. 263, 128272.

van der Meij, S. E., Draisma, S. G., & Waheed, Z. 2018. Multiple observations of the sea anemone *Phyllodiscus semoni* Kwietniewski, 1897 (Actiniaria: Aliciidae) from Sabah, Borneo represent first records for Malaysia. *Regional Studies in Marine Science*. 18, 135 – 138.

Vianna, G. M., Meekan, M. G., Rogers, A. A., Kragt, M. E., Alin, J. M., & Zimmerhackel, J. S. 2018. Shark-diving tourism as a financing mechanism for shark conservation strategies in Malaysia. *Marine Policy*. 94, 220 – 226.

Voris, K. 2015. Marine snake diversity in the mouth of the Muar River, Malaysia. *Tropical Natural History*. 15(1), 1 – 21.

W

Waheed, Z., Adnan, F. A. F., Hwa, L. C. H., & Hashim, S. R. M. 2007. Status of coral reefs and sedimentation at Kota Kinabalu: a preliminary study at Gaya Bay and Sepangar Bay. *Borneo Journal of Marine Science and Aquaculture*, 27 – 43.

Wan Zabidii, W. M., Siti Akmar Khadijah, A. R., Richard, R., Jamil, M., & Ruhana, H. 2017. Checklist of Gastropods from the Exclusive Economic Zone (EEZ), Sarawak, Malaysia. *Tropical Life Sciences Research*. 28(1), 117 – 129.

Wan-Lotfi, W. M., Samat, A., Cob, Z. C., & Ghaffar, M. A. 2010. Checklist of Marine Epibenthic Invertebrate Species from Mersing, Johor. *Siri Penyelidikan & Maklumat Perairan Malaysia*. 2, 203 – 212.

Wee, H. B., Reimer, J. D., Safuan, M., Saidin, J., Tan, C. H., & Bachok, Z. 2017. Zoantharian abundance in coral reef benthic communities at Terengganu Islands, Malaysia. *Regional Studies in Marine Science*. 12, 58 – 63.

Wong, N. L. W. S. & Arshad, A. 2011. A brief review on marine shelled mollusca (Gastropoda and Bivalvia) record in Malaysia. *Journal of Fisheries and Aquatic Science*. 6(7), 669 – 699.

Wong, N. L. W. S., Arshad, A., Yusoff, F. M., Japar Sidik, B., and Mazlan, A. G. 2014. The epifaunal marine bivalves and macrophytes in Merambong Shoal, Pulai River Estuary, Straits of Malacca. *Malayan Nature Journal*. 66(1–2), 41 – 53.

Woo, S. P., The, C. P., Norhanis, M. R., Nithiyaa, N., Amelia-Ng, P. F., Zulfigar, Y., and Tan, S. H. 2014. Sea cucumber species of the Merambong Shoal with notes on the distribution and habitat of the dominant species. *Malayan Nature Journal*. 66(1–2), 159 – 167.

Y

Yahya, N., Idris, I., Rosli, N. S., & Bachok, Z. 2018. Population dynamics of mangrove clam, *Geloina expansa* (Mousson, 1849) (Mollusca, Bivalvia) in a Malaysian mangrove system of South China Sea. *Journal of Sustainability Science and Management*. 13(5), 203 – 216.

Yahya, N., Idris, I., Rosli, N. S., & Bachok, Z. 2020. Mangrove-associated bivalves in Southeast Asia: A review. *Regional Studies in Marine Science*. 38, 101382.

Yap, C. K., & Tan, S. G. 2010. Heavy metal concentrations in the different tissues of horseshoe crabs collected from intertidal sites of the polluted Juru River and the relatively unpolluted Sepang Besar River, Peninsular Malaysia. *Malaysian Journal of Science*. 29(2), 137 – 152.

Yew, W. T., Lam, W. H., Soon, C., & Aziz, R. 2014. Seabed Condition from Single Beam Echo Sounder from Penang Port, Malaysia. In *Applied Mechanics and Materials*, 567, pp. 301-306. Trans Tech Publications Ltd.

Yie, W. S., Hartstein, N. D., Maxey, J. D., Bakar, M. S. B., & Hui, L. C. 2021. Coastal upwelling along the west coast of Sabah and its impact on coastal aquaculture management. *Ocean & Coastal Management,* 211, 105781.

Yin, C. S., Chai, Y. J., Carey, D., Yusri, Y., & Barry, G. J. 2020. Anthropogenic marine debris accumulation in mangroves on Penang Island, Malaysia. *Journal of Sustainability Science and Management*. 15(6), 36 – 60.

Yong, H. L., Mustapa, N. I., Lee, L. K., Lim, Z. F., Tan, T. H., Usup, G., Gu, H., Litaker, R. W., Tester, P. A., Lim, P. T. & Leaw, C. P. 2018. Habitat complexity affects benthic harmful dinoflagellate assemblages in the fringing reef of Rawa Island, Malaysia. *Harmful Algae*. 78, 56 – 68.

Yong, Y. L., Chew, L. L., Lee, C. W., & Chong, V. C. 2016. Monsoonal and lunar variability in microzooplankton abundance and community structure in the terusan mangrove creek (Malaysia). *Marine Biology Research*. 12(3), 278 – 293.

Yule, C. M., & Gomez, L. N. 2009. Leaf litter decomposition in a tropical peat swamp forest in Peninsular Malaysia. *Wetlands Ecology and Management*. 17(3), 231 – 241.

Yurimoto, T. 2020. Risk Assessment for Paralytic Shellfish poisoning (PSP) toxins from the blood cockle, *Tegillarca granosa* (Linnaeus, 1758), off the Selangor Coast, Peninsular Malaysia. *Malaysian Fisheries Journal*. 19, 80 – 96.

Yurimoto, T. 2020. Status of blood cockle, *Tegillarca granosa* (Linnaeus, 1758), aquaculture and sustainable production in Selangor, Malaysia. *Malaysian Fisheries Journal*. 19, 1 – 20.

Yurimoto, T., Kassim, F. M., & Man, A. 2014. Sexual maturation of the blood cockle, *Anadara granosa*, in Matang mangrove estuary, Peninsular Malaysia. *International Journal of Aquatic Biology*. 2(3), 115 – 123.

Yurimoto, T., Kassim, F. M., Fuseya, R., Matsuoka, K., & Man, A. 2021. Food availability estimation of the blood cockle, *Anadara granosa* (Linnaeus, 1758), from the aquaculture grounds of the Selangor coast, Malaysia. *International Journal of Aquatic Biology*. 9(2), 88 – 96.

Yurimoto, T., Kassim, F. M., Man, A., & Fuseya, R. 2014. Spawning season and larval occurrence of blood cockle (*Anadara granosa*) off the Selangor coast, Peninsular Malaysia. *International Journal of Aquatic Biology*. 2(6), 299 – 304.

Yurimoto, T., Mohd Kassim, F., Fuseya, R., & Man, A. 2014. Mass mortality event of the blood cockle, *Anadara granos*a, in aquaculture ground along Selangor coast, Peninsular Malaysia. *International Aquatic Research*, 6(4).

Yusoff, A. H., & Mohamed, C. A. R. 2019. Sedimentation rate and 210Pb sediment dating at Kuantan and Kemaman harbours, Malaysia. In *AIP Conference Proceedings*. 2068(1), 020025. AIP Publishing LLC.

Yusop, S. M., & Mustapha, M. A. 2018. Mapping distribution of *Rastrelliger kanagurta* in the Exclusive Economic Zone (EEZ) of Malaysia using maximum entropy modeling approach. In *AIP Conference Proceedings*, 1940(1), 020051. AIP Publishing LLC.

Z

Zainal Abidin, D. H., Lavoué, S., Hassan Alshari, N. F. M. A., Nor, S. A. M., Rahim, M. A., & Mohammed Akib, N. A. 2021. Ichthyofauna of Sungai Merbok mangrove forest reserve, northwest Peninsular Malaysia, and its adjacent marine waters. *Check List*. 17(2), 601 – 631.

Zainol, Z., & Akhir, M. F. M. 2016. Coastal upwelling at Terengganu and Pahang coastal waters: Interaction of hydrography, current circulation and phytoplankton biomass. *Jurnal Teknologi*, 78(8).

Zaiton, S., Huda-Farhana, M. M., & Hasan-Basri, B. 2019. Conservation of mangroves in Kuala Perlis, Malaysia—A case study of socio-economic attributes of fishermen driving valuation in sustaining livelihoods through forest management. *Journal of Tropical Forest Science*. 31(4), 433 – 442.

Zakaria, M. & Rajpar, M. N. 2015. Assessing the fauna diversity of Marudu Bay mangrove forest, Sabah, Malaysia, for future conservation. *Diversity*. 7(2), 137 – 148.

Zaki, M. R. M., Ying, P. X., Zainuddin, A. H., Razak, M. R., & Aris, A. Z. 2021. Occurrence, abundance, and distribution of microplastics pollution: an evidence in surface tropical water of Klang River estuary, Malaysia. *Environmental Geochemistry and Health*. 43, 3733 – 3748.

Zaki, M., Mohsin, A. K., & Ambak, M. A. 1994. Reproductive Characteristics of *Nemipterus peronii* (Valenciennes) from the East Coast of Peninsular Malaysia. Pertanika Journal of Tropical Agricultural Science. 17(1), 1 – 5.

Zaleha, K., Hazwani, I., Hamidah, H. S., Kamaruzzaman, B. Y., & Jalal, K. C. A. 2011. Effect of salinity on the egg hatching and Early Larvae of Horseshoe Crab *Tachypleus gigas* (Muller, 1785) in laboratory culture. *Journal of Applied Sciences*. 11(14), 2620 – 2626.

Zaleha, K., John, B. A., Atika, H. E., Kamaruzzaman, B. Y., & Jalal, K. C. A. 2012. Spawning and Nesting Behaviour of *Tachypleus gigas* along the East Coast of Peninsular Malaysia. *International Journal of Biology*, 4(2).

Zanuri, N. B. M., Abdullah, M. B., Darif, N. A. M., Nilamani, N., & Hwai, A. T. S. 2020. Case study of marine pollution in Teluk Bahang, Penang, Malaysia. In *IOP Conference Series: Earth and Environmental Science*. 414(1), 012032). IOP Publishing.

Zauki, N. A. M., Satyanarayana, B., Fairuz-Fozi, N., Nelson, B. R., Martin, M. B., Akbar-John, B., & Chowdhury, A. J. K. 2019. Horseshoe crab bio-ecological data from Balok, east coast peninsular Malaysia. *Data in brief*. *22*, 458 – 463.

Zawawi, M. H., Idris, M. H., Kamal, A. H. M., & Wong, S. K. 2014. Seaweed composition from Bintulu Coast of Sarawak, Malaysia. *Pakistan Journal of Biological Sciences*. 17(8), 1007 – 1014.

Zhila, H., Mahmood, H., & Rozainah, M. Z. 2014. Biodiversity and biomass of a natural and degraded mangrove forest of Peninsular Malaysia. *Environmental Earth Sciences*. 71(11), 4629 – 4635.

Zubir, A. A., Saad, F. M., & Dahalan, F. A. 2018. The Study of Heavy Metals on Sediment Quality of Kuala Perlis Coastal Area. In *E3S Web of Conferences*, 34, 02018. EDP Sciences.

Zuldin, W. H., Shapawi, R., Shaleh, S. R. M., Kadar, N. A., & Lal, M. T. M. 2019. First occurrence of *Caulerpa macrodisca* (Caulerpaceae, Chlorophyta) in Malaysia based on the molecular and morphological evidence. *Malaysian Journal of Science*, 72 – 83.

Zulfigar, Y., Sim, Y. K., & Aileen Tan, S. H. 2007. The distribution of sea cucumbers in Pulau Aur, Johore, Malaysia. Publications of the Seto Marine Biological Laboratory. *Special Publication Series*. 8, 73 – 86.

Zuraire, M., Cob, Z. C., Toda, T., Othman, B. H. R., Othman, B. H. R., & Yoshida, T. 2018. Seasonal changes in abundance of four Acartia species (Copepoda, Calanoida) in the coastal waters of Peninsular Malaysia; relationship with monsoon transition. *Regional Studies in Marine Science*. 22, 101 – 111.

CHAPTER 5

MARINE PLANTS

Emienour Muzalina Mustafa
Siti Mariam Muhammad Nor
Daud Awang
Nuridan Abd Han
Siti Aishah Abdullah
Phang Siew Moi
Jillian Ooi Lean Sim
Tariq Mubarak Husin

1.0 INTRODUCTION

Malaysia is an archipelago country located in a tropical area with potential marine resources and has a total coastline of 4,675 kilometres (2,905 mi), with Peninsular Malaysia has 2,068 kilometres (1,285 mi), while East Malaysia has 2,607 kilometres (1,620 mi) of coastline. Located near the equator, Malaysia's climate is hot and humid throughout the year. The average rainfall is 250 centimetres (98 in) a year, and the average temperature is 27 °C (80.6 °F). Malaysia faces two monsoon seasons: the Southwest Monsoon from late May to September and the Northeast Monsoon from October to March. The Northeast Monsoon brings in more rainfall than the Southwest Monsoon, originating in China and the North Pacific. The southwest monsoon originates from the deserts of Australia. March and October form transitions between the two monsoons. Malaysia is also exposed to the El Niño effect, which reduces rainfall in the dry season.

Coastal vegetation, including microalgae, seaweed, seagrasses, and mangroves, is a diverse and widespread group of photosynthetic organisms. They can be found in almost all marine aquatic environments, from marine to brackish areas. Microalgae, seaweeds, seagrass, and mangroves are essential components of coastal marine ecosystems that provide valuable ecosystem functions and play a significant role as primary producers, providing food, habitat structure, breeding grounds, shelter for many coastal organisms, act as water filtration, recycling of nutrients, detrital producer, involved in degradation and carbon fixation, buffers shores and retains sediments from the effects of erosive processes, such as tides, waves, and storms.

Microalgae are a diverse group of microorganisms comprising eukaryotic photoautotrophic protists and prokaryotic cyanobacteria (sometimes called blue-green algae). These microbes contribute to half of the global photosynthetic activity and are virtually found in euphotic niches. (Anderson, 1996). Moreover, these microalgae form the source of the food chain for more than 70% of the world's biomass. Microalgae can be cultivated photosynthetically using solar energy and carbon dioxide as a carbon source (Garmendia, 2013). Microalgae are classified into more than a dozen influential groups, predominantly based on pigment composition, storage profile of products, and diversity of ultrastructural features. Various molecular biology techniques have recently determined the families of the different algal groups and their relationships to other taxonomic groups (Guiry & Guiry, 2021).

Seaweeds (marine macroalgae) are a group of photosynthesizing organisms that generally attach to rock or other hard substrata in coastal areas. Seaweeds are found between high and low tide and in the sub-tidal region up to a depth where 0.01 % photosynthetic light is available. Plant pigments, light, exposure, depth, temperature, waves, and shore characteristics combine to create a different environment that determines the distribution and variety among seaweeds (Wong, 2007).

Seagrasses are rhizomatous clonal angiosperms that live in a marine environment with a long evolutionary history and a global distribution (Ooi et al.,2006). They are found in various habitats, including estuaries, coastal embayment, tropical reef tops, and deep-water environments. Yet, they have a surprisingly low taxonomic diversity of ca. 60–70 species worldwide. Seagrasses are foundation species that can significantly enhance marine biodiversity by providing food and habitat for other organisms. Seagrass communities include species from all of life's broad taxonomic groups, from bacteria to algae, invertebrates, fish, birds, reptiles, and mammals, often in orders of magnitude greater than in adjacent bare habitats. The increased biodiversity of seagrass systems generally has a positive influence on essential ecosystem functions through improvements in productivity, resilience, and resource use and is likely to maintain the most significant number and diversity of ecosystem services. The enhancement and preservation of biodiversity guide conservation and restoration efforts in seagrass ecosystems (Arshad et al., 2006).

Mangrove plants include shrubs, ferns, trees, and palms that occupy the inter-tidal areas between land and sea of tropical and subtropical regions (Clough, 2013; Tomlinson, 1986). They are restricted to the tidal zone, which is the strip of coast starting from the lowest low water level to the highest high-water level (spring tide). In Malaysia, mangrove forests comprised 630,000 ha (Azhar and Nik, 2003) where this forest is mainly found in Sabah (60%), followed by Sarawak (22%) and Peninsular Malaysia (18%) respectively (Omar et al. 2018). Mangrove plants are generally divided into two groups, namely, i) True Mangrove Species and ii) Mangrove Associate Species. Valid mangrove species thrive mainly in a mangrove environment, do not extend into terrestrial plant communities, and are morphologically, physiologically, and reproductively adapted to saline, waterlogged and anaerobic conditions. Generally, True Mangrove Species are categorized as 'exclusive' species limited to the mangrove environment. Mangrove Associate Species are classified as 'nonexclusive' species mainly distributed in a terrestrial or aquatic habitat and the mangrove ecosystem.

Biodiversity studies of tropical seaweeds, seagrass, and mangroves are currently gaining attention. However, more efforts are needed to understand its status. The effects of human activities, such as beach grooming, coastal erosion, and sea-level rise on coastal, estuarine and open ocean habitats, will influence these marine plants diversity, abundance, and distribution. The previous data on the biodiversity of seaweeds in the Straits of Malacca was reported by Phang et al. (2008; 2005) on the marine algae of Pulau Jarak, Sembilan Group of Islands, and Pulau Perak. As written in 2006 by Phang et al. (2006), the recorded marine algae in Malaysia comprise 381 taxa with 105 taxa from Chlorophyta, 186 taxa from Rhodophyta, 73 taxa from Phaeophyta and 17 taxa from Cyanophyta. However, based on a preliminary literature search, there are duration gaps and a lack of comprehensive data and related information on the status of diversity and distribution of marine plants in Peninsular Malaysia, Sabah, and Sarawak. Therefore, we need to gather the latest data and related information on Malaysia's diversity and distribution of marine plants. Microalgae, seaweed, seagrass, and mangroves are critical components of marine biodiversity and play vital roles in ecosystem function, yet many

species are vulnerable to global environmental change and anthropogenic impacts. Understanding how such effects have affected marine plants' diversity and distribution patterns will facilitate predictions of how aquatic plants will respond to ongoing global environmental change and thus inform management and conservation strategies. In this context, this study will provide reliable baseline information for monitoring and evaluating the impact of rapid coastal development on microalgae, seaweed, seagrass, and mangrove diversity and distribution. We hope this study will serve as authentic reference material for students, teachers, researchers, and policy planners interested in marine bio-resources and their sustainable utilization.

2.0 OBJECTIVES

The objectives of this project are:

(i) To record, document, and analyze marine plant diversity information and data resulting from previous studies in Malaysian waters to be translated into a comprehensive inventory report, including the production of a geospatial map of marine resources

(ii) To analyze information gaps and the need for further research to obtain additional information to ensure that it represents the area of interest to be protected more comprehensively

(iii) To identify potential areas to be protected as MPAs with the creation of marine ecological corridors

3.0 MATERIALS AND METHODS

For Focus Group Five (FG5), under the topic of Marine Plants, the team's members consist of eleven researchers from different universities and government agencies who contributed the journal articles and books to be used in this project. The list of members is shown in Table 1.

Table 1: List of members for FG5: Marine Plants

No	Name	Institution	Role
i.	Dr Emienour Muzalina Mustafa	Universiti Malaysia Terengganu	FG5 group leader; contributed to the data, analyzed all the data and was involved in the report writing for marine microalgae, seaweed & seagrass, and compilation of all information.
ii.	Dr Siti Mariam Muhammad Nor	Universiti Malaysia Terengganu	Contributed to the data, analyzed the data, and was involved in the report writing for mangrove.
iii.	Mr. Daud Awang	Fisheries Research Institute, Bintawa, Sarawak	A representative from the Department of Fisheries, Malaysia
iv.	Mrs. Nuridan Abd Han	Fisheries Research Institute, Bintawa, Sarawak	Representative from Department of Fisheries, Malaysia
v.	Dr Siti Aishah Abdullah	Universiti Malaysia Terengganu	Contributed to the data & pictures
vi.	Prof Emeritus Dr. Phang Siew Moi	University Malaya & UCSI University	Contributed to the data
vii.	Dr. Jillian Ooi Lean Sim	University Malaya	Contributed to the data
viii	Mr. Tariq Mubarak Husin	Malaysia Forest Research Institute	Contributed to the data
ix.	Ms. Nur Nadirah Mohd Musir	Universiti Malaysia Terengganu	Research Assistant
x.	Ms. Zarifah Mohd Zaifurizan	Universiti Malaysia Terengganu	Research Assistant
xi	Ms. Nadiatul Azimah Mohd Razali	Universiti Malaysia Terengganu	Research Assistant

Duration of works

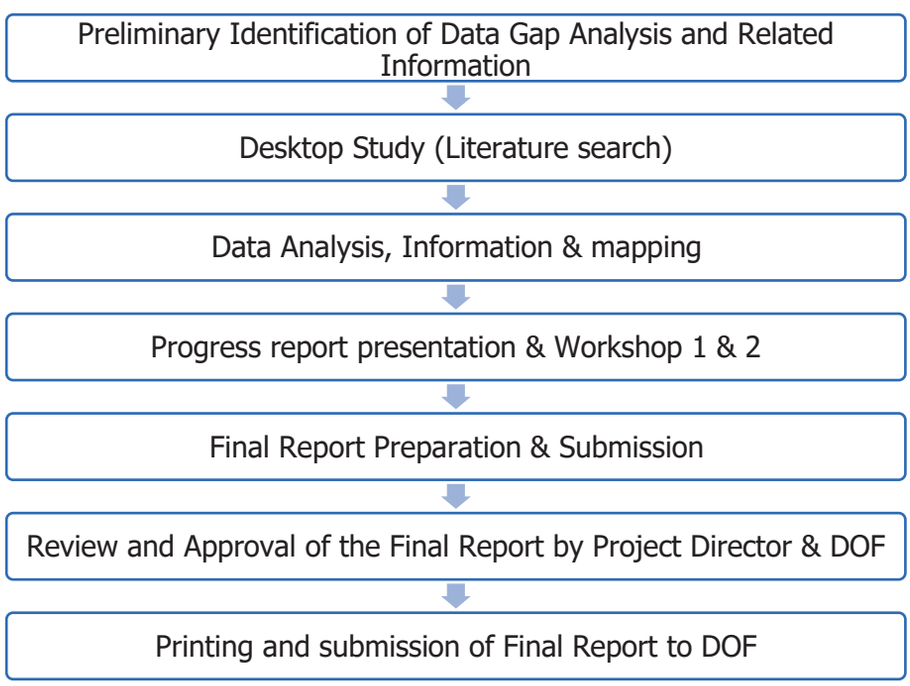
1 Aug 2021 to 31 Oct 2022 (15 Months)

Scope of works

The data and related information on species composition, abundance, and distribution of marine plants, including microalgae, seaweed, seagrass, and mangrove around Malaysia's coastlines, estuaries, along rivers and open ocean areas of Peninsular Malaysia, Sarawak and Sabah were searched via desktop study.

The information was collected from various sources, including online & offline research articles, conference proceedings, reference books, monographs, government agency reports, thesis, posters, newspapers, etc. The data was analyzed, sorted out, and classified into several items, such as the species list at each location, the study area coverage, threat, water quality data, etc. All these data on the status of diversity and abundance of marine plants in Malaysia were presented and discussed during workshops and finally compiled as a reference book or monograph, in addition to one geospatial (GIS) map produced.

Flow chart of research work



4.0 RESULTS & DATA ANALYSIS

4.1 Total publication per year for marine plants

In total, 430 published articles on Malaysian marine plants, including marine microalgae (97 articles), seaweed (121 articles), seagrass (85 articles), and mangroves (127 articles), were found via desktop study and analyzed in this project. Generally, the number of published articles increased gradually the following time, as shown in Figure 1 (marine microalgae), Figure 2 (seaweed), Figure 3 (seagrass) & Figure 4 (mangroves). Generally, before the year 2007, not many articles on marine plants could be obtained via desktop study. However, since 2010, the number of published articles online has increased gradually.

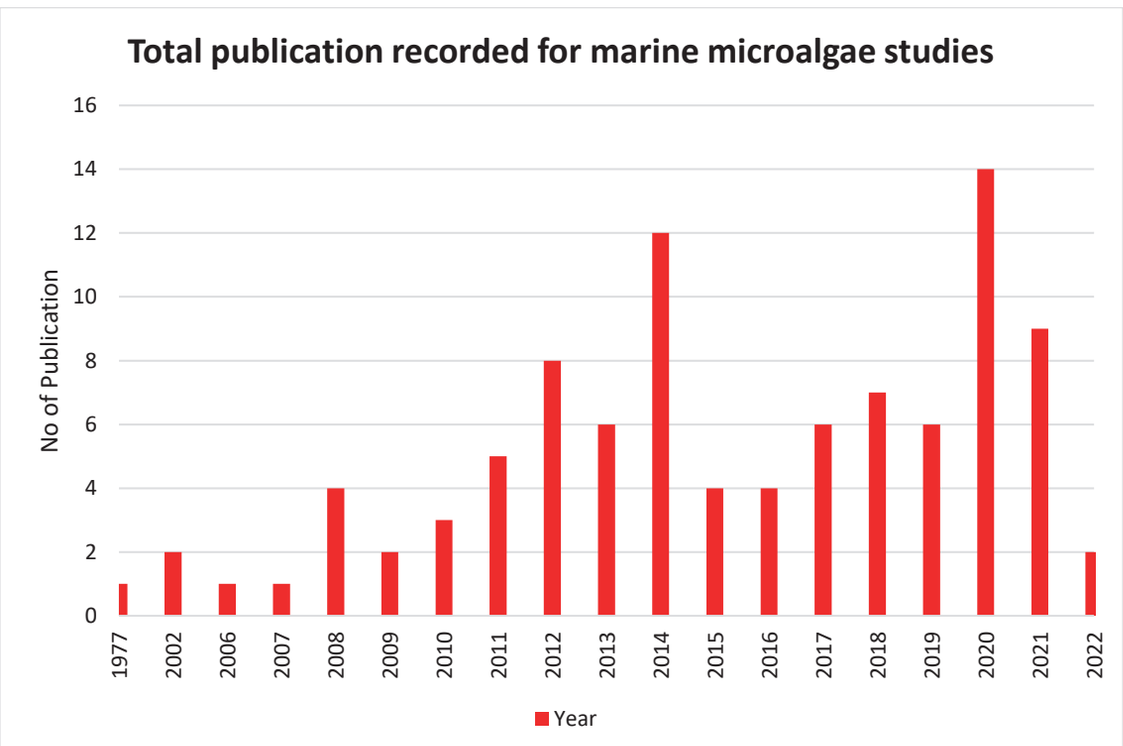


Figure 1: Total publication on Malaysian marine microalgae study recorded from the year 1977 to 2022

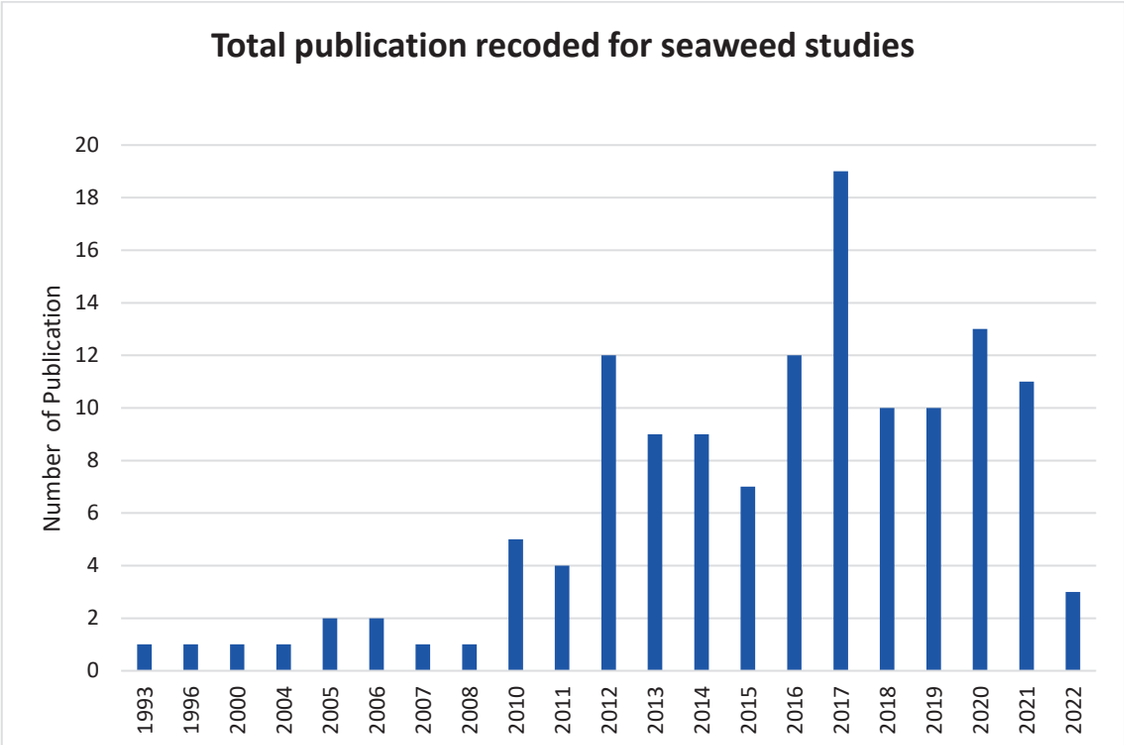


Figure 2: Total publication on seaweed recorded in Malaysia from the year 1993 to 2022

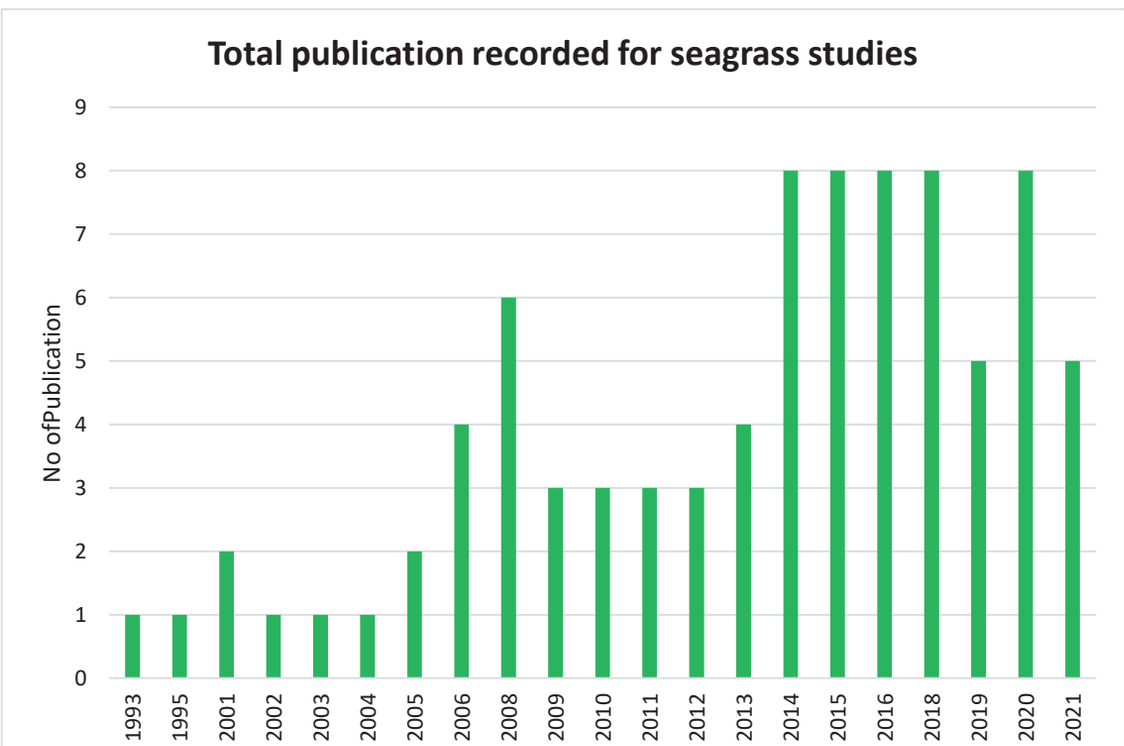


Figure 3: Total publication on seagrass recorded in Malaysia from the year 1993 to 2021

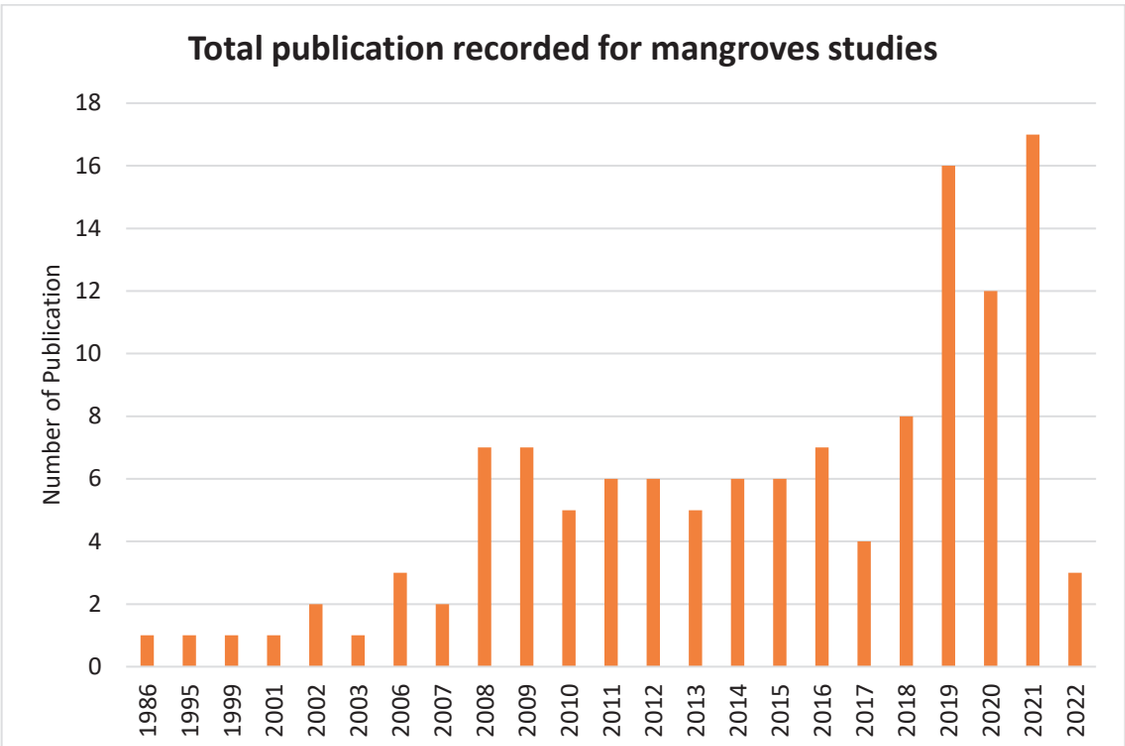


Figure 4: Total publication on mangroves recorded in Malaysia from the year 1986 to 2022

4.2 Types of References for marine plants

In this study, we managed to get information on marine plants (marine microalgae, seaweed, seagrass, and mangrove) from various sources such as a book (4.1%), chapters in the book (0.4%), research articles in journals (78.8%), monographs (0.6%), newspaper (0.2%), poster (0.6%), conference proceedings (8.1%), technical reports (3.3%) and thesis (3.9%). as shown in Figure 5.

4.3 Source of marine plants used for research

From the published articles analyzed, all the samples of seaweed, seagrass, and mangroves used for the research were obtained by sample collection during fieldwork. However, for the microalgae, 80% of the marine microalgae used for analysis were obtained from the culture collection deposited at research institutions such as University Malaya, Universiti Putra Malaysia, Universiti Malaysia Terengganu, Universiti Malaysia Sabah, etc. Only 20% of the research was conducted using the microalgae collected directly from the field at microalgal habitats (Figure 6). The majority of the microalgae collected in-situ from their habitats were used for biodiversity (44.4%), algae bloom (38.8%); biochemical compound extraction (38.8%); biofuel (27.7%), and bioremediation (27.7%) studies.

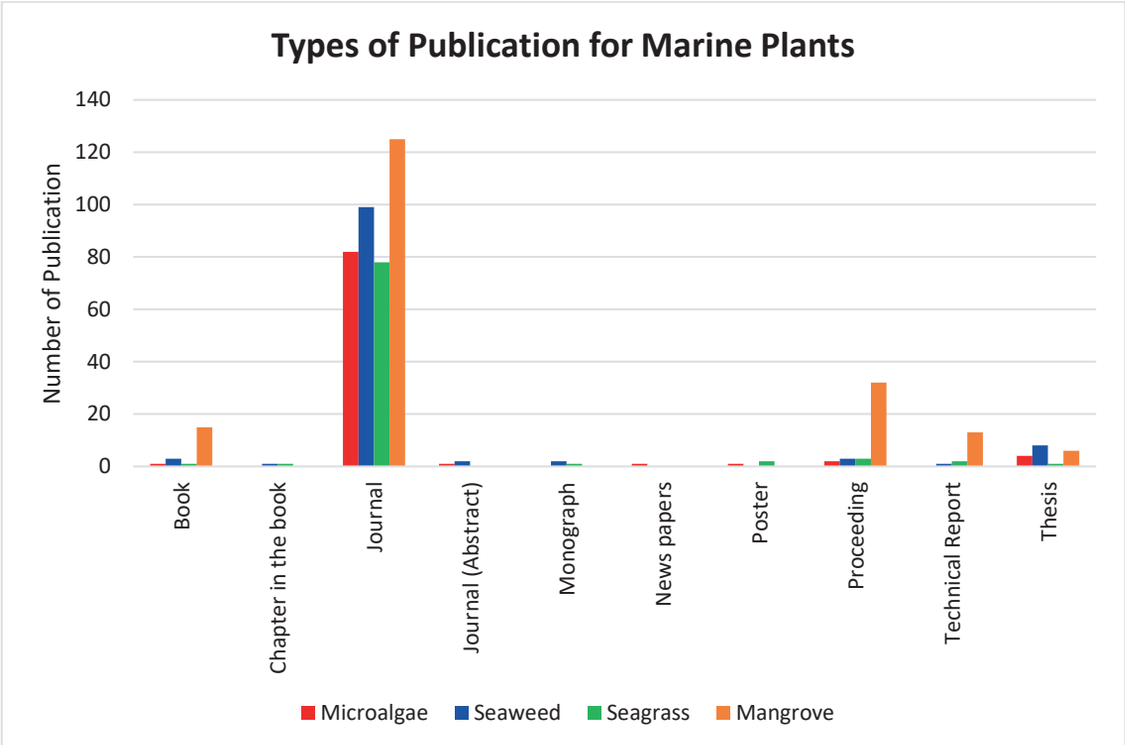


Figure 5: Sources of information on Malaysian marine plants obtained in the study

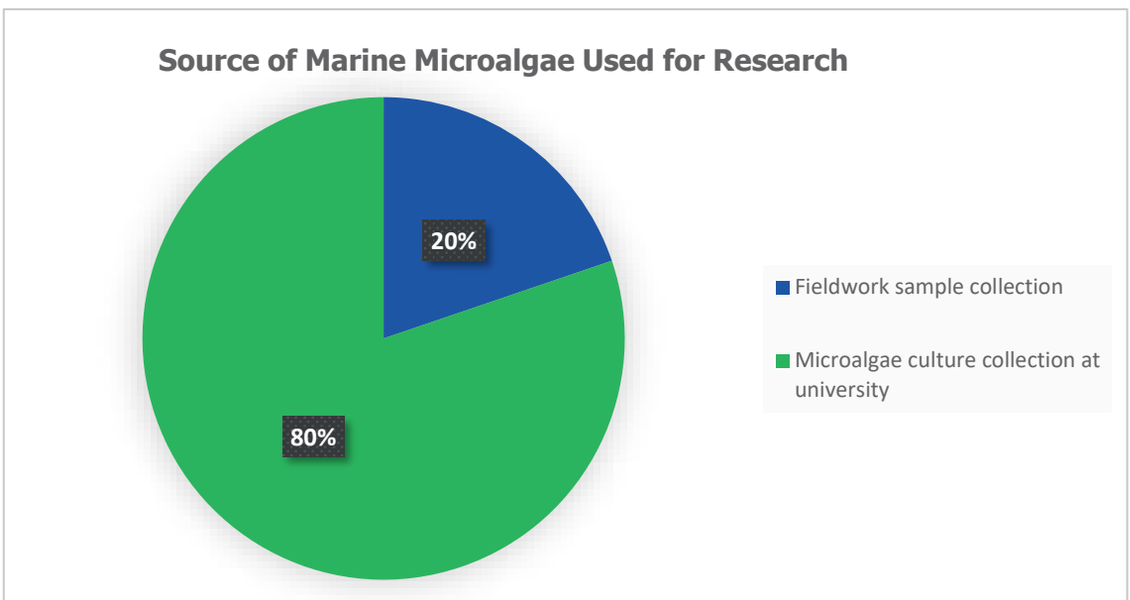


Figure 6: Source of the marine microalgae used for research in Malaysia.

4.4 Marine plants research application

For the marine microalgae that are cultured in the lab and directly obtained during fieldwork, the main research application involved is the extraction of the biochemical compounds (20.0%) followed by bioremediation and water quality analysis (13.3%), abiotic stress (13.3%), growth study (10.0%), microalgae bloom (10.0%) and 7.78% biodiversity study as shown in Figure 7.

The same trend as marine microalgae, the dominant research topic on seaweed conducted in Malaysia is biochemicals composition extraction (51.0%), followed by biodiversity (14.6%), seaweed cultivation (6.3%), biotechnology (5.2%), production of seaweed-based products (4.2%), abiotic stress (3.1%), morphology description (3.1%), policy (3.1%) and others (9.4%) as shown in Figure 8. For this project, the majority of the seaweed diversity and distribution data were obtained from the biodiversity study.

For the seagrass, the dominant research topic on seaweed conducted in Malaysia is biotic relationship (40.0%), followed by ecology (21.2%), biodiversity (11.8%), remote sensing (8.3%), abiotic stress (4.7%), biochemicals composition extraction (2.4%), bioindicator and water quality (2.4%), and others (9.2%) as shown in Figure 9.

In this study, we found different mangrove research applications throughout Malaysian states. (Figure 10). There were 12 categories of research applications recorded. Biodiversity and taxonomy studies were the most explored by Malaysian mangrove researchers, representing 61.4 % of the total research application. This was followed by an investigation of the mangrove forest community structure study (46.6%), carbon stock evaluation (34.3%), mangrove restoration (8.6%), coastal erosion (5.6%), and microplastic study (4.3%). The rest of the study was less than 2% each for mangrove mapping, climate change impact, heavy metal, ecological research, and social and economic analysis.

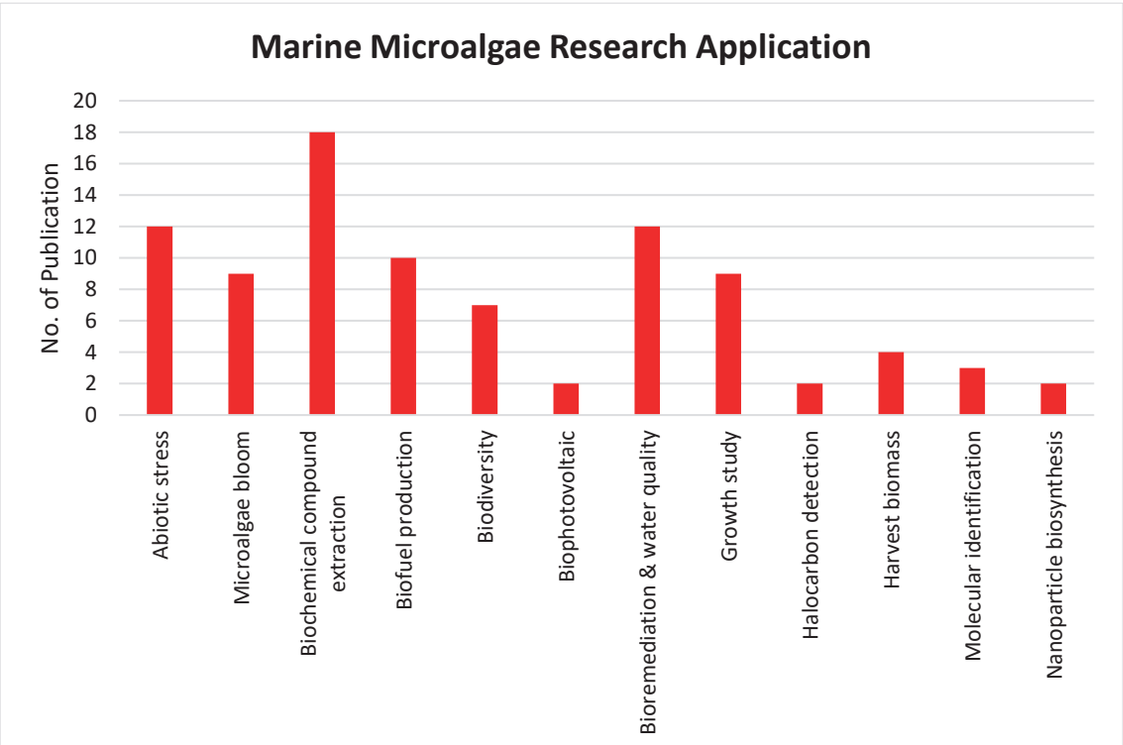


Figure 7: Types of marine microalgae research application conducted in Malaysia.

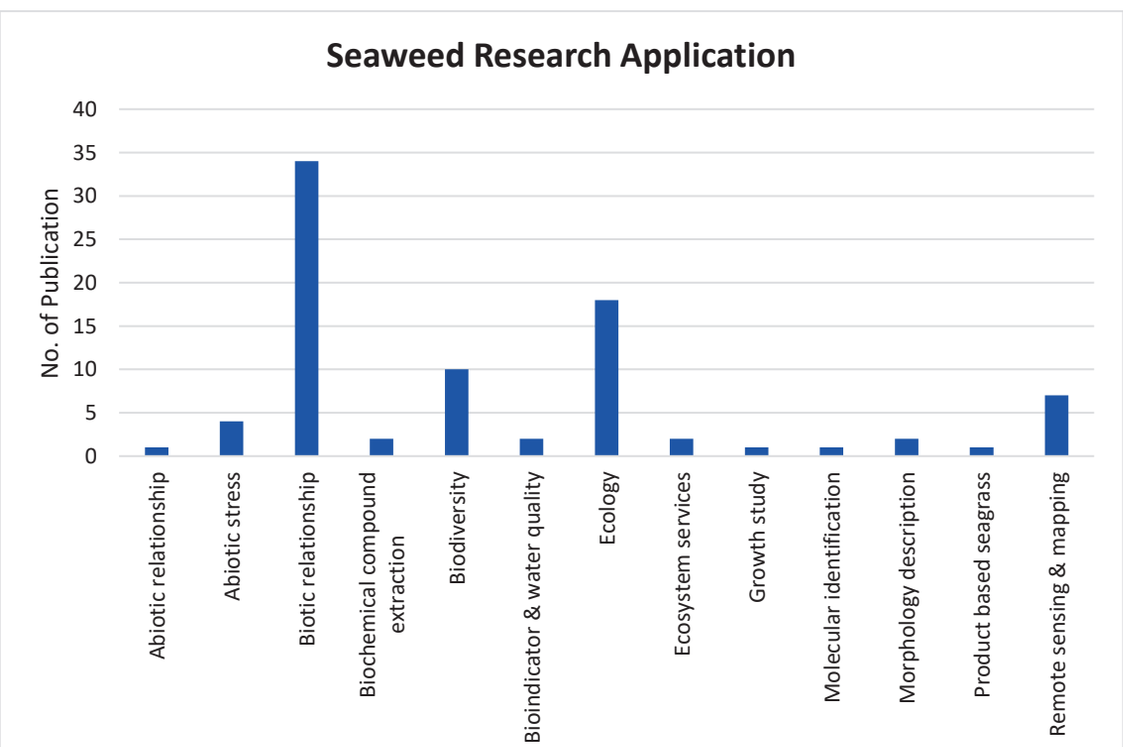


Figure 8: The seaweed research application conducted in Malaysia.

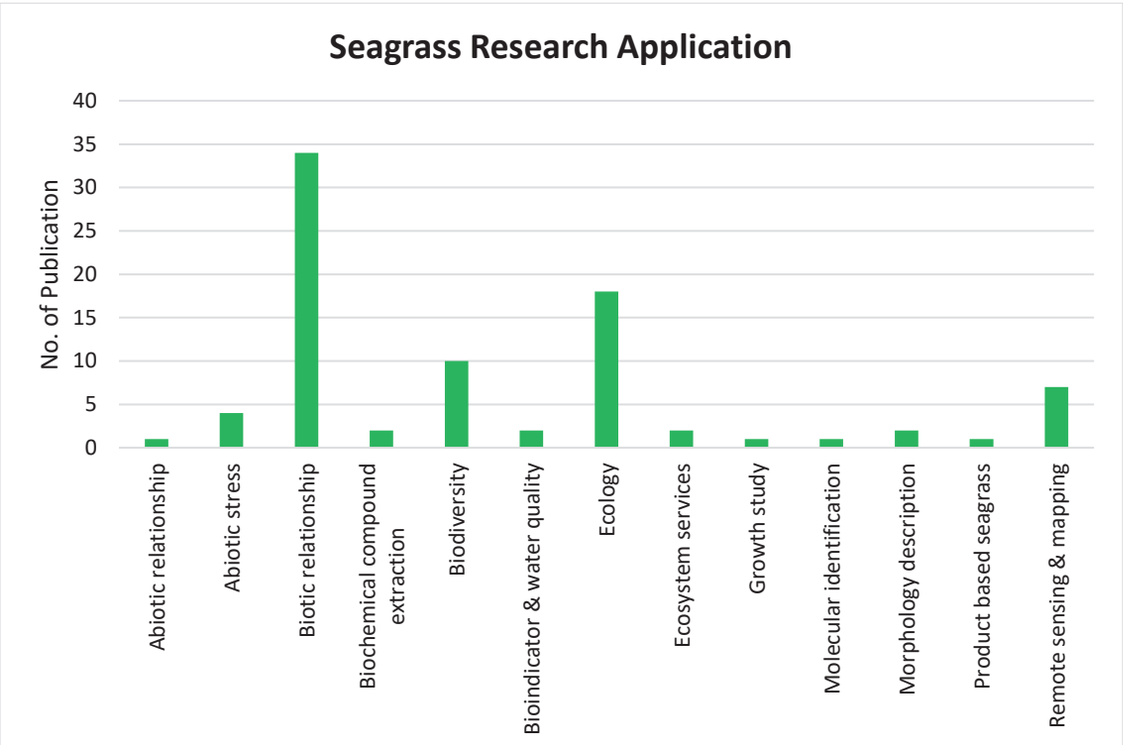


Figure 9: Types of seagrass research application conducted in Malaysia

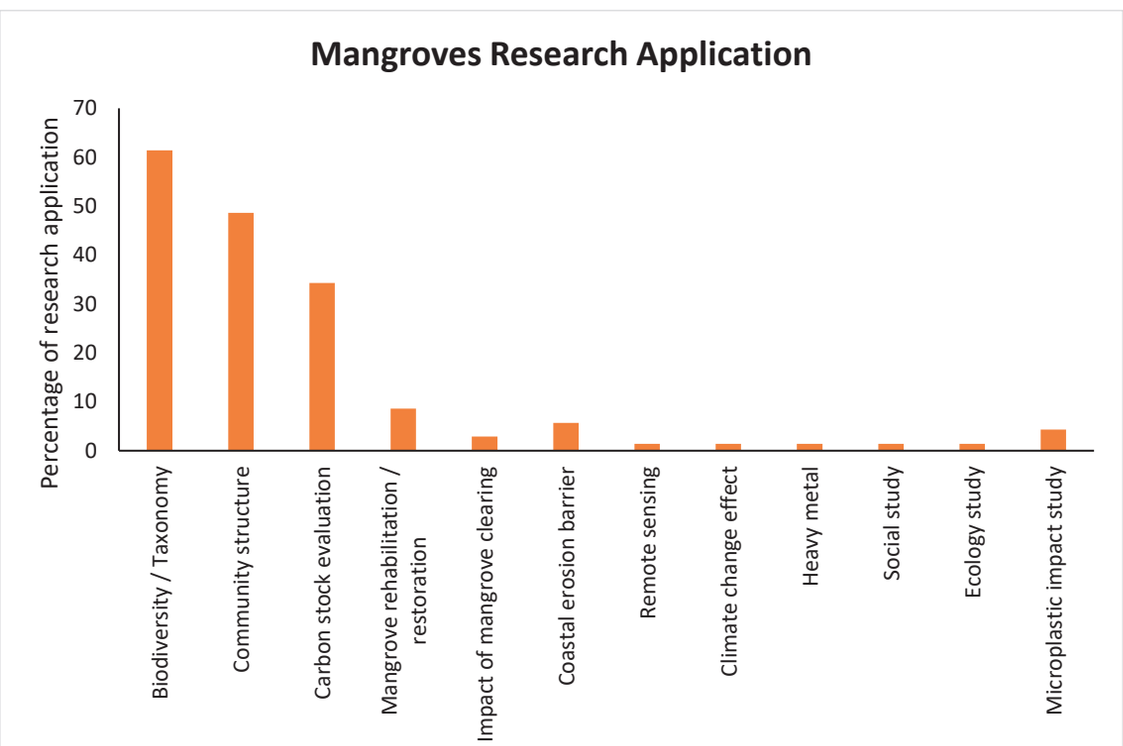


Figure 10: The mangrove research application conducted in Malaysia

4.5. Marine plant species diversity and distribution in Malaysia found in this desktop study

4.5.1 Marine microalgae species composition and distribution in Malaysia recorded from 1977 to 2022

Marine waters in Peninsular Malaysia, Sabah, and Sarawak are rich in marine microalgae resources. Figure 11 shows the number of published articles and the number of marine microalgae habitats recorded for each state in Malaysia. We found that; studies conducted in the Selangor area were the highest due to many universities and government agencies being situated in Selangor. The majority of the studies conducted here; were using marine microalgae that were kept as culture collection in these universities and research institutions. However, for the research conducted in the microalgae habitats, it depends on the purpose and importance of the study area. For example, Terengganu has the highest number of marine microalgae habitats investigated due to a scientific expedition, The East Coast Peninsular Malaysia Expedition I 2005; had been carried out at Universiti Malaysia Terengganu in 2005 to assess the diversity of seaweed, seagrass and marine microalgae in coastal area of Terengganu (Gan et al., 2008). In Sabah, many research articles have been published from this area, due to the harmful algae bloom incidents that usually occurred and recorded in Malaysia since 1976.

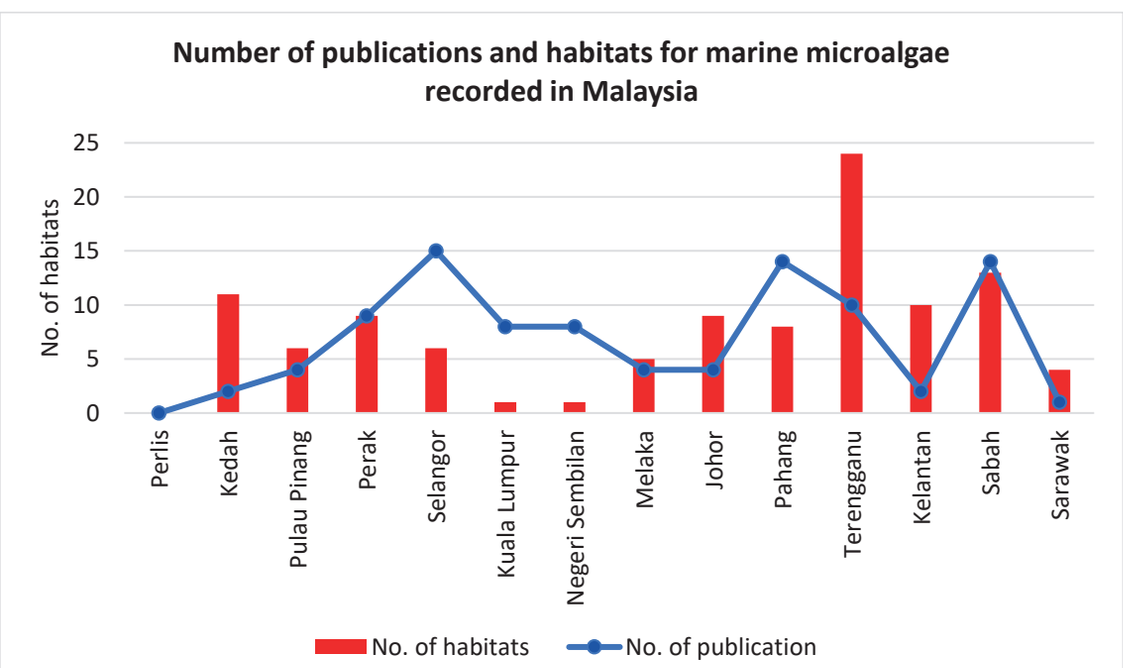
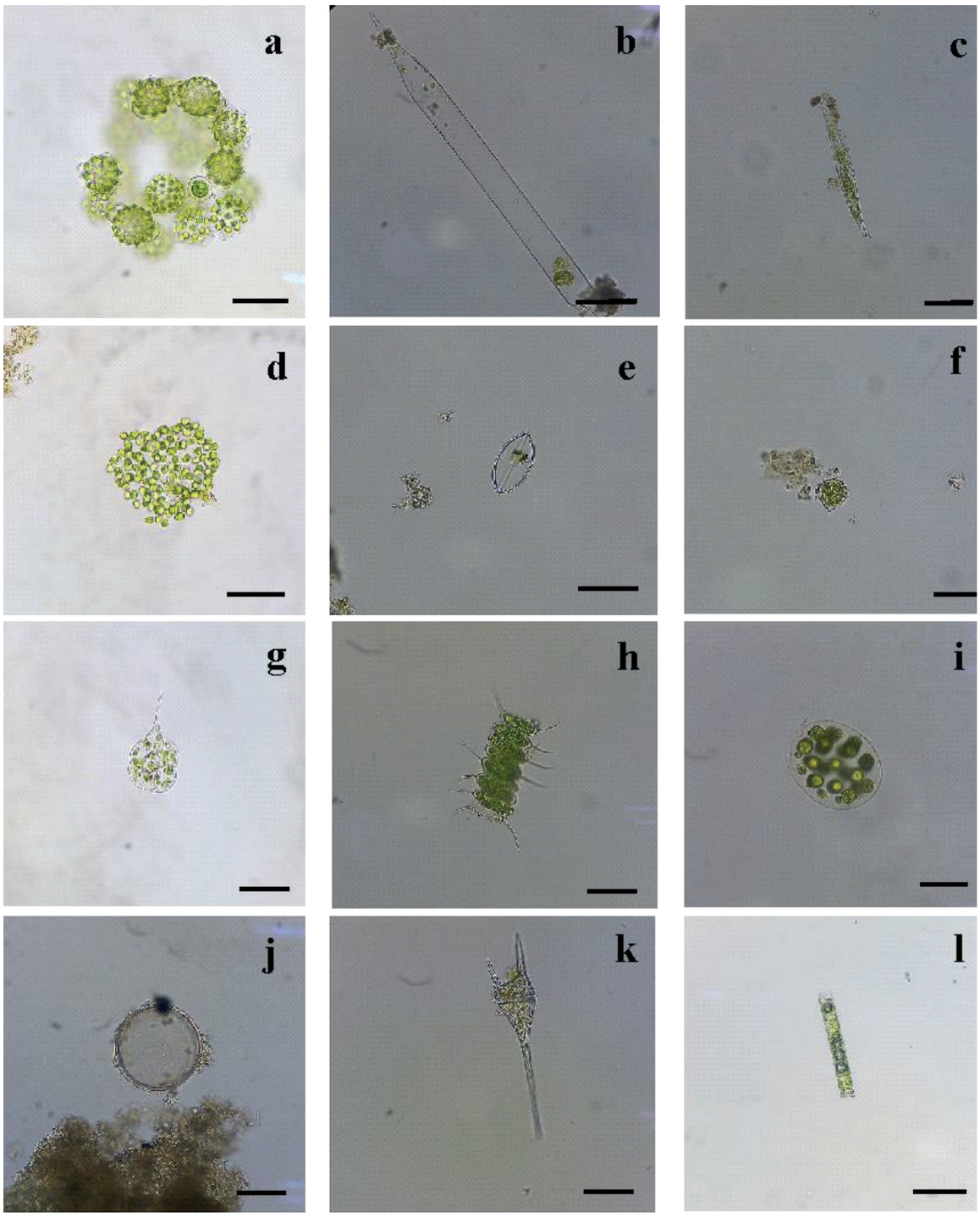


Figure 11: The number of published articles and marine microalgae habitats recorded in Malaysia from 1977- 2022.

Based on this study, 223 taxa of marine microalgae were recorded, comprising Bacillariophyta (116 taxa, 32 family), Chlorophyta (5 families, 9 taxa), Cyanophyta (2 families, 3 taxa), Ciliophora (2 family, 2 taxa), Euglenozoa (1 family, 1 taxa), Haptophyta (2 family, 4 taxa), Miozoa (19 family, 76 taxa) and Ochorophyta (2 families, 6 taxa). Figure 12 shows selected marine and brackish microalgae usually found in Malaysian marine waters and Table 2 summarizes the marine microalgae species diversity and distribution reported in the coastal waters of Malaysia from 1977 to 2022. The maps of marine microalgae distribution in Peninsular Malaysia, Sabah, and Sarawak are shown in Figure 13.

In general, based on data recorded from this desktop study (Table 2), the top five microalgae habitats investigated containing the highest microalgae taxa are Kampung Tedung Pantai, Merlimau, Melaka (76 taxa), followed by Pulau Aman, Penang (49 taxa), Tanjung Pelepas, Gelang Patah, Johor (45 taxa), Kuala Sibuti, Miri, Sarawak (39 taxa) and Merbuk River estuary (37 taxa).



a. *Coelastrum* sp.
b. *Rhizosolenia* sp.
c. *Pleurosigma* sp.
d. *Dictyosperium* sp.
e. *Navicula* sp.
f. *Peridinium* sp.
g. *Phacus* sp.
h. *Scenedesmus* sp.
i. *Pandorina* sp.
j. *Coscinodiscus* sp.
k. *Ceratium* sp.
l. *Ulotrix* sp.

Figure 12: Marine and brackish microalgae species found in Malaysian waters

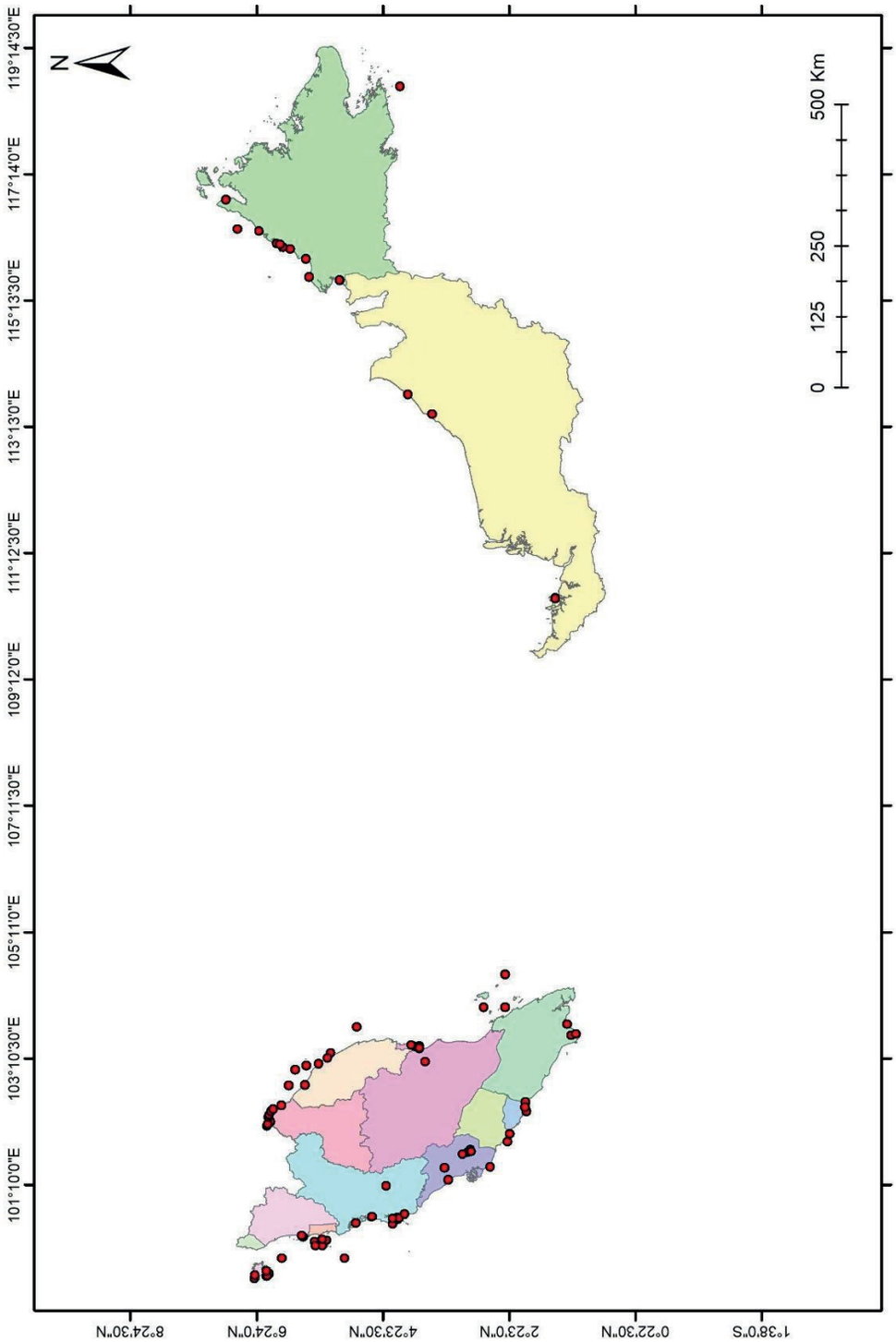


Figure 13: The map of marine microalgae distribution in Malaysia

Table 2: Summary of marine microalgae species compositions at their habitats reported in Malaysian marine waters recorded from 1977- 2022

State	No	Location	Species Composition
Perlis	1.	No data obtained	No data obtained
Kedah	1.	Merbok river estuary, Kedah	*Achnanthes sp., Actinastrum sp., Alexandrium sp., Amphora sp., Bacteriastrum sp., Biddulphia sp.,Ceratium sp., Chaetoceros sp., Climacodium sp., Chlorella sp., Cocconeis sp., Coscinodiscus sp., Cylindrotheca sp., Dinophysis sp., Euglena sp., Gambierdiscus sp., Gonyaulax sp., Guinardia sp., Gyrosigma sp., Lingulodinium sp., Melosira sp., Navicula sp., Nitzschia sp., Oscillatoria sp., Oocystis sp., Pentapharsodinium sp., Pleurosigma sp., Protoceratium sp., Protoperidinium sp., Pseudo-nitzschia sp., Rhizosolenia sp., Skeletonema sp., Surirella sp., Synedra sp., Thalassionema sp.,Trachelomonas sp., Triceratium sp.* (37 taxa)
	2.	National Prawn Fry Production and Research Centre (NAPFRE), Pulau Sayak, Kedah.	*Chlorella sp., Isochrysis galbana, Isochrysis sp., Nannochloropsis sp., Tetraselmis sp., Tetraselmis tetrahele* (6 taxa)
	3.	Pulau Langkawi, Kedah	*Brachytrichia quoyi,* (1 taxa)
	4.	Pantai Tengkorak, Pulau Langkawi, Kedah.	*Achanthes brevipes, Grammatophora marina, Navicula abrupta, Nitzschia commutata, Oscillatoria sp.* (5 taxa)
	5.	Pulau Beras Basah, Pulau Langkawi, Kedah.	*Coscinodiscus curvatulus, Cylcotella kutzingiana, Diplonei gravelleana, Grammatophora marina, Navicula abrupta, Navicula elegans* (6 taxa)
	6.	Pulau Datai, Pulau Langkawi, Kedah	*Cylcotella kutzingiana, Diplonei gravelleana, Grammatophora marina, Navicula sp., Navicula elegans* (5 taxa)
	7.	Pulau Dayang Bunting, Pulau Langkawi, Kedah.	*Cylcotella kutzingiana, Pleurosigma elongatum* (2 taxa)

State	No	Location	Species Composition
	8.	Pulau Kentut Kecil, Pulau Langkawi, Kedah.	*Achanthes brevipes, Amphora ovalis, Bacteriastrum sp., Coscinodiscus curvatulus, Cylcotella kutzingiana, Grammatophora marina, Navicula abrupta, Synedra sp.* (8 taxa)
	9.	Pulau Singa, Pulau Langkawi, Kedah.	*Cylcotella kutzingiana, Grammatophora marina, Navicula abrupta, Synedra sp.,* (4 taxa)
	10.	Teluk Belimbing, Pulau Langkawi, Kedah	*Amphora lanceolata, Coscinodiscus curvatulus, Diplonei gravelleana, Navicula abrupta* (4 taxa)
	11.	Teluk Tembus, Pulau Dendang, Pulau Langkawi, Kedah	*Brachytrichia quoyi,* (1 taxa)
Pulau Pinang	1.	Aman Island, Northern Strait of Malacca, Melaka	*Akashiwo sanguinea, Alexandrium spp., Amphora spp., Asteromphalus spp., Bacillaria paxillifera, Bacteriastrum spp., Bellerochea spp., Ceratium spp., Chaetoceros sp., Corethron spp., Coscinodiscus spp., Cylindrotheca closterium, Detonula spp., Dinophysis spp., Ditylum spp., Eucampia spp., Gonyaulax sp., Gymnodinium spp., Gyrodinium spp., Gyrosigma spp., Guinardia spp., Helicotheca tamensis, Hemiaulus spp., Karlodinium australe, Lauderia spp., Leptocylindrus spp., Lithodesmium spp., Melosira spp., Meuniera membranacea, Navicula spp., Nitzschia longissima, Noctiluca scintillans, Odontella sp., Paralia sp., Peridinium spp., Planktoniella sol, Pleurosigma spp., Polykrikos sp., Prorocentrum spp., Protoperidinium spp., Pseudo-nitzschia spp., Pyrophacus sp., Rhizosolenia spp., Skeletonema sp., Surirella spp., Synedra spp., Thalassiosira sp., Thallasionema spp., Triceratium spp.* (49 taxa)
	2.	Fisheries Research Institute, Department of Fisheries, Batu Maung, Penang.	*Chlorella sp., Chaetoceros calcitrans, Nannochloropsis sp.* (3 taxa)

State	No	Location	Species Composition
	3.	Penang coastal water, Penang	*Chlorella salina, Isochrysis maritima, Neoceratium furca* (3 taxa)
	4.	Shrimp farm, Kuala Jalan Bharu, Balik Pulau, Penang.	*Amphora sp., Chlamydomonas sp., Chlorella sp., Coscinodiscus sp., Cylindrotheca closterium, Dunaliella sp., Gyrosigma sp., Lauderia sp., Navicula sp., Nitzschia sp., Oscillatoria sp., Pleurosigma sp., Suriella sp., Thalasiosira sp., Triceratium sp.,* (15 taxa)
	5.	Teluk Aling, Penang National Park coastal waters, Penang.	*Chaetoceros calcitrans, Isochrysis galbana, Isochrysis maritima, Nannochloropsis oculata, Tetraselmis tetrahele.* (5 taxa)
	6.	Universiti Sains Malaysia (Culture collection), Penang	*Chlorella salina, Cylindrotheca fusiformis* (2 taxa)
Perak	1.	Lumut, Perak	*Neoceratium furca* (1 taxa)
	2.	Pulau Pangkor, Perak	*Neoceratium furca* (1 taxa)
	3.	Sangga Kechil mangrove estuary, Matang Mangrove Forest Reserve (MMFR), Perak	*Ceratium furca, Coscinodiscus sp., Pleurosigma sp., Protoperidinium obtusum, Skeletonema costatum, Thalassionema nitzschioides.* (6 taxa)
	4.	Sultan Azlan Shah Power Station, Manjung, Perak	*Amphora sp., Chaetoceros curvisetus, Chaetotoceros lorenzianus, Chlorella sp., Cylindrotheca closterium, Ditylum brightwellii, Isochrysis sp., Nannochloropsis sp., Navicula transitans, Pleurosigma sp., Pseudonitzschia heimii, Tetraselmis sp., Odontella sinensis, Oscillatoria corallinae.* (14 taxa).
	5.	Near lighthouse at TelukRubiah, Sultan Azlan Shah Power Station (SASPS), Manjung, Perak	*Ceratium sp., Chlorella sp., Codonellopsis sp., Dinophysis sp., Favella sp., Isochrysis sp., Nannochloropsis sp., Peridinium sp., Protoperidinium sp., Tetraselmis sp., Trichodesmium thiebautii.* (11 taxa)

State	No	Location	Species Composition
	6.	Near coal jetty, Sultan Azlan Shah Power Station (SASPS), Manjung, Perak	*Ceratium sp., Chlorella sp., Codonellopsis sp., Dinophysis sp., Favella sp., Isochrysis sp., Nannochloropsis sp., Peridinium sp., Protoperidinium sp., Tetraselmis sp., Trichodesmium thiebautii* (11 taxa)
	7.	Mouth of Perak river, Sultan Azlan Shah Power Station (SASPS), Manjung, Perak	*Ceratium sp., Codonellopsis sp., Dinophysis sp., Favella sp., Isochrysis sp., Nannochloropsis sp., Peridinium sp., Protoperidinium sp., Tetraselmis sp., Trichodesmium thiebautii* (10 taxa)
	8.	University Tun Abdul Razak (UTAR) Microalgae Sdn. Bhd., Kampar, Perak	*Nannochloropsis oculata* (1 taxa)
	9.	Sungai Jarum Mas, Larut-Matang, Perak	*Akashiwo sanguinea, Alexandrium sp., Amphora sp., Bacillaria sp., Bacteriastrum sp., Bellerochea sp., Ceratium furca, Chaetoceros sp., Corenthron sp., Cosnodiscus sp., Cylindrotheca sp , Dinophysis sp., Dinophysis caudata, Ditylum sp., Eucampia sp., Guinardia sp., Gyrosigma sp., Hemiaulus sp., Lauderia sp., Leptocylindrus sp., Navicula sp., Nitzschia sp., Nitzschia longissima, Noctiluca scintillans, Odontella sp., Pleurosigma sp., Prorocentrum sp., Protoperidinium sp., Pseudo nitzschia sp., Rhizosolenia sp., Rhizosolenia setigera, Skeletonema sp., Surirella sp., Synedra sp., Thallassionema sp., Thallassiosira sp.* (36 taxa)
Selangor	1.	Agro-Biotechnology Institute, (ABI) Malaysia (Culture collection), Serdang, Selangor.	*Nannochloropsis oculata* (1 taxa)
	2.	Algaetech International Research and Development Centre, Selangor	*Nannochloropsis sp., Nannochloropsis oculate, Tetraselmis sp.,* (3 taxa)
	3.	Marine shrimp pond, Kuala Selangor, Selangor	*Chaetoceros calcitrans, Nannochloropsis oculata, Oscillatoria sp.* (3 taxa)

State	No	Location	Species Composition
	4.	Sea Bass Pond at Sepang, Selangor	*Chlorella* sp. (1 taxa)
	5.	Universiti Putra Malaysia, Selangor.(Culture collection)	*Chaetoceros sp., Chaetoceros calcitrans, Chlorella sp., Geitlerinema sp., Isochyrsis galbana, Nannochloropsis sp., Nannochloropsis oculate, Tetraselmis sp.* (8 taxa)
	6.	Universiti Selangor (UNISEL), Selangor (Culture collection)	*Tetraselmis* sp. (1 taxa)
Kuala Lumpur	1.	University of Malaya Algae Culture Collection (UMACC), University Malaya, Kuala Lumpur	*Amphiprora sp., Amphora sp., Amphora turgida, Chaetoceros sp., Chlorella sp., Chlorella vulgaris, Nannochloropsis oculata, Nannochloris baccilaris, Navicula sp., Nitzschia inconspicua, Oscillatoria sp., Prasinococcus sp., Porphyridiun cruentum, Symbiodinium sp., Tetraselmis sp., Tetraselmis suecica* (16 taxa)
Negeri Sembilan	1.	Port Dickson, Negeri Sembilan	*Alexandrium minitum; Chaetoceros calcitrans, Chaetoceros gracilis, Chlorella sp., Diploneis sp.; Isochyrsis galbana, Nannochloropsis sp., Nannochloropsis oculata, Navicula sp., Skeletonema sp., Tetraselmis sp., Tetraselmis tetrathele.* (12 taxa)
Melaka	1.	Pulau Besar, Melaka	*Amphiprora gigantean, Cylcotella kutzingiana, Grammatophora marina, Odontella aurita, Pleurosigma elongatum.* (5 taxa)
	2.	Sebatu, Melaka	*Alexandrium lusitanicum, Alexandrium minitum, Alexandrium tamiyavanichii, Alexandrium tropicale* (4 taxa)
	3.	Middle zone of Malacca Straits, Melaka	*Ceratium furca, Ceratium inflatum, Ceratocorys horrida, Gonyaulax spinifera, Gyrodinium sp., Noctiluca scintillans, Protoperidinium ovum.* (7 taxa)

State	No	Location	Species Composition
	4.	Northern and Southern zone of Malacca straits, Melaka	*Alexandrium bidentata, Ceratium furca, Ceratocorys horrida, Dinophysis caudata, Gyrodinium sp., Gymnodinium sp., Gymnodinium simplex, Noctiluca scintillans, Protoperidinum ovum.* (9 taxa)
	5.	Kampung Tedung Pantai, Merlimau, Melaka.	*Achnantes longipes, Asterionela japonicas, Bacillaria paradoxa, Biddulphia sp., Biddulphia aurita, Biddulphia pulcella, Biddulphia sinensis, Ceratium fasus, Ceratium furca, Ceratium tripos, Chaetoceros sp., Chlorella sp., Coscinodescus sp., Coscinodescus asteramphalus, Coscinodescus marginnatus, Coscinodescus nitidus, Coscinodescus rothii, Coscinodescus radiatus, Coscinodescus wailesii, Dinophysis ovum, Diploneis sp., Favella sp., Glenodinium sp., Gonyaulax sp., Guinardia flaccid, Gymnodinium sp., Gymnodinium viridescens, Gyrosigma fasciola, Leptocylindricus danicus, Leptocylindricus minimus, Melosira sp., Navicula sp., Navicula cancellate, Navicula elegans, Navicula transitans, Nitzschia sp., Nitzschia lanceolata, Nitzschia panduriformis, Nitzschia sigma, Noctiluca scintillans, Ocillatoria sp., Peridinium sp., Pleurosigma sp., Pleurosigma angulatus, Pleurosigma elegans, Pleurosigma elongatum, Pleurosigma normanii, Pleurosigma salinarum, Prorocentrum micans, Prorocentrum minimum, Protoperidinum sp., Protoperidinum curtipes, Protoperidinum divergens, Protoperidinum majus, Protoperidinum pentagonum, Protoperidinum oblongum, Protoperidinum ovum, Rhizosolenia sp., Rhizosolenia alata, Rhizosolenia calca avis, Rhizosolenia styriformis, Scenedesmus quadricauda, Skeletonema costatum, Surirella sp., Surirella gemma, Surirella salina, Surirella ovalis, Synedra sp., Thallassiosira sp., Thallassiosira lepiopus, Thallassiosira wailessi, Triceratium alternans, Triceratium favus, Ulothrix sp., Ulothrix moniliformis, Ulothrix zonata.* (76 taxa)

State	No	Location	Species Composition
Johor	1.	Johor straits, Johor	*Akashiwo sanguinea, Alexandrium sp., Amphora sp., Bacillaria paxillifera, Blixaea quinquecornis, Chattonella sp., Chaetoceros sp., Climacosphenia sp., Coscinodiscus sp., Cylindrotheca closterium, Detonula sp., Dactyliosolen sp., Dinophysis sp., Ditylum sp., Eucampia sp., Guinardia sp., Gonyaulax sp., Gyrodinium sp., Hemiaulus sp., Karenia sp., Karlodinium sp., Leptocylindrus sp., Lauderia sp., Licmophora sp., Melosira sp., Navicula sp., Nitzschia sp., Noctiluca scintillans, Odontella sp., Palmerina sp., Pleurosigma sp., Prorocentrum sp., Prorocentrum gracile, Prorocentrum micans, Protoperidinium sp., Pseudo-nitzschia, Pyrophacus sp., Rhizosolenia sp., Skeletonema sp., Synedra sp., Surirella sp., Thalassionema sp., Thalassiosira sp., Triceratium sp., Tripos sp.,* (45 taxa)
	2.	Pulau Aur, Johor	*Grammatophora marina, Navicula abrupta, Navicula advena* (3 taxa)
	3.	Pulau Besar, Johor	*Navicula sp.* (1 taxa)
	4.	Pulau Sibu, Johor	*Brachytrichia quoyi, Lyngbya majuscula,* (2 taxa)
	5.	Pulau Tinggi, Johor	*Brachytrichia quoyi, Lyngbya majuscula,* (2 taxa)
	6.	Sungai Pulai, Pulai, Johor	*Coscinodiscus sp., Euglena sp., Gonyaulax sp.* (3 taxa)
	7.	Tanjung Kopok, Pasir Gudang, Johor	*Lyngbya majuscula,* (1 taxa)
	8.	Tanjung Pelepas, Gelang Patah, Johor	*Akashiwo sanguinea, Alexandrium sp., Amphora sp., Bacillaria paxillifera, Blixaea quinquecornis, Chaetoceros sp., Chattonella sp., Climacosphenia sp., Coscinodiscus sp., Cylindrotheca closterium, Detonula sp., Ditylum sp, Dinophysis sp., Eucampia sp., Gonyaulax sp., Guinardia sp., Gyrodinium sp., Hemiaulus sp., Karenia sp., Karlodinium sp., Lauderia sp., Leptocylindrus sp., Licmophora sp.,*

State	No	Location	Species Composition
			Melosira sp., Navicula sp., Nitzschia sp., Nitzschia longissima, Noctiluca scintillans,
			Odontella sp., Palmerina sp., Pleurosigma sp., Protoperidinium sp., Prorocentrum sp., Prorocentrum gracile, Prorocentrum micans, Pseudo-nitzschia, Pyrophacus sp., Rhizosolenia sp., Skeletonema sp., Synedra sp., Surirella sp., Thalassionema sp., Thalassiosira sp., Triceratium sp., Tripos sp. (45 taxa)
	9.	Tebrau Straits, Johore Bahru, Johor	*Chatonella ovata, Karlodinium veneficum, Prorocentrum minimum,* (3 taxa)
Pahang	1.	Jabatan Perikanan Malaysia, Kuantan, Pahang	*Chlorella sp., Nannochloropsis sp.,* (2 taxa)
	2.	Kuantan coast, Pahang	*Chlorella sp., Lyngbya sp., Oscillatoria sp* (3 taxa)
	3.	Balok coastal area, Kuantan, Pahang	*Amphora copulata, Chlorella sp., Gyrosigma sp.,* (3 taxa)
	4.	Pantai Batu Hitam, Kuantan, Pahang	*Nannochloropsis sp.,* (1 taxa)
	5.	Pantai Gelora, Kuantan, Pahang	*Chlorella sp.* (1 taxa)
	6.	Pulau Tioman, Pahang	*Oscillatoria sp., Calothrix crustacea* (1 taxa)
	7.	Teluk Cempedak, Kuantan, Pahang	*Amphora sp., Amphiprora sp., Pleurosigma sp.* (3 taxa)
	8.	Universiti Malaysia Pahang, Pahang (Culture collection).	*Isochrysis sp.* (1 taxa)
Terengganu	1.	Coastal area of Kuala Terengganu, Terengganu	*Chlorella sp.* (1 taxa)
	2.	Pantai Bari Kecik, Permaisuri, Terengganu	*Oscillatoria subbrevis*

State	No	Location	Species Composition
	3.	Pantai Batu Buruk, Kuala Terengganu, Terengganu	*Lyngbya penicillata,* (1 taxa)
	4.	Pantai Bukit Keluang, Besut, Terengganu	*Lyngbya majuscula,* (1 taxa)
	5.	Pantai Chendering, Kuala Terengganu, Terengganu	*Brachytrichia quoyi, Lyngbya confervoides, Lyngbya majuscula, Trichormus variabilis,* (4 taxa)
	6.	Pantai Kemasik, Kemaman, Terengganu	*Lyngbya semiplena, Rivularia atra,* (2 taxa)
	7.	Pantai Kuala Abang, Dungun, Terengganu	*Lyngbya majuscula, Trichormus variabilis,* (2 taxa)
	8.	Pantai Marina, Kemaman, Terengganu	*Calothrix contarenii,* (1 taxa)
	9.	Pulau Bidong, Terengganu	*Chlorella sp., Chaetoceros calcitrans, Nannochloropsis sp.,* (3 taxa)
	10.	Pulau Bidong Laut, Terengganu	*Calothrix contarenii, Dichotrix sp., Lyngbya majuscula, Lyngbya penicillata, Phormidium gracile, Scytonema sp.,* (36 taxa)
	11.	Pulau Kapas, Terengganu	*Nannochloropsis oceanica* (1 taxa)
	12.	Pulau Karah, Terengganu	*Lyngbya majuscula,* (1 taxa)
	13.	Flora Beach Resort, Pulau Perhentian Besar, Terengganu	*Brachytrichia sp.,* (1 taxa)
	14.	Pulau Redang, Terengganu	*Chlorella sp., Nannochloropsis oceanica* (2 taxa)
	15.	Chagar Hutang, Pulau Redang, Terengganu	*Brachytrichia quoyi, Calothrix contarenii, Lyngbya majuscula, Osccilatoria yonedae, Symploca hydnoides,* (5 taxa)

State	No	Location	Species Composition
	16.	Pulau Perhentian Marine Park, Terengganu	*Chlorella sp., Prorocentrum caipirignum, Prorocentrum concavum, Prorocentrum cf. emarginatum, Prorocentrum foraminosum, Prorocentrum lima, Prorocentrum malayense. Prorocentrum mexicanum* (8 taxa)
	17.	Pulau Pinang, Marine Park, Terengganu	*Anabaenopsis sp., Blennothrix lyngbyacea, Leptolyngbya crosbyana, Lyngbya sordida, Planktothrix rubescens, Schizothrix calcicole, Symplocastrum coccineum* (7 taxa)
	18.	Pulau Tengol A, Terengganu	*Navicula elegans* (1 taxa)
	19.	Pulau Tengol B, Terengganu	*Grammatophora marina, Navicula elegans, Pleurosigma elongatum* (3 taxa)
	20.	Setiu Wetlands, Setiu, Terengganu	*Lyngbya meneghiniana, Lyngbya sordida, Phormidium nigroviride* (3 taxa)
	21.	Shrimp Pond, Terengganu	*Amphora coffeiformis, Thalassiosira weissflogii* (2 taxa)
	22.	Tanjung Jara, Dungun, Terengganu	*Lyngbya majuscula,* (1 taxa)
	23.	Teluk Kalong, Kemaman, Terengganu	*Brachytrichia quoyi, Lyngbya meneghiniana, Lyngbya semiplena, Rivularia atra,* (4 taxa)
	24.	Universiti Malaysia Terengganu, Terengganu (Culture collection)	*Chaetoceros sp., Chaetoceros calcitrans, Chlorella sp., Dunaliella sp., Isochrysis sp., Nannochloropsis sp., Nannochloropsis oceania., Nitzschia sp., Oscillatoria sp., Pavlova sp., Tetraselmis sp., Thalassiosira weissflogii* (12 taxa)
Kelantan	1.	Pantai Cahaya Bulan, Kota Bharu, Kelantan	*Chlorella sp.* (1 taxa)

State	No	Location	Species Composition
	2.	Pantai Genting, Tumpat, Kelantan	*Navicula sp.* (1 taxa)
	3.	Pantai Kampung Kelawang, Bachok, Kelantan	*Chorella sp., Oscillatoria sp.;* (2 taxa)
	4.	Pantai Mek Mah, Kota Bharu, Kelantan	*Coscinodiscus sp.; Melosira sp.; Navicula sp.; Rhizosolenia sp.; Skeletonema sp.* (5 taxa)
	5.	Pantai Melawi, Bachok, Kelantan	*Chorella sp.* (1 taxa)
	6.	Pantai Sabak, Pengkalan Chepa, Kelantan	*Biddulphia sp.; Coscinodiscus sp.; Melosira sp.; Pleurosigma sp.; Skeletonema sp.* (5 taxa)
	7.	Pantai Sungai Golok, Pengkalan Kubor, Kelantan	*Chlorella sp., Navicula sp.;* (2 taxa)
	8.	Lagoon 1, Pantai Tanjung Tujuh, Tumpat, Kelantan	*Navicula sp.* (1 taxa)
	9.	Lagoon 2, Pantai Tanjung Tujuh, Tumpat, Kelantan	*Chlorella sp.; Navicula sp.; Peridinium sp., Rhizosolenia sp.; Skeletonema sp.* (5 taxa)
	10.	Tumpat, Kelantan	*Alexandrium lusitanicum, Alexandrium minitum, Alexandrium tamiyavanichii, Alexandrium tropicale* (4 taxa)
Sabah	1.	Guroh Guroh, Sipitang, Sabah	*Pyrodinium Bahamense* (1 taxa)
	2.	Kimanis Bay, Papar, Sabah	*Pyrodinium bahamense var. compressum* (1 taxa)
	3.	Kota Belud, Sabah	*Alexandrium minitum* (1 taxa)
	4.	Kota Kinabalu Bay, Sabah	*Alexandrium tamiyavanichii, Gambierdiscus pacificus; Pyrodinium bahamense var. compressum* (3 taxa)

State	No	Location	Species Composition
	5.	Kuala Penyu, Kota Kinabalu, Sabah	*Pyrodinium bahamense* (1 taxa)
	6.	Malaysian Fisheries Department, Kota Kinabalu, Sabah	*Isochrysis* sp. (1 taxa)
	7.	Marudu Bay, Sabah	*Ceratium furca, Ceratium fursus, Dinophysis caudata, Dinophysis miles, Prorocentrum micans, Prorocentrum sigmoides, Prorocentrum triestinum, Pseudo-nitzschia sp.* (8 taxa)
	8.	Menengo, Sipitang, Sabah	*Pyrodinium Bahamense* (1 taxa)
	9.	Sepanggar Bay, Kota Kinabalu, Sabah	*Cochlodinium polykrikoides, Pyrodinium bahamense var compressum* (2 taxa)
	10.	Pulau Mantanani, Kota Belud, Sabah	*Pyrodinium Bahamense* (1 taxa)
	11.	Pulau Sipadan, Sabah	*Gambierdiscus pacificus* (1 taxa)
	12.	Maruntum, Penampang, Sabah	*Pyrodinium Bahamense* (1 taxa)
	13.	Universiti Malaysia Sabah, Sabah (Culture collection)	*Chaetoceros gracilis, Isochrysis sp., Nannochloropsis sp., Nannochloropsis oceanica, Tetraselmis sp., Thalassiosira weissflogii* (6 taxa)
Sarawak	1.	Kuching, Sarawak	*Alexandrium taylori, Alexandrium peruvianum* (2 taxa)
	2.	Muara Tebas, Kuching, Sarawak	*Cochlodinium polykrikoides* (1 taxa)
	3.	Kuala Sibuti, Miri, Sarawak	*Amphisolenia bidentata, Ceratium carriense, Ceratium furca, Ceratium fusus, Ceratium lineatum, Ceratium paradoxides, Chaetoceorspseudo curvisetus, Chaetoceors affinis, Coscinodiscus sp., Coscinodiscus centralis, Coscinodiscus granii, Coscinodiscus*

State	No	Location	Species Composition
			thorii, Dinophysis sp., Dinophysis caudata, Dinophysis miles, Eucampia zodiacus, Hyalodiscus sp., Nitzschia sp., Nitzschia sigma., Oscillatolaria sp.,
			Phalacroma sp., Pleurosigma elongatum, Pleurosigma normanii, Protoperidinium sp., Protoperidinium depressum, Protoperidinium divergents, Protoperidinium oceanicum, Pyrophacus sp., Rhizosolenia alata, Rhizosolenia clevei, Rhizosolenia curvata, Rhizosolenia imbrcata, Rhizosolenia polydactyla, Skeletonema costatum, Thalassiothrix sp., Thalassiothrix longisima, Thalassionema frauenfeldi, Triceratium sp., Triceratium favus (39 taxa)
	4.	Kuala Nyalau, Bintulu, Sarawak	*Actinoptychus senarius, Bacteriastrum comosum, Ceratium carriense, Ceratium furca, Ceratium fusus, Ceratium lineatum, Ceratium paradoxides, Ceratium tripos, Chlorella sp., Coscinodiscus sp., Coscinodiscus centralis, Coscinodiscus granii, Coscinodiscus jonesianus, Coscinodiscus thorii, Dinophysis miles, Ditylum brightwelli, Hyalodiscus sp., Navicula sp.Nitzschia sp., Odontella sp., Pleurosigma normanii, Pyrocystis sp., Rhizosolenia alata, Rhizosolenia clevei, Rhizosolenia curvata, Rhizosolenia polydactyla, Thalassiothrix sp. Thalassionema sp., Triceratium sp., Triceratium favus* (30 taxa)

4.5.2 Seaweed species composition and distribution in Malaysia found in this desktop study

Based on this desktop study, 416 taxa of seaweed were recorded, comprising Chlorophyta (17 families, 117 taxa); Rhodophyta (33 families, 184 taxa), and Ochrophyta (10 families, 112 taxa). Table 3 recorded the lists of seaweed species composition and their habitats reported in the coastal area of Malaysia from 1993 to 2022. We found that; different seaweed habitats were investigated in the Sabah area, and it was the highest (22%), followed by Kedah (21%), Terengganu (20%), Johor (14%), Sarawak (8%), Pahang (7%) and other areas (8%). Sabah has the highest number of seaweed habitats investigated and publications recorded (Figure 14) due to the abundance of islands found in the Sabah area. Terengganu, Kedah and Johor also have a high number of seaweed habitats investigated due to the several scientific expeditions, that have been carried out by universities to assess the diversity of seaweed, in the coastal area of Terengganu (Gan et al., 2008), Langkawi, Kedah (Phang et al, 2005) and groups of islands in Johor (Amri, et al,2005).

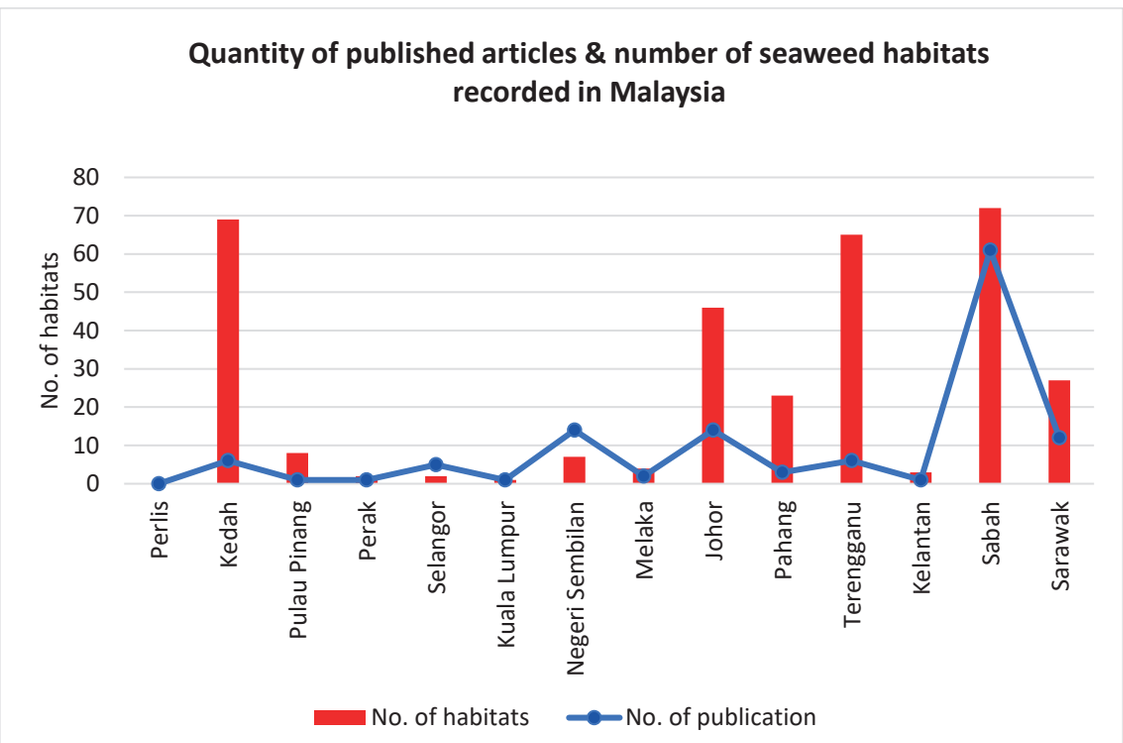
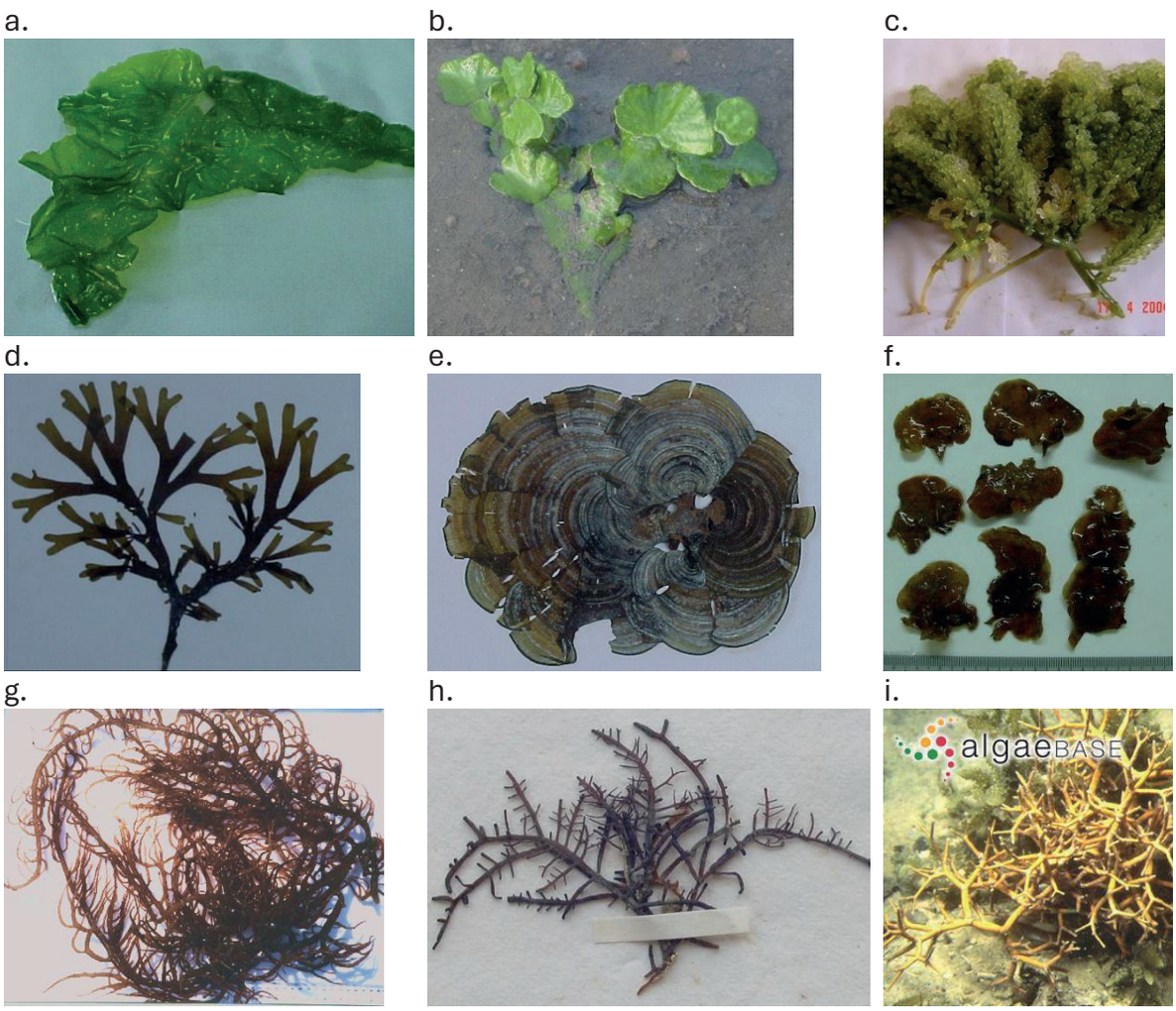


Figure 14: The number of published articles and seaweed habitats recorded in Malaysia from 1993 to 2022.

In general, based on data recorded from this desktop study (Table 3), the top ten seaweed habitats investigated containing the highest seaweed taxa are Pulau Langkawi, Kedah (82 taxa), Pulau Mantanani, Kota Belud, Sabah (65 taxa), Similajau National Park,

Sarawak (55 taxa), Pulau Sibu, Johor (52 taxa), Pulau Tioman, Pahang (48 taxa), Pulau Merabong, Johor (47 taxa), Blue Lagoon, Port Dickson, Negeri Sembilan (47 taxa), Pulau Redang, Terengganu (39 taxa), Tanjung Lompat, Johor (38 taxa) and Pasir Lanun, Johor (36 taxa).

Figure 15 shows selected seaweed usually found in Malaysian marine waters. Many of these seaweeds are located in the open ocean, estuarine and intertidal areas along the coastline of Malaysia. They are usually grown on a sandy, mud-sandy, muddy substrate or coral rubble. The maps of seaweed distribution in Peninsular Malaysia, Sabah, and Sarawak are shown in Figure 16.



a. *Ulva lactuca.*
b. *Halimeda macroloba*.
c. *Caulerpa lentilifera*.
d. *Dictyota* sp.
e. *Padina* sp.
f. *Lobophora variegata*
g. *Kappaphycus* sp
h. *Gelidiella acerosa*
i. *Amphiroa* sp.

Figure 15: The seaweed is usually found in Malaysian waters.

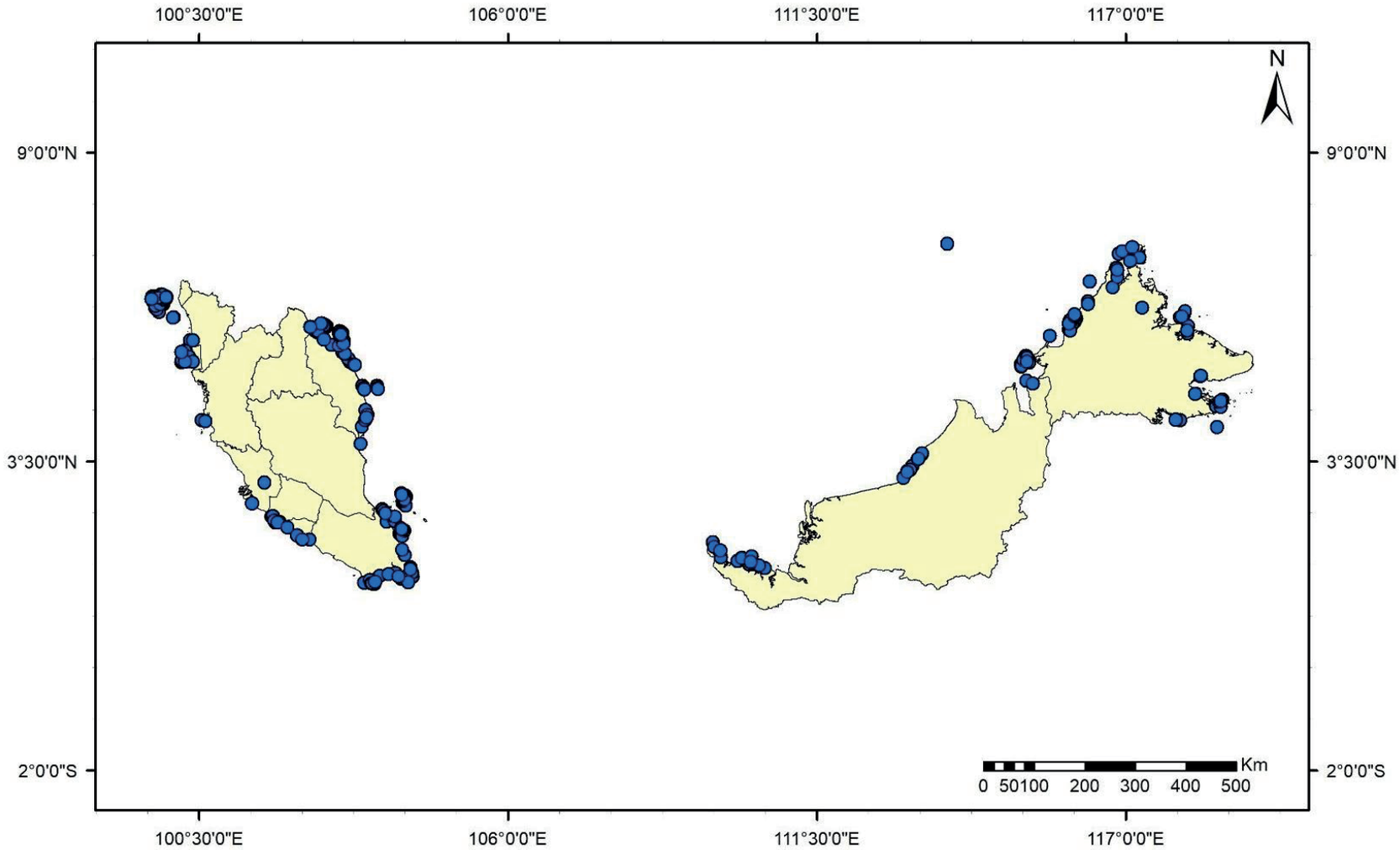


Figure 16: Map of seaweed distribution in Malaysia.

Table 3: Summary of seaweed species compositions at their habitats reported in Malaysian marine waters recorded from 1993-2022

State	No	Location	Species Composition
Perlis	1.	No data obtained	No data obtained
Kedah	1.	Pulau Langkawi, Kedah	*Acanthophora spicifera, Actinotrichia sp., Amphiroa fragillissima, Anotrichium tenue, Asparagopsis taxiformis, Avrainvillea erecta, Avrainvillea lacerata, Bostrychia tenella, Bryopsis sp., Boodlea composita(Cladophora composita), Caulacanthus ustulatus, Caulerpa sp., Caulerpa peltata, Caulerpa racemosa, Caulerpa serrulata, Caulerpa sertularoides, Caulerpa verticillata, Centroceras clavulatum, Ceratiodictyon spongiosum, Chondracanthus intermedius, Chaetomorpha sp., Champia sp., Cladophora sp., Cladophoropsis sp., Codium sp., Codium geppiorum, Colpomenia sp., Congracilaria sp., Cryptonemia yendoi, Dasya malaccensis, Dictyosphaeria cavernosa, Dictyota atomaria, Dictyota cervicornis, Dictyota dichotoma, Enteromorpha clathrata, Enteromorpha intestinalis, Galaxaura sp., Galaxaura obtusata, Gelidiella acerosa, Gelidiella pannosa, Gracilaria sp., Gracilaria canaliculata, Gracilaria changii, Gracilaria manilaensis, Gracilaria salicornia, Gracilaria tenuistipitata, Griffithsia schousboei, Halimeda macroloba, Halimeda simulans, Halymenia dilatata, Halymenia durvillei, Halymenia maculata, Herposiphonia pacifica, Heterosiphonia crispella, Hypnea sp., Hypoglossum simulans, Jania sp., Kappaphycus alvarezii, Leveillea jungermannioides, Lobophora variegata, Martensia fragilis, Microdictyon sp., Neosiphonia flaccidissima, Padina sp., Padina boryana, Padina tetrastromatica, Peyssonnelia sp., Polysiphonia sp., Polysiphonia scopulorum, Pterocladiella caerulescens, Rhizoclonium sp., Rhipidosiphon javense, Rosenvingea orientalis, Sargassum sp., Sargassum acutifolium, Stypopodium sp., Taenioma dotyi, Tolypiocladia sp., Turbinaria sp., Udotea javensis, Valonia aegagropila, Valonia utricularis* (82 taxa)

State	No	Location	Species Composition
	2.	Ayer Hangat Mangrove, Langkawi, Kedah	*Cladophora* sp., *Gracilaria canaliculata, Gracilaria salicornia, Hypnea* sp. (4 taxa)
	3.	Burau Bay, Langkawi, Kedah	*Lobophora variegata, Padina sp., Udotea javense* (3 taxa)
	4.	Fish Cages, Japanese Restaurant, Langkawi, Kedah	*Gracilaria salicornia, Lobophora sp.* (2 taxa)
	5.	Fishery Research Institute, Ban Merbok, Kedah,	*Caulerpa corynephora, Caulerpa microphysa, Dictyota dichotoma, Gracilaria* sp., *Gracilaria changii., Laurencia intricata, Padina minor, Sargassum siliquosum.* (8 taxa)
	6.	Gua Cherita, Langkawi, Kedah	*Amphiroa fragillissima, Caulerpa sertulariodes, Centroceras clavulatum, Cladophora* sp., *Galaxaura* sp., *Gracilaria canaliculata, Halimeda macroloba, Halimeda simulans, Hypnea* sp., *Lobophora sp., Padina tetrastromatica, Stypopodium* sp., *Udotea javense* (13 taxa)
	7.	South of Gua Cherita, Langkawi, Kedah	*Amphiroa fragilissima, Avrainvillea erecta, Ceratiodictyon spongiosum, Congracilaria* sp., *Halimeda macroloba, Halimeda simulans, Hypnea* sp., *Lobophora sp., Padina tetrastromatica, Rhizoclonium* sp., *Stypopodium* sp. (11 taxa)
	8.	Dataran Lang Bridge, Kuah, Langkawi, Kedah	*Gracilaria tenuistipitata* (1 taxa)
	9.	Kuah, Langkawi, Kedah	*Gracilaria tenuistipitata, Enteromorpha intestinalis, Gracilaria tenuistipitata,* (3 taxa)
	10.	Kuala Kubu Badak, Langkawi, Kedah	*Caulerpa sertulariodes* (1 taxa)
	11.	Kuala Kubang Badak, Langkawi, Kedah	*Acanthophora spicifera, Gracilaria manilaensis, Hypnea* sp., *Neosiphonia* sp. (4 taxa)

State	No	Location	Species Composition
	12.	Kuala Sungai, Merbok (Kedah)	*Gracilaria changii* (1 taxa)
	13.	Pantai Kok, Langkawi, Kedah	*Caulacanthus ustulatus,* (1 taxa)
	14.	Pasir Hitam, Langkawi, Kedah	*Amphiroa fragillissima, Cladophora* sp., *Codium geppiorum, Gelidiella acerosa, Gracilaria changii, Rosenvingea orientalis,* (6 taxa)
	15.	Pasir Panjang, Langkawi, Kedah	*Amphiroa fragillissima, Caulerpa racemosa, Halimeda macroloba* (3 taxa)
	16.	Pasir Panjang (near Tanjung Kemarong), Langkawi, Kedah	*Caulerpa racemosa, Dictyosphaeria cavernosa, Galaxaura obtusata* (3 taxa)
	17.	Pasir Talam Dua Muka, Langkawi, Kedah	*Chaetomorpha* sp., *Padina tetrastromatica*, (2 taxa)
	18.	South of Pulau Anak Cerita, Langkawi, Kedah	*Amphiroa fragillissima, Caulerpa racemosa, Cryptonemia* sp., *Enteromorpha clathrata, Halimeda macroloba, Padina tetrastromatica, Udotea javense* (7 taxa)
	19.	Pulau Beras Basah, Langkawi, Kedah	*Caulerpa peltata, Caulerpa racemosa, Ceratiodictyon spongiosum, Colpomenia* sp., *Dasya malaccensis, Enteromorpha intestinalis, Lobophora variegata, Lobophora sp., Padina tetrastromatica, Sargassum* sp., *Sargassum acutifolium, Sargassum dotyi, Turbinaria* sp., (13 taxa)
	20.	Jetty Point, Pulau Bunga, Langkawi, Kedah	*Polysiphonia scopulorum,* (1 taxa)
	21.	Pulau Burau, Langkawi, Kedah	*Caulacanthus ustulatus,* (1 taxa)
	22.	Pulau Dangli, Langkawi, Kedah	*Eucheuma denticulatum (Euchema spinosum), Kappaphycus alverazii (Eucheuma cottonii, Kappaphycus cottonii)* (2 taxa)

State	No	Location	Species Composition
	23.	Teluk Cina, Pulau Dendang, Langkawi, Kedah	*Caulerpa racemosa* (1 taxa)
	24.	Teluk Tembus, Pulau Dendang, Langkawi, Kedah	*Amphiroa fragillissima, Lobophora sp., Martensia fragilis, Neosiphonia* sp., *Tolypiocladia sp., Udotea javense,* (6 taxa)
	25.	Pulau Dendang (East), Langkawi, Kedah	*Amphiroa fragillissima, Acanthophora spicifera, Gracilaria canaliculata, Gracilaria salicornia, Herposiphonia* sp., *Neosiphonia sp., Lobophora sp., Udotea javense,* (8 taxa)
	26.	Tanjung Genting, Pulau Genting, Langkawi, Kedah	*Neosiphonia* sp. (1 taxa)
	27.	Teluk Genting, Pulau Genting, Langkawi, Kedah	*Dasya malaccensis, Heterosiphonia crispella, Halymenia durvillei, Halymenia maculata, Neosiphonia flaccidissima,* (5 taxa)
	28.	Pulau Gua, Langkawi, Kedah	*Gracilaria canaliculata*, (1 taxa)
	29.	Pulau Gua Cherita, Langkawi, Kedah	*Caulerpa racemosa, Caulerpa serrulata, Halimeda macroloba, Halimeda simulans, Halymenia maculata, Stypopodium* sp. (6 taxa)
	30.	Pulau Kentut Besar, Langkawi, Kedah	*Caulerpa racemosa, Lobophora variegata, Lobophora sp.*, (3 taxa)
	31.	Pulau Langun, Langkawi, Kedah	*Cladophora* sp., *Udotea javense, Padina tetrastromatica*, (3 taxa)
	32.	Pulau Langun, Teluk Dalam, Langkawi, Kedah	*Cladophora* sp. (1 taxa)
	33.	Pasir Hitam, Pulau Langgung, Langkawi, Kedah	*Champia* sp. (1 taxa)
	34.	Pulau Lembu, Pulau Payar, Langkawi, Kedah	*Taenioma dotyi* (1 taxa)

State	No	Location	Species Composition
	35.	Pulau Nyior Setali, Langkawi, Kedah	*Gelidiella pannosa,* (1 taxa)
	36.	Pulau Pasir, Langkawi, Kedah	*Caulacanthus ustulatus, Colpomenia* sp., *Gelidiella pannosa, Leveillea jungermannioides, Padina* sp. (5 taxa)
	37.	Teluk Gua, Pulau Payar, Langkawi, Kedah	*Polysiphonia scopulorum*, (1 taxa)
	38.	Pulau Puchong, Langkawi, Kedah	*Griffithsia schousboei,* (1 taxa)
	39.	Pulau Singa Besar, Langkawi, Kedah	*Bostrychia tenella, Ceratiodictyon spongiosum, Herposiphonia* sp., *Heterosiphonia crispella, Herposiphonia pacifica,* (5 taxa)
	40.	Pulau Singa Besar, Teluk Sepai, Langkawi, Kedah	*Anotrichium tenue,* (1 taxa)
	41.	Pulau Tanjung Dendang, Langkawi, Kedah	*Caulerpa racemosa* (1 taxa)
	42.	Teluk China Mati, Pulau Tanjung Dendang, Langkawi, Kedah	*Anotrichium tenue, Griffithsia schousboei, Martensia fragilis, Rhipidosiphon javense,* (4 taxa)
	43.	Teluk Tembus, Pulau Tanjung Dendang, Langkawi, Kedah	*Actinotrichia sp, Chaetomorpha* sp., *Cladophoropsis* sp., *Valonia aegagropila* (4 taxa)
	44.	Pulau Tepor, Langkawi, Kedah	*Cladophoropsis* sp., *Dasya malaccensis, Halymenia dilatata, Halymenia maculata, Heterosiphonia crispella, Polysiphonia scopulorum,* (6 taxa)
	45.	Pulau Tibi, Langkawi, Kedah	*Lobophora variegata,* (1 taxa)
	46.	Seaweed Farm, Kedah	*Gracilaria* sp. (1 taxa)
	47.	Sungai Air Hangat, Langkawi, Kedah	*Enteromorpha intestinalis, Hypnea* sp., (1 taxa)

State	No	Location	Species Composition
	48.	Sungai Kilim, Langkawi, Kedah	*Acanthophora spicifera, Asparagopsis taxiformis, Bryopsis* sp.*, Caulerpa racemosa, Caulerpa sertulariodes, Centroceras clavulatum, Dictyota dichotoma, Gracilaria canaliculata, Gracilaria manilaensis, Gracilaria salicornia, Hypnea* sp.*, Lobophora sp.,* (12 taxa)
	49.	Sungai Kilim, near river mouth, Langkawi, Kedah	*Acanthophora spicifera, Asparagopsis taxiformis, Boodlea composita (Cladophora composita), Caulerpa* sp.*, Caulerpa racemosa, Caulerpa sertulariodes, Centroceras clavulatum, Enteromorpha clathrata, Gracilaria salicornia, Hypnea* sp., (10 taxa)
	50.	Middle of Sungai Kilim, Langkawi, Kedah	*Asparagopsis taxiformis, Boodlea composita* (*Cladophora composita*)*, Bryopsis sp., Caulerpa sp., Caulerpa racemosa, Caulerpa sertulariodes, Hypnea* sp. (7 taxa)
	51.	Sungai Kisap, Langkawi, Kedah	*Caulerpa* sp., (1 taxa)
	52.	Middle Sungai Kisap, Langkawi, Kedah	*Caulerpa* sp., (1 taxa)
	53.	Sungai Pinang Karong, Langkawi, Kedah	*Caulerpa sertulariodes, Caulerpa* sp., (2 taxa)
	54.	Near to North Tanjung Berangan, Langkawi, Kedah	*Chaetomorpha* sp., (1 taxa)
	55.	Tanjung Datai, Langkawi, Kedah	*Halymenia durvillei*, (1 taxa)
	56.	Tanjung Datai Besar, Langkawi, Kedah	*Dasya iyengarii, Dasya malaccensis, Gelidiella pannosa, Heterosiphonia crispella,* (4 taxa)
	57.	Tanjung Dendang, Langkawi, Kedah	*Caulerpa racemosa* (1 taxa)
	58.	Tanjung Rhu, Langkawi, Kedah	*Amphiroa fragillissima, Asparagopsis taxiformis, Avrainvillea erecta, Caulerpa racemosa, Dictyota atomaria, Dictyota cervicornis,*

State	No	Location	Species Composition
			Enteromorpha clathrata, Enteromorpha intestinalis, Gracilaria changii, Lobophora sp., Polysiphonia sp., *Rosenvingea orientalis, Turbinaria* sp., (13 taxa)
	59.	Tanjung Rhu (between two rivers), Langkawi, Kedah	*Acanthophora spicifera, Dictyota cervicornis, Dictyota dichotoma, Enteromorpha clathrata, Hypnea sp., Padina tetrastromatica, Rhizoclonium* sp., (7 taxa)
	60.	Tanjung Rhu Beach, Langkawi, Kedah	*Caulerpa sertulariodes, Dictyota cervicornis, Enteromorpha clathrata, Hypnea* sp., (4 taxa)
	61.	Tanjung Tembus, Langkawi, Kedah	*Gelidiella acerosa*, (1 taxa)
	62.	Teluk Anak Gua Cerita, Langkawi, Kedah	*Avrainvillea lacerata, Enteromorpha clathrata, Caulerpa serrulata, Codium* sp., *Cryptonemia* sp., *Halimeda macroloba, Halimeda simulans, Microdictyon* sp., *Gracilaria canaliculata, Gracilaria salicornia, Peyssonnelia* sp., *Udotea javensis,* (12 taxa)
	63.	Teluk Cina Mati, Langkawi, Kedah	*Caulerpa racemosa, Cladophora* sp., *Dictyosphaeria cavernosa, Enteromorpha clathrata, Hypnea* sp., *Jania* sp., *Neosiphonia* sp., *Udotea javensis,* (8 taxa)
	64.	Teluk China Mati, Langkawi, Kedah	*Caulerpa peltata, Caulerpa racemosa, Caulerpa verticillate* (3 taxa)
	65.	Teluk Dalam, Langkawi, Kedah	*Cryptonemia* sp., *Gracilaria* sp., *Gracilaria canaliculata, Lobophora sp., Padina tetrastromatica, Pterocladiella caerulescens* (Syn: *Pterocladia caerulescens*), (6 taxa)
	66.	Teluk Dedap, Langkawi, Kedah	*Cladophora* sp., *Udotea javense*, (2 taxa)
	67.	Teluk Ewa, Langkawi, Kedah	*Amphiroa fragillissima, Hypoglossum simulans, Lobophora sp., Polysiphonia scopulorum, Valonia utricularis,* (5 taxa)

State	No	Location	Species Composition
	68.	Teluk Tama, Langkawi, Kedah	*Cladophoropsis* sp (1 taxa)
	69.	Teluk Tembus, Pulau Dendang, Langkawi, Kedah	*Cladophoropsis sp., Valonia aegagropila,* (2 taxa)
Pulau Pinang	1.	Batu Ferringhi; Penang	*Gracilaria multifurcata* (1 taxa)
	2.	Fisheries Research Institute, Batu Maung, Penang.	*Gracilaria changii* (1 taxa)
	3.	Middle Banks, Penang	*Gracilariopsis bailiniae, Gracilaria changii* (2 taxa)
	4.	Pasir Pandak; Penang	*Gracilaria multifurcata* (1 taxa)
	5.	Pasir Panjang, Penang	*Gracilaria multifurcata* (1 taxa)
	6.	Pulau Gedung, Penang	*Acanthophora spicifera* (1 taxa)
	7.	Sungai Batu; Penang	*Gracilaria multifurcata* (1 taxa)
	8.	Teluk Kerachut, Penang	*Gracilaria multifurcata* (1 taxa)
Perak	1.	Pulau Pangkor, Perak	*Kappaphycus alvarezii var. tambalang* (1 taxa)
	2.	SE Aquatech, Lumut, Perak	*Gracilaria manilaensis,* (1 taxa)
Selangor	1.	Pantai Morib, Selangor	*Gracilaria edulis, Gracilaria changii., Gracilaria salicornia* (3 taxa)
	2.	Morib mangroves, Selangor	*Gracilaria edulis, Gracilaria changii, Gracilaria salicornia* (3 taxa)

State	No	Location	Species Composition
Kuala Lumpur	1.	Institute of Ocean and Earth Sciences (IOES) of University of Malaya, Kuala Lumpur	*Kappaphycus* sp., *Halimeda* sp., *Padina* sp., *Sargassum* sp. (4 taxa)
Negeri Sembilan	1.	Blue Lagoon, Port Dickson, Negeri Sembilan	*Acanthophora spicifera, Analipus japonicus, Caulerpa lentillifera, Caulerpa microphysa, Caulerpa racemosa, Caulerpa serrulata, Caulerpa sertularioides, Caulerpa subserrata, Caulerpa verticillata, Chaetomorpha sp., Codium yezoense, Colpomenia sp., Dictyota ciliolate, Dictyota dentata, Dictyota dichotoma, Dictyotaceae sp., Dictyopteris delicatula, Enteromorpha clathrate, Enteromorpha intestinalis, Eucheuma alvarezii, Gracilaria sp., Gracilaria arcuate, Glacilaria blodgettii, Gracilaria foliifera, Gracilaria vermiculophylla, Jania decussatodichotoma, Laurencia cartilaginea, Lithophyllum pygmaeum, Lobophora variegata, Padina sp, Padina australis, Padina japonica, Padina minor, Padina tetrastomatica, Sargassum asperifolium, Sargassum cristaefolium, Sargaasum ilicifolium, Sargassum oligocystum, Sargassum polycystum, Sargassum siliquosum, Turbinaria conoides, Turbinaria luzonensis, Turbinaria ornata, Udotea argentea, Udotea javensis, Ulva fasciata, Ulva lactuca.* (47 taxa)
	2.	Pantai Dickson, Port Dickson, Negeri Sembilan	*Gracilaria changii* (1 taxa)
	3.	Pasir Panjang, Port Dickson, Negeri Sembilan	*Gracilaria* sp., *Padina* sp. (2 taxa)
	4.	Petroleum Industry of Malaysia Mutual Aid Group (PIMM AG) Base, Port Dickson, Negeri Sembilan	*Padina sp, Sargassum sp., Colpomenia sp.,* (3 taxa)
	5.	Port Dickson, Negeri Sembilan	*Caulerpa corynephora, Caulerpa microphysa, Caulerpa sertularioides, Dictyota dichotoma, Gracilaria salicornia, Laurencia intricata, Sargassum baccularia, Sargassum binderi, Sargassum duplicatum,*

State	No	Location	Species Composition
			Sargassum flavellum, Sargassum plagyophillum, Sargassum siliquosum, Padina australis, Padina minor, Turbinaria conoides., Turbinaria turbinata. (16 taxa)
	6.	Teluk Kemang beach, Port Dickson, Negeri Sembilan	*Amphiroa fragilissima, Caulerpa racemosa, Caulerpa macrophysa, Colpomenia* sp., *Dictyota dichotoma, Halimeda macroloba, Padina sp, Padina antillarum, Padina minor, Sargassum* sp., *Sargassum duplicatum, Sargassum siliquosum, Sargassum polycystum, Turbinatia conoides, Ulva intestinalis,* (15 taxa)
	7.	Teluk Pelanduk, Port Dickson, Negeri Sembilan	*Gracilaria changii, Gracilaria edulis* (2 taxa)
Melaka	1.	Batu Besar, Melaka	*Gracilaria changii, Gracilaria edulis, Gracilaria salicornia,* (3 taxa)
	2.	Batu Tengah, Melaka	*Gracilaria changii* (1 taxa)
	3.	Gua Tanah, Melaka	*Gracilaria changii* (1 taxa)
	4.	Pulau Besar, Melaka	*Amphiroa fragilissima, Boergesenia forbesii, Gracilaria salicoria, Padina sp., Ulva reticulata,* (5 taxa)
Johor	1.	Batu Layar, Kota Tinggi, Johor	*Colpomenia* sp., *Padina sp, Sargassum sp.* (3 taxa)
	2.	Desaru, Johor	*Mesospora schmidtii, Neoralfsia expansa, Ralfsia expansa,* (3 taxa)
	3.	Desaru, Tanjung Batu, Johor	*Acanthophora spicifera, Caulerpa racemosa, Chaetomorpha linum, Gelidiella sp., Gracilaria salicornia, Padina boryana, Sargasssum sp.* (7 taxa)

State	No	Location	Species Composition
	4.	Gelang Patah, Johor	*Gracilaria manilaensis,* (1 taxa)
	5.	Johor Bahru, Johor	*Gracilaria* sp. (1 taxa)
	6.	Kampung Pasir Gogok, Johor	*Acanthophora spicifera, Avrainvilea erecta, Caulerpa peltata, Caulerpa racemosa, Caulerpa sertularioides, Chaetomorpha crassa, Gracilaria edulis, Gracilaria salicornia, Halimeda macroloba, Halymenia dilatata, Halymenia floresii, Halymenia sp., Solieria robusta, Ulva reticulata,* (14 taxa)
	7.	Kukup, Johor	*Gracilaria changii, Gracilaria coronopifolia, Gracilaria edulis, Gracilaria verrucosa, Sargassum oligocystum, Sargassum siliquosum,* (6 taxa)
	8.	Pantai Mersing, Johor	*Cladophora vagabunda, Gracilaria sp., Gracilaria changii, Lobophora variegata, Padina sp, Sargassum sp., Sargassum cinereum, Ulva intestinalis,* (8 taxa)
	9.	Pantai Pasir Lanun, Johor	*Acanthophora muscoides, Acanthophora spicifera, Acetabularia acetabulum, Amphiroa fragilissima, Canistrocarpus cervicornis, Caulerpa racemosa, Chaetomorpha sp., Cladophora stimpsonii, Cladophora vagabunda, Chladophoropsis membranacea, Ceratodictyon intricatum, Chondrus crispus, Dictyota dichotoma, Dictyota mertensii, Dictyopteris delicatula, Galaxaura rugosa, Gracilaria arcuata, Gracilaria bursa-pastoris, Gracilaria changii, Gracilaria coronopifolia, Gracilaria salicornia, Hypnea cervicornis, Hypnea spinella, Jania adhaerens, Padina australis, Padina boergesenii, Padina minor, Polysiphonia coacta, Pterocladiella caloglossoides, Sargassum sp., Sargassum oligosystum, Sargassum paniculatum, Sargassum polycystum, Ulva clathrata, Ulva intestinalis, Valonia aegagropila,* (36 taxa)

State	No	Location	Species Composition
	10.	Pulau April, Johor	*Chamaebotrys boergesenii* (1 taxa)
	11.	Pulau Babi Tengah, Johor	*Halymenia durvillei* (1 taxa)
	12.	Tanjung Data, Pulau Babi Besar, Johor	*Halymenia durvillei* (1 taxa)
	13.	Kampung Busong, Pulau Babi Besar, Johor	*Chondria econstricta, Heterosiphonia crispella, Laurencia majuscula, Neosiphonia apiculata,* (4 taxa)
	14.	Kampung Penaga, Pulau Babi Besar, Johor	*Sargassum siliculosoides,* (1 taxa)
	15.	Kampung Penaga, Pulau Babi Besar, Johor	*Chondria econstricta, Champia vieillardii* (2 taxa)
	16.	Pulau Mawar, Johor	*Ceratodictyon intricatum, Chladophoropsis membranacea, Padina minor, Sargassum paniculatum, Sargassum polycystum* (5 taxa)
	17.	Pulau Merambong, Johor	*Acanthophora spicifera, Anadyomene plicata, Avrainvillea erecta, Avrainvillea obscura, Boodlea composita, Bryopsis pennata, Bryopsis plumosa, Canistrocarpus cervicornis, Caulerpa racemosa, Caulerpa sertularioides, Centroceras sp., Ceramium flaccidum, Ceratodictyon intricatum, Chaetomorpha aerea, Chaetomorpha crassa, Chaetomorpha ligustica, Chaetomorpha linum, Chaetomorpha minima, Chlorodesmis fastigiata, Cladophora sericea, Cladophoropsis membranacea, Dictyota dichotoma, Ectocarpus siliculosus, Gelidiella acerosa, Gracilaria arcuata, Gracilaria blodgetii, Gracilaria canaliculata, Gracilaria changii, Gracilaria coronopifolia, Gracilaria salicornia, Gracilaria verrucosa, Halimeda discoidea, Hypnea cervicornis, Hypnea spinella, Jania adhaerens, Laurencia flexilis, Laurencia intricata, Padina australis, Padina minor, Polysiphonia coacta, Sargassum polycystum, Solieria robusta, Ulva clathrata, Ulva compressa, Ulva intestinalis, Ulva lactuca, Ulva reticulata,* (47 taxa)

State	No	Location	Species Composition
	18.	Sandy area, Pulau Merambong, Johor	*Acanthophora spicifera, Anadyomene plicata, Avrainvillea erecta, Avrainvillea obscura, Boodlea composita, Bryopsis pennata, Bryopsis plumosa, Caulerpa racemosa, Caulerpa sertularioides, Ceramium flaccidum, Ceratodictyon intricatum, Chaetomorpha crassa, Chaetomorpha ligustica, Chaetomorpha linum, Chaetomorpha minima, Chlorodesmis fastigiata, Cladophoropsis membranacea, Dictyota dichotoma, Gelidiella acerosa, Gracilaria arcuata, Gracilaria blodgetii, Gracilaria changii, Gracilaria coronopifolia, Gracilaria salicornia, Hypnea cervicornis, Hypnea spinella, Jania adhaerens, Laurencia flexilis, Padina australis, Polysiphonia coacta, Sargassum polycystum, Solieria robusta, Ulva clathrata, Ulva compressa, Ulva intestinalis, Ulva lactuca, Ulva reticulata,* (37 taxa)
	19.	Rocky area, Pulau Merambong, Johor	*Acanthophora spicifera, Avrainvillea erecta, Bryopsis pennata, Centroceras sp., Ceratodictyon intricatum, Chaetomorpha aerea, Chaetomorpha ligustica, Chaetomorpha linum, Chaetomorpha minima, Chlorodesmis fastigiata, Cladophora sericea, Cladophoropsis membranacea, Ectocarpus siliculosus, Gelidiella acerosa, Gracilaria salicornia, Gracilaria verrucosa, Halimeda discoidea, Hypnea cervicornis, Jania adhaerens, Laurencia intricata, Padina australis, Padina minor, Ulva clathrata, Ulva compressa, Ulva lactuca, Ulva reticulata,* (26 taxa)
	20.	Muddy area, Pulau Merambong, Johor	*Avrainvillea erecta, Avrainvillea obscura, Chaetomorpha aerea, Chaetomorpha ligustica, Chaetomorpha linum, Chaetomorpha minima, Chlorodesmis fastigiata,* (7 taxa)
	21.	Mangrove area, Pulau Merambong, Johor	*Canistrocarpus cervicornis, Ceratodictyon intricatum, Chaetomorpha aerea, Chaetomorpha ligustica, Chaetomorpha linum, Chaetomorpha minima, Cladophoropsis membranacea, Laurencia intricata, Polysiphonia coacta,* (9 taxa)

State	No	Location	Species Composition
	22.	Pulau Rawa, Johor	*Sargassum crassifolium,* (1 taxa)
	23.	Pulau Sibu, Johor	*Acanthophora spicifera, Amphiroa fragilissima, Amphiroa rigida, Avrainvillea erecta, Avrainvillea longicaulis, Avrainvillea obscura, Bryopsis pennata, Caulerpa lentillifera, Caulerpa microphysa, Caulerpa racemosa, Caulerpa serrulata, Caulerpa verticillata, Centroceras minutum, Ceramium flaccidum, Chaetomorpha linum, Chaetomorpha minima, Chondria armata, Cladophora vagabunda, Cladophoropsis membranaceae, Cystoseira trinodis,Dictyota cervicornis, Dictyota dichotoma, Dictyota jamaicensis, Dictyota mertensii, Feldmannia indica, Gelidiella acerosa, Halimeda macroloba, Halimeda opuntia, Halimeda simulans, Halimeda tuna, Halymenia durvillei, Hormophysa cuneiformis, Hypnea pannosa, Hypnea spinella, Laurencia corymbosa, Leveillea junggermanniodes, Lobophora variegata, Padina australis, Padina boergesenii, Padina boryana, Padina minor, Polysiphonia decussata, Sargasssum sp., Sargassum polycystum, Sargassum siliquosum, Solieria robusta, Turbinaria conoides, Turbinaria ornata, Udotea javensis, Ulva fasciata, Ulva reticulata, Valonia aegagropila,* (52 taxa)
	24.	Kampung Duku, Pulau Sibu, Johor	*Sargassum erumpens* (1 taxa)
	25.	Pulau Sibu Tengah, Johor	*Amphiroa fragilissima, Avrainvillea obscura, Bryopsis plumosa, Chondria econstricta, Dictyota mertensii, Neomeris annulata, Padina australis, Ulva clathrata,* (8 taxa)
	26.	Pulau Sibu Hujung, Johor	*Avrainvillea erecta, Colpomenia* sp., *Enteromorpha* sp., (3 taxa)
	27.	Pulau Simbang, Johor	*Dasya pilosa* (1 taxa)

State	No	Location	Species Composition
	28.	Pulau Tinggi, Johor	*Avrainvillea erecta, Cladophoropsis sp., Dictyota indica, Enteromorpha sp., Halimeda sp., Hydroclathrus clathratus, Padina tetrastromatica, Sargassum sp., Udotea sp., Valonia aegagrophila,* (10 taxa)
	29.	Pasir Panjang, Pulau Tinggi, Johor	*Martensia fragilis* (1 taxa)
	30.	Pulau Apil, Pulau Tinggi, Johor	*Martensia fragilis* (1 taxa)
	31.	Teluk Pinang, Pulau Tinggi, Johor	*Neosiphonia savatieri* (1 taxa)
	32.	Sedili Kechil	*Padina sp, Sargassum sp.* (1 taxa)
	33.	Sungai Kong Kong, Johor	*Gracilaria changii* (1 taxa)
	34.	Sungai Pulai, Johor	*Gracilaria articulata, Gracilaria changii, Gracilaria edulis, Sargassum oligocystum,* (4 taxa)
	35.	Tanjung Adang Shoal, Sungai Pulai, Johor	*Jania adhaerens,* (1 taxa)
	36.	Merambong shoal, Sungai Pulai estuary, Johor	*Ceramium sp., Chaetomorpha minima, Glacilaria sp., Gracilaria manilaensis, Jania sp., Sargassum sp, Ulva sp.* (7 taxa)
	37.	Sungai Santi, Johor	*Ulva reticulata* (1 taxa)
	38.	Sungai Rengit, Johor	*Gracilaria sp., Sargassum sp.,* (2 taxa)
	39.	Tanjung Balau, Johor	*Mesospora schmidtii, Neoralfsia expansa, Padina sp, Sargassum sp.* (4 taxa)
	40.	Tanjung Belumbang, Johor	*Mesospora schmidtii* (1 taxa)

State	No	Location	Species Composition
	41.	Tanjung Lompat, Johor	*Acanthophora muscoides, Acanthophora spicifera, Acetabularia acetabulum, Amphiroa fragilissima, Canistrocarpus cervicornis, Caulerpa racemosa, Ceratodictyon intricatum, Chaetomorpha sp., Cladophora stimpsonii, Cladophora vagabunda, Chladophoropsis membranacea, Chondrus crispus, Dictyota dichotoma, Dictyota mertensii, Dictyopteris delicatula, Galaxaura rugosa, Gracilaria arcuata, Gracilaria bursa-pastoris, Gracilaria changii, Gracilaria coronopifolia, Gracilaria salicornia, Jania adhaerens, Hypnea cervicornis, Hypnea spinella, Mesospora schmidtii, Neoralfsia expansa, Padina australis, Padina boergesenii, Padina minor, Polysiphonia coacta, Pterocladiella caloglossoides, Sargassum sp., Sargassum oligosystum, Sargassum paniculatum, Sargassum polycystum, Ulva clathrata, Ulva intestinalis, Valonia aegagropila* (38 taxa)
	42.	Tanjung Kopok, Johor	*Bryopsis pennata, Caulerpa sp., Caulerpa racemosa, Caulerpa scalpelliformis, Caulerpa sertularioides, Caulerpa verticillata, Chaetomorpha sp., Chaetomorpha crassa, Cladophora sp., Dictyota atomaria, Enteromorpha sp., Gelidiella sp., Gracilaria changii, Gracilaria edulis, Gracilaria salicornia, Halymenia dilatata, Hypnea sp., Sargassum siliquosum, Solieria robusta, Ulva sp., Ulva fasciata, Ulva reticulata,* (22 taxa)
	43.	Tanjung Kupang, Johor	*Caulerpa recemosa* (1 taxa)
	44.	Tanjung Sedili Kecil, Johor	*Mesospora schmidtii* (1 taxa)
	45.	Tanjung Surat, Johor	Caulerpa racemosa., Ulva reticulata, (1 taxa)

State	No	Location	Species Composition
	46.	Telok Gorek Gorek, Johor	*Canistrocarpus cervicornis, Chaetomorpha sp., Chladophoropsis membranacea, Dictyota mertensii, Jania adhaerens, Padina australis, Padina boergesenii, Sargassum paniculatum, Sargassum polycystum,* (1 taxa)
Pahang	1.	Cherating, Kuantan, Pahang	*Padina sp.* (1 taxa)
	2.	Pulau Tioman, Pahang	*Amphiroa rigida, Boergesenia forbesii, Boodlea struveoides, Bryopsis corymbosa, Bryopsis pennata, Caulerpa racemosa, Caulerpa taxifolia, Ceramium diaphanum, Chaetomorpha minima, Cladophora catenata, Cladophora prolifera, Champia compressa, Codium geppiorum, Derbesia prolifica, Feldmannia enhali, Gracilaria coronopifolia, Gracilaria crassa, Gracilaria damicornis, Gracilaria edulis, Gracilaria salicornia, Galaxaura sp., Halimeda opuntia, Halimeda tuna, Halymenia dilatata, Halymenia floresii, Halymenia maculata, Hormophysa cuneiformis, Laurencia corymbosa, Laurencia parvipapillata, Leveillea junggermanniodes, Padina boryana, Padina tetrastromatica, Polysiphonia fucoides, Polysiphonia violacea, Sargassum cristaefolium, Sargassum fluitans, Sargassum ilicifolium, Sargassum ilicifolium var conduplicatum, Sargassum torvum, Spyridia filamentosa, Struvea ramosa, Tricleocarpa cylindrica, Ulva fasciata, Ulva intestinalis, Ulva reticulata, Valonia aegagropila, Valonia utricularis, Wrangelia bicuspidata,* (48 taxa)
	3.	Kampung Ayer Batang, Pulau Tioman, Pahang	*Caulerpa peltata, Dictyopteris sp., Lobophora variegata,* (3 taxa)

4.	Kampung Genting, Pulau Tioman, Pahang	*Actinotrichia fragilis, Caulerpa racemosa, Chamaebotrys boergesenii, Colpomenia sinuosa, Dictyopteris sp., Dictyosphaeria cavernosa, Dictyosphaeria versluysii, Halimeda opuntia, Lobophora variegata, Portieria hornemannii, Tydemania expeditionis, Ventricaria ventricosa,* (12 taxa)
5.	Kampung Lalang, Pulau Tioman, Pahang	*Dictyosphaeria versluysii, Gelidiopsis intricata, Gelidiopsis sp., Lobophora variegata, Neomeris annulata, Padina australis* (6 taxa)
6.	Kampung Mukut, Pulau Tioman, Pahang	*Actinotrichia fragilis, Amphiroa foliacea, Anadyomene plicata, Caulerpa peltata, Caulerpa serrulata, Caulerpa verticillata, Champia parvula, Colpomenia sinuosa, Dictyopteris sp., Dictyosphaeria versluysii, Gelidiella acerosa, Halimeda opuntia, Halymenia formosa, Laurencia caduciramulosa, Lobophora variegata, Portieria hornemannii, Tolypiocladia glomerulata, Tricleocarpa fragilis, Turbinaria ornata,* (19 taxa)
7.	Kampung Paya, Pulau Tioman, Pahang	*Caulerpa lentillifera, Caulerpa racemosa,* (2 taxa)
8.	Kampung Tekek, Tioman Island, Pahang	*Padina tetrastromatica* (1 taxa)
9.	Pulau Chebah, Pulau Tioman, Pahang	*Tydemania expeditionis* (1 taxa)
10.	Pulau Rengis, Pulau Tioman, Pahang	*Caulerpa racemosa, Chamaebotrys boergesenii, Gelidiopsis sp., Gelidiopsis intricata, Lobophora variegata, Lomentaria monochlamydea, Pterocladia caloglossoides,* (7 taxa)
11.	Pulau Tanjung Paya, Pulau Tioman, Pahang	*Caulerpa racemosa, Dictyosphaeria versluysii, Lobophora variegata, Tydemania expeditionis,* (4 taxa)
12.	Pulau Tulai, Pulau Tioman, Pahang	*Tolypiocladia glomerulata* (1 taxa)
13.	Salang Beach, Pulau Tioman, Pahang	*Colpomenia sinuosa, Lobophora variegata, Ulva clathrata,* (3 taxa)
14.	Salang Wreck, Pulau Tioman, Pahang	*Tydemania expeditionis, Colpomenia sinuosa,* (2 taxa)
15.	Swallow Cave, Salang, Pulau Tioman, Pahang	*Lobophora variegata, Tricleocarpa cylindrica,* (2 taxa)

State	No	Location	Species Composition
	16.	Tanjung Keramat, Pulau Tioman, Pahang	*Turbinaria conoides,* (1 taxa)
	17.	Tanjung Layar, Pulau Tioman, Pahang	*Actinotrichia fragilis, Amphiroa foliacea, Jania rubens, Laurencia concreta,* (4 taxa)
	18.	Teluk Dalam, Pulau Tioman, Pahang	*Sargassum crassifolium,* (1 taxa)
	19.	Teluk Juara, Pulau Tioman, Pahang	*Laurencia majuscula, Turbinaria ornata* (2 taxa)
	20.	Teluk Salang, Pulau Tioman, Pahang	*Amphiroa foliacea, Anadyomene plicata, Asparagopsis taxiformis, Boodlea composita, Caulerpa peltata, Caulerpa racemosa, Caulerpa serrulata, Champia parvula, Colpomenia sinuosa, Dictyota dichotoma, Dictyota divaricata, Dictyosphaeria sp., Hydroclathrus clathratus, Hypnea pannosa, Lobophora variegata, Padina australis, Portieria hornemannii, Tolypiocladia glomerulata, Tydemania expeditionis,* (19 taxa)
	21.	Teluk Tekek, Pulau Tioman, Pahang	*Acanthophora spicifera, Avrainvillea obscura, Coelarthrum sp., Dictyosphaeria cavernosa, Jania adhaerens,* (5 taxa)
	22.	Pulau Tulai, Pahang	*Tydemania expeditionis* (1 taxa)
	23.	Teluk Cempedak, Kuantan, Pahang	*Colpomenia sp., Gracilaria sp., Padina sp, Sargassum sp.,* (4 taxa)
Terengganu	1.	Kampung Gong Batu, Terengganu	*Gracilaria changii* (1 taxa)
	2.	Pantai Bari, Setiu, Terengganu	*Gelidiella pusillum, Padina japonica, Ulva intestinalis,* (3 taxa)
	3.	Pantai Bari Kecik, Terengganu	*Acanthophora muscoides, Antithamnionella elegans, Centroceras clavulatum, Chaetomorpha crasa, Feldmannia columellaris, Gelidiella pannosa, Gelidiella pusillum, Hypnea charoides, Laurencia decumbens, Padina sp., Phyllodictyon anastomosans,*

State	No	Location	Species Composition
			Pterocladia caloglossoides, Sphacelaria novae-hollandiae, Ulva intestinalis (15 taxa)
	4.	Pantai Batu Buruk, Terengganu	*Acanthophora muscoides, Centroceras clavulatum, Chaetomorpha minima, Cladophoropsis sundanensis, Dictyota divaricata, Gelidiella pusillum, Gloiopeltis cf. tenax, Hypnea charoides, Jania ungulata, Phyllodictyon anastomosans, Pterocladia nana, Ulva clathrata,* (12 taxa)
	5.	Pantai Bukit Keluang, Terengganu	*Acanthophora muscoides, Feldmannia columellaris, Gelidiella pannosa, Hypnea charoides,* (4 taxa)
	6.	Pantai Chendering, Terengganu	*Amphiroa zonata, Caulerpa serrulata, Chaetomorpha minima, Chaetomorpha spiralis, Cheilosporum acutilobum, Feldmannia irregularis, Gelidiella pannosa, Gelidiopsis repens, Gracilaria rhodymenioides, Griffithsia schousboei, Hypnea charoides, Jania ungulata, Padina sp, Phyllodictyon anastomosans, Pterocladia nana, Sargassum sp., Ulva clathrata, Valoniopsis pachynema, Wrangelia plumosa,* (20 taxa)
	7.	Batu Chendering, Pantai Chendering, Kuala Terengganu, Terengganu	*Sargassum binderi,* (1 taxa)
	8.	Pantai Batu Rakit, Terengganu	*Cladophoropsis sundanensis, Pterocladia nana,* (2 taxa)
	9.	Pantai Kuala Abang, Terengganu	*Amphiroa zonata, Centroceras clavulatum, Cladophora aokii, Cladophoropsis sundanensis, Dictyota crispata, Gelidiella pusillum, Gelidiella pannosa, Gelidiopsis repens, Gloiopeltis cf. tenax, Gracilaria rhodymenioides, Griffithsia schousboei, Herposiphonia pacifica, Hypnea charoides, Laurencia botryoides, Laurencia patentiramea, Liagora sp., Neosiphonia apiculata, Phyllodictyon anastomosans, Sargassum ilicifolium var conduplicatum,*

State	No	Location	Species Composition
			Sphacelaria novae-hollandiae, Tricleocarpa cylindrica, Ulva clathrata, Valoniopsis pachynema, (23 taxa)
	10.	Pantai Kemasik, Terengganu	*Acanthophora muscoides, Ahnfeltiopsis pygmaea, Amphiroa zonata, Asteronema breviarticulatum, Ceramium californicum, Ceramium cimbricum, Chaetomorpha antennina, Cladophoropsis sundanensis, Cheilosporum acutilobum, Dictyota ciliolata, Dictyota crispata, Feldmannia irregularis, Gelidiella pusillum, Gelidiopsis repens, Gloiopeltis cf. tenax, Gracilaria fisheri, Gracilaria rhodymenioides, Grateloupia livida, Jania ungulata, Laurencia patentiramea, Padina sp, Phyllodictyon anastomosans, Sargassum sp. Valoniopsis pachynema, Ulva clathrata* (25 taxa)
	11.	Pantai Kijal	*Padina sp.* (1 taxa)
	12.	Pantai Kuala Besut, Terengganu	*Ulva flexuosa, Padina antilarum,* (2 taxa)
	13.	Pantai Kuala Terengganu, Terengganu	*Gracilaria verrucosa, Lobophora nigrescens,* (2 taxa)
	14.	Pantai Marina, Terengganu	*Laurencia patentiramea, Ulva clathrata,* (2 taxa)
	15.	Pantai Universiti Malaysia Terengganu, Terengganu	*Gelidiella pannosa, Hypnea charoides, Laurencia patentiramea,* (3 taxa)
	16.	Breakwater area, Pantai Universiti Malaysia Terengganu, Terengganu	*Centroceras sp., Dictyota sp., Laurencia sp., Padina sp., Polysiphonia sp.,* (5 taxa)
	17.	Pulau Batu Rusa, Terengganu	*Cladophora cf. patentiramea, Gelidiopsis hachijoensis, Griffithsia. schousboei, Hypnea charoides, Phyllodictyon anastomosans,* (5 taxa)

State	No	Location	Species Composition
	18.	Pulau Bidong Laut, Terengganu	*Acanthophora muscoides, Acrochaetium sp., Amphiroa anastomosans, Caulerpa mexicana, Caulerpa nummularia, Caulerpa peltata, Caulerpa serrulata, Caulerpa serrulata f. lata, Caulerpa serrulata var. boryana, Chondria decidua, Dictyopteris repens, Dictyota bartayresiana, Dictyota cervicornis, Dictyota ceylanica, Dictyota ciliolate, Dictyota dichotoma, Dictyota divaricata, Feldmannia columellaris, Feldmannia irregularis, Gelidiella pusillum, Gelidiopsis repens, Griffithsia schousboei, Herposiphonia pacifica, Hypnea charoides, Hypoglossum simulans, Neosiphonia apiculata, Padina boryana, Parvocaulis exiguus, Phyllodictyon anastomosans, Pterocladia nana, Rosenvingea intricata, Tricleocarpa cylindrica,* (32 taxa)
	19.	Tanjung Pasir, Pulau Bidong Laut, Terengganu	*Herposiphonia pacifica* (1 taxa)
	20.	Tanjung Pasir Cina, Pulau Bidong Laut,	*Peyssonnelia inamoena, Chamaebotrys boergesenii,* (2 taxa)
	21.	Pulau Ekor Tebu, Terengganu	*Herposiphonia pacifica* (1 taxa)
	22.	Pulau Geluk, Terengganu	*Ceramium gardneri, Chondracanthus sp., Cladophora herpestica, Dictyopteris repens, Gelidiella pusillum, Gelidiopsis repens, Lomentaria cf. gracillima, Parvocaulis exiguus, Pterocladia nana,* (9 taxa)
	23.	Pulau Kapas, Terengganu	*Caulerpa serrulata, Halimeda macroloba* (2 taxa)
	24.	Hujung Tenggara, Pulau Kapas, Terengganu	*Champia compressa,* (1 taxa)
	25.	Pulau Karah, Terengganu	*Amphiroa zonata, Dictyopteris repens, Dictyota ciliolate, Dictyota dichotoma, Dictyota divaricata, Gelidiella pusillum, Gelidiopsis repens, Hypoglossum caloglossoides, Rosenvingea intricata* (9 taxa)

State	No	Location	Species Composition
	26.	Pulau Nyireh, Terengganu	*Champia compressa* (1 taxa)
	27.	Pulau Paku Besar, Terengganu	*Halymenia dilatata,* (1 taxa)
	28.	Pulau Perhentian, Terengganu	*Bryopsis hypnoides, Caulerpa racemosa, Lobophora variegata, Spyridia filamentosa, Ulva clathrata,* (5 taxa)
	29.	Site B: Channel in front of Department of Fisheries, Pulau Perhentian, Terengganu	*Caulerpa sertulariodes* (1 taxa)
	30.	Tanjung Batu Lepir, Pulau Perhentian, Terengganu	*Dasya iyengarii, Peyssonnelia inamoena,* (2 taxa)
	31.	Flora Beach Resort, Pulau Perhentian Besar, Terengganu	*Acanthophora spicifera, Caulerpa serrulata, Caulerpa serrulata var. boryana,* Gelidiales sp., *Turbinaria conoides,* (5 taxa)
	32.	Pulau Perhentian Besar, Terengganu	*Boodlea composita, Bryopsis pennata, Bryopsis plumosa, Caulerpa serrulata, Ventricaria ventricosa,* (5 taxa)
	33.	Teluk Kecil, Pulau Perhentian Besar, Terengganu	*Acanthophora spicifera* (1 taxa)
	34.	Pasir Tiga Ruang, Pulau Perhentian Besar, Terengganu	*Amphiroa fragilissima, Gelidiella acerosa, Laurencia caduciramulosa, Turbinaria conoides,* (4 taxa)
	35.	Tanjung Genting, Pulau Perhentian Besar, Terengganu	*Lobophora variegata,* (1 taxa)
	36.	Teluk Gadung, Pulau Perhentian Besar, Terengganu	*Chamaebotrys boergesenii, Peyssonnelia inamoena, Polysiphonia scopulorum,* (3 taxa)

State	No	Location	Species Composition
	37.	Teluk Dalam, Pulau Perhentian Besar, Terengganu	*Lobophora variegata,* (1 taxa)
	38.	Pulau Perhentian Kecil, Terengganu	*Acanthophora muscoides, Amphiroa foliacea, Caulerpa serrulata, Centroceras clavulatum, Turbinaria decurrens, Turbinaria ornata* (6 taxa)
	39.	Batu Mgong, Pulau Perhentian Kecil, Terengganu	*Acanthophora spicifera, Actinotrichia fragilis, Amphiroa anceps, Lobophora variegata, Padina antilarum, Turbinaria conoides,* (6 taxa)
	40.	Pasir Mas, Pulau Perhentian Kecil, Terengganu	*Acanthophora spicifera, Actinotrichia fragilis, Amphiroa fragilissima, Turbinaria conoides,* (4 taxa)
	41.	De lagoon, Pulau Perhentian Kecil, Terengganu	*Acanthophora spicifera, Hormophysa cuneiformis,* (2 taxa)
	42.	Tanjung Batu Payong, Pulau Perhentian Kecil, Terengganu	*Neosiphonia savatieri* (1 taxa)
	43.	Tanjung Guntong Laut, Pulau Perhentian Kecil, Terengganu	*Polysiphonia scopulorum, Peyssonnelia inamoena,* (1 taxa)
	44.	Kg. Tanjung Aur (Rajawali), Pulau Perhentian Kecil, Terengganu	Udotea sp. (1 taxa)
	45.	Marine Park, Pulau Pinang, Terengganu	*Caulerpa nummularia, Caulerpa serrulata f. lata, Caulerpa serrulata var. boryana, Chlorodesmis sp., Dictyopteris repens, Gelidiella pusillum, Hypnea charoides, Hypnea spinella, Laurencia patentiramea, Parvocaulis exiguus,* (10 taxa)
	46.	Pulau Rawa, Terengganu	*Dictyota ciliolata, Gelidiella pusillum, Lobophora variegata, Padina australis,* (4 taxa)

State	No	Location	Species Composition
	47.	Pulau Redang, Terengganu	*Acetabularia pusila, Amphiroa anceps, Amphiroa foliacea, Amphiroa fragilissima, Amphiroa tribulus, Boodlea coacta, Boodlea composita, Caulerpa racemosa, Caulerpa serrulata, Ceramium corniculatum, Ceramium flaccidum, Chaetomorpha aerea, Cladophora coelothrix, Codium tomentosum, Dictyota divaricata, Dictyota friabilis, Dictyota submaritima, Feldmannia simplex, Fosliella dispar, Gastroclonium compressum, Gracilaria verrucosa, Halimeda opuntia, Herposiphonia secunda, Hypnea pannosa, Jania adhaerens, Jania capillacea, Laurencia implicata, Laurencia papillosa, Liagora ceranoides, Lobophora variegata, Padina caulescens, Padina minor, Polysiphonia coacta, Polysiphonia subtillissima, Ptilothamnion codicolum, Rhizoclonium hookeri, Turbinaria ornata, Udotea cyathiformis, Ulva clathrata* (39 taxa)
	48.	Chagar Hutang, Pulau Redang, Terengganu	*Caulerpa nummularia, Caulerpa serrulata f. lata, Dictyota ciliolata, Gelidiella pannosa, Gelidiella pusillum, Gelidiella pusillum var. pacificum, Gelidiopsis hachijoensis, Phyllodictyon anastomosans, Pterocladia nana, Rosenvingea intricata, Tricleocarpa cylindrica, Ulva clathrata, Ulva intestinalis,* (13 taxa)
	49.	Mak Simpan, Pulau Redang, Terengganu	*Champia compressa, Heterosiphonia crispella, Hypoglossum caloglossoides, Polysiphonia scopulorum,* (4 taxa)
	50.	Pasir Panjang Kecil, Pulau Redang, Terengganu	*Chamaebotrys boergesenii, Peyssonnelia inamoena,* (2 taxa)
	51.	Pulau Kerengga Besar, Pulau Redang, Terengganu	*Acetabularia parvula, Boodlea composita, Bryopsis indica, Bryopsis pennata, Caulerpa peltata, Ceramium fimbriatum, Champia compressa, Cladophora catenata, Cladophora stimpsonii, Dictyosphaeria cavernosa, Dictyopteris sp., Gelidiopsis intricata, Herposiphonia secunda, Jania decussato-dichotoma, Laurencia articulata, Laurencia corymbosa, Laurencia papillosa,*

State	No	Location	Species Composition
			Laurencia perforata, Murrayellopsis dawsonii, Pterocladia caloglossoides, Struvea anastomosans, Tolypiocladia calodictyon, (22 taxa)
	52.	Pulau Kerengga Kecil, Pulau Redang, Terengganu	*Anotrichium tenue, Callophyllis heanophylla, Caulerpa peltata, Caulerpa racemosa, Chaetomorpha linum, Chondria armata, Dictyota ciliolata, Hypnea spinella, Laurencia articulata, Pterocladia caloglossoides, Tolypiocladia glomerulata, Wrangelia argus,* (12 taxa)
	53.	Tanjung Lang, Pulau Redang, Terengganu	*Sargassum cervicorne* (1 taxa)
	54.	Tanjung Gua Kawah, Pulau Redang, Terengganu	*Sargassum crassifolium,* (1 taxa)
	55.	Teluk Dalam Kecil, Pulau Redang, Terengganu	*Dasya iyengarii,* (1 taxa)
	56.	Teluk Kalong Besar, Pulau Redang, Terengganu	*Laurencia majuscula,* (1 taxa)
	57.	Pulau Ru, Terengganu	*Cladophora aokii, Gracilaria fisheri, Ulva intestinalis,* (3 taxa)
	58.	Pulau Susu Dara, Terengganu	*Turbinaria decurrens,* (1 taxa)
	59.	Pulau Tenggol, Terengganu	*Champia compressa, Chamaebotrys boergesenii, Hypoglossum rhizophorum, Polysiphonia scopulorum, Valonia aegagropila,* (5 taxa)
	60.	Batu Tokong Daik, Pulau Tenggol, Terengganu	*Laurencia calliclada* (1 taxa)
	61.	Kampung Tanjung Balau, Pulau Tinggi, Terengganu	*Sargassum granuliferum* (1 taxa)

State	No	Location	Species Composition
	62.	Setiu Wetlands, Terengganu	*Chaetomorpha antennina, Cladophora herpestica, Gracilaria fisheri, Hypnea charoides, Padina australis, Sargassum cristaefolium, Ulva compressa, Ulva flexuosa, Ulva intestinalis (Entermorpha intertanalis), Ulva lactuca, Urospora doliifera, Urospora penicilliformis,* (12 taxa)
	63.	Tanjung Jara, Terengganu	*Chaetomorpha antennina, Cheilosporum acutilobum, Chondracanthus intermedius, Dictyopteris jamaicensis, Dictyota cervicornis, Dictyota crispata, Dictyota mertensii, Gelidiella pannosa, Gelidiella pusillum, Gelidiopsis repens, Griffithsia schousboei, Hypnea charoides, Jania ungulata, Laurencia patentiramea, Lobophora nigrescens, Padina sp., Pterocladia nana, Sargassum sp., Sargassum polycystum, Ulva clathrata, Valoniopsis pachynema,* (21 taxa)
	64.	Teluk Bidara Beach, Dungun, Terengganu	*Caulerpa corynephora, Caulerpa microphysa, Dictyota dichotoma, Laurencia intricata, Padina minor, Sargassum siliquosum.* (6 taxa)
	65.	Teluk Kalong, Terengganu	*Acanthophora muscoides, Ceramium gardneri, Dictyota bartayresiana, Dictyota cervicornis, Dictyota crispata, Feldmannia irregularis, Gelidiopsis repens, Griffithsia schousboei, Hypnea charoides, Jania ungulata, Laurencia cartilaginea, Laurencia patentiramea, Sargassum heterocystum, Spongomorpha arcta, Ulva clathrata, Ulva intestinalis,* (16 taxa)
Kelantan	1.	Kuala Semarak, Bachok, Kelantan	*Centroceras minutum, Gelidiales sp., Gelidiella sp., Pterocladiella sp., Rhizoclonium sp., Ulva compressa, Ulva reticulata,* (6 taxa)
	2.	Sungai Semarak, Bachok, Kelantan	*Ulva flexuosa,* (1 taxa)
	3.	Hutan Paya Simpan, Sungai Semarak, Bachok, Kelantan	*Gelidiales sp.* (1 taxa)

State	No	Location	Species Composition
Sabah	1.	Kota Belud, Sabah	*Eucheuma Cottoni, Eucheuma denticulatum,* (2 taxa)
	2.	Pulau Mantanani, Kota Belud, Sabah	*Acanthophora spicifera, Actinotrichia fragilis, Anadyomene plicata, Anadyomene wrightii, Avrainvillea sp., Boergesenia forbesii, Boodlea composita, Bornetella nitida, Caulerpa cupressoides, Caulerpa lentilifera, Caulerpa racemosa var clavifera f macrophysa, Caulerpa racemosa var. laetavirens, Caulerpa racemosa var. lamourouxii, Caulerpa serrulata var. boryana, Caulerpa serrulata var serrulata f lata, Caulerpa sertulariodes f longipes, Cladophoropsi sherpestica, Codium geppiorum, Dasyaceae sp., Dictyopteris sp., Dictyota sp., Dictyota dentata, Dictyota dichotoma, Dictyota linearis, Dictyota spinulosa, Dictyosphaeria cavernosa, Enteromorpha compressa, Enteromorpha prolifera, Galaxaura lapidescens, Gelidiopsis intricata, Glacilaria sp., Glacilaria arcuata, Glacilaria salicornia, Glacilariopsis bailiniae, Halimeda macroloba, Halimeda discoidea, Halimeda opuntia, Helminthocladia australis, Hypnea pannosa, Kappaphycus alvarezii, Laurencia majuscula, Laurencia nangii, Laurencia papilosa, Laurencia similis, Laurencia snackeyi, Liagora sp., Lobophora sp., Lobophora variegata, Microdictyon japonicum, Neomeris annulata, Padina australis, Padina boryana, Padina minor, Portiera hornemannii, Sargassum denticarpum, Sargassum mcclurei, Sargassum oligocystum, Sargassum swartzii, Spyridia hypnoides, Turbinaria conoides, Turbinaria ornata, Ulva lactuca, Valonia fastigiata, Valonia utricularis, Valonia ventricosa,* (65 taxa)
	3.	Teluk Ambong, Kota Belud, Sabah	*Eucheuma denticulatum (Eucheuma spinosum),* (1 taxa)
	4.	Coastal water nearby Borneo Marine Research Institute (BMRI), Kota Kinabalu, Sabah	*Sargassum polycystum.* (1 taxa)

State	No	Location	Species Composition
	5.	Creagh Reef, Kota Kinabalu, Sabah	*Sargassum oligocystum* (1 taxa)
	6.	Gaya Bay, Kota Kinabalu, Sabah	*Colpomenia sinuosa, Padina boryana, Sargassum tenerrimum, Turbinaria conoides,* (4 taxa)
	7.	Kota Kinabalu Coastal Areas Kota Kinabalu, Sabah	*Caulerpa lentillifera, Caulerpa racemosa, Dictyota dentata, Eucheuma sp., Eucheuma denticulatum, Euchema denticulatum var. Endong, Gracilaria sp., Hormophysa cuneiformis, Kappaphycus sp., Kappaphycus alvarezii, Kappaphycus malesianus, Kappaphycus striatus, Sargassum duplicatum, Sargassum filipendula, Sargassum siliquosum, Sargassum tenerrimum, Solieria sp.,* (17 taxa)
	8.	Likas Bay, Kota Kinabalu, Sabah	*Hormophysa cuneiformis, Sargassum duplicatum, Sargassum tenerrimum,* (3 taxa)
	9.	Pantai Sembulan, Kota Kinabalu, Sabah	*Sargassum cinereum, Sargassum tenerrimum,* (2 taxa)
	10.	Pulau Dinawan, Kota Kinabalu, Sabah	*Cryptonemia crenulata, Halymenia durvillei, Sargassum oligocystum, Sargassum polycystum,* (4 taxa)
	11.	Pulau Gaya, Kota Kinabalu, Sabah	*Amphiroa foliacea, Anotrichium tenue, Caulerpa racemosa, Colpomenia sinuosa, Dasya iyengarii, Dasya longifila, Halimeda opuntia, Halymenia durvillei, Hormophysa cuneiformis, Laurencia nangii, Laurencia similis, Sargassum balingasayense, Sargassum cinereum, Sargassum duplicatum, Sargassum polycystum, Sargassum siliquosum, Tricleocarpa cylindrica, Turbinaria conoides, Ventricaria ventricosa,* (19 taxa)
	12.	Pulau Mantukud, Kota Kinabalu, Sabah	*Anotrichium tenue,* (1 taxa)
	13.	Pulau Manukan, Kota Kinabalu, Sabah	*Laurencia papillosa, Sargassum grevillei,* (2 taxa)

State	No	Location	Species Composition
	14.	Pulau Sapangar, Kota Kinabalu, Sabah	*Herposiphonia vietnamica, Laurencia papillosa, Laurencia similis, Kappaphycus cottonii* (4 taxa)
	15.	Pulau Sapi, Kota Kinabalu, Sabah	*Ceratodictyon spongiosum, Colpomenia sinuosa, Halimeda opuntia, Halimeda tuna, Hydroclathrus clathratus,* (5 taxa)
	16.	Pulau Sulong, Kota Kinabalu, Sabah	*Caulerpa sertulariodes, Sargassum cinereum, Sargassum duplicatum, Sargassum filipendula, Turbinaria conoides,* (5 taxa)
	17.	Pulau Sulug, Kota Kinabalu, Sabah	*Halymenia dilatata, Laurencia nangii,* (2 taxa)
	18.	Pulau Tetagan, Kota Kinabalu, Sabah	*Sargassum oligocystum, Sargassum polycystum,* (2 taxa)
	19.	Pulau Tiga, Kota Kinabalu, Sabah	*Amphiroa foliacea, Amphiroa fragilissima, Amphiroa tribulus, Caulerpa serrulata, Ceratodictyon spongiosum, Colpomenia sinuosa, Dasya longifila, Gracilaria solicornia, Halimeda opuntia, Halimeda tuna, Hormophysa cuneiformis, Hydroclathrus clathratus, Laurencia nangii, Lobophora variegata, Spatoglossum vietnamense, Tricleocarpa cylindrica, Turbinaria conoides, Ulva fasciata,* (18 taxa)
	20.	Pulau Udar Kecil, Teluk Sepangar, Kota Kinabalu, Sabah	*Laurencia similis, Sargassum microcystum* (2 taxa)
	21.	Tanjung Kaitan, Kota Kinabalu, Sabah	*Amansia rhodantha, Dasya pilosa, Halymenia durvillei, Kappaphycus cottonii, Laurencia majuscula, Sargassum wightii, Zellera tawallina,* (7 taxa)
	22.	Kota Marudu, Sabah	*Kappaphycus alverazii* (1 taxa)
	23.	Kudat, Sabah	*Caulerpa lentilifera, Eucheuma sp., Eucheuma denticulatum (Euchema spinosum), Kappaphycus sp., Kappaphycus alverazii (Eucheuma cottonii, Kappaphycus cottonii)* (5 taxa)

State	No	Location	Species Composition
	24.	Carrington Reef, Kudat, Sabah	*Laurencia majuscula* (1 taxa)
	25.	Kampung Parapat, Kudat, Sabah	*Eucheuma denticulatum (Eucheuma spinosum),* (1 taxa)
	26.	Pantai Bak-Bak, Kudat, Sabah	*Amphiroa fragilissima, Amphiroa tribulus, Caulerpa lentillifera, Caulerpa serrulata, Caulerpa taxifolia, Caulerpa verticillata, Colpomenia sinuosa, Dictyota dichotoma, Gracilaria salicornia, Halimeda discoidea, Halimeda opuntia, Halimeda tuna, Hormophysa cuneiformis, Hypnea spinella, Hydroclathrus clathratus, Lobophora variegata, Padina boryana, Padina gymnospora, Tricleocarpa cylindrica, Spatoglossum vietnamense, Sargassum cinereum, Sargassum duplicatum, Sargassum tenerrimum, Turbinaria conoides, Ulva fasciata,* (25 taxa)
	27.	Pangaraban Beach, Tanjong Kapor, Kudat, Sabah	*Hormophysa cuneiformis, Padina boryana, Padina gymnospora, Sargassum cinereum, Sargassum duplicatum, Sargassum tenerrimum,* (6 taxa)
	28.	Beach East of Sungei Kelangan, Pulau Balambangan, Kudat, Sabah	*Halimeda opuntia, Hydroclathrus clathratus, Padina boryana, Padina gymnospora, Sargassum cinereum, Sargassum duplicatum, Sargassum tenerrimum,* (7 taxa)
	29.	Pulau Balambangan, Kudat, Sabah	*Laurencia majuscula* (1 taxa)
	30.	Pulau Bangi, Teluk Marudu, Kudat, Sabah	*Caulerpa lentilifera, Eucheuma sp., Eucheuma denticulatum (Eucheuma spinosum), Kappaphycus sp., Kappaphycus alverazii (Eucheuma cottonii),* (5 taxa)
	31.	Pulau Bankawan, Kudat, Sabah	*Coelarthrum sp., Herposiphonia vietnamica, Heterosiphonia crispella, Martensia australis, Laurencia majuscula, Halymenia dilatata,* (6 taxa)
	32.	Tanjung Mengayau, Kudat, Sabah	*Acanthophora sp., Gracilaria sp., Hypnea sp., Sargassum sp*. (4 taxa)

State	No	Location	Species Composition
	33.	Telutuh, Kudat, Sabah	*Laurencia majuscula* (1 taxa)
	34.	Kunak, Sabah	*Caulerpa lentilifera, Caulerpa racemosa, Eucheuma sp., Eucheuma denticulatum (Eucheuma spinosum), Gracilaria sp., Kappaphycus sp., Kappaphycus alverazii (Eucheuma cottonii), Kappaphycus malesianus, Kappaphycus striatus, Solieria sp.,* (10 taxa)
	35.	Lahad Datu, Sabah	*Caulerpa lentilifera, Caulerpa racemose, Eucheuma sp., Eucheuma denticulatum (Eucheuma spinosum), Gracilaria sp., Kappaphycus sp., Kappaphycus alverazii (Eucheuma cottonii), Kappaphycus malesianus, Kappaphycus striatus, Solieria sp.,* (10 taxa)
	36.	Balck Rock, Sandakan, Sabah	*Dasya iyengarii,* (1 taxa)
	37.	Pulau Bai, Sandakan, Sabah	*Anotrichium tenue, Gracilaria bailiniae, Grateloupia filicina, Laurencia nangii, Martensia australis, Sargassum myriocystum, Solieria anastomosa, Taenioma perpusillum,* (8 taxa)
	38.	Pulau Gulisan, Sandakan, Sabah	*Halymenia durvillei, Sargassum siliquosum,* (2 taxa)
	39.	Pulau Nunuyan Laut, Sandakan, Sabah	*Halymenia durvillei, Laurencia majuscula, Martensia australis, Sargassum granuliferum, Sargassum laxifolium,* (5 taxa)
	40.	Pulau Selingaan, Sandakan, Sabah	*Neosiphonia savatieri* (1 taxa)
	41.	Pulau Tikus, Sandakan, Sabah	*Laurencia lageniformis, Laurencia majuscula, Martensia australis, Sargassum binderi, Solieria anastomosa,* (5 taxa)
	42.	Tanjung Pendaras, Sandakan, Sabah	*Sargassum ilicifolium* (1 taxa)
	43.	Batu Manikar, Labuan, Sabah	*Heterosiphonia crispella, Hypnea stellulifera, Sargassum siliquosum,* (3 taxa)

State	No	Location	Species Composition
	44.	Pantai Membidai, Pulau Labuan, Sabah	*Anadyomene stellata, Acetabularia crenulata, Colpomenia sinuosa, Dictyota hauckiana, Gracilaria crassa, Gracilaria dura, Hydroclathrus clathratus, Sargassum cinereum, Sargassum filipendula, Sargassum tenerrimum,* (10 taxa)
	45.	Pantai Layang-Layangan, Pulau Labuan, Sabah	*Colpomenia sinuosa, Hydroclathrus clathratus, Sargassum cinereum, Sargassum duplicatum, Sargassum siliquosum, Sargassum tenerrimum,* (6 taxa)
	46.	Lubok Termiang Beach, Pulau Labuan, Sabah	*Acetabularia crenulata, Sargassum cinereum, Sargassum tenerrimum* (3 taxa)
	47.	Pohon Batu Beach, Pulau Labuan, Sabah	*Dictyota dentata, Dictyota hauckiana, Gracilaria crassa, Gracilaria dura, Hormophysa cuneiformis, Hydroclathrus clathratus, Sargassum cinereum, Sargassum tenerrimum, Turbinaria conoides,* (9 taxa)
	48.	Pulau Burung, Labuan, Sabah	*Halymenia dilatata* (1 taxa)
	49.	Pulau Kuraman, Labuan, Sabah	*Anotrichium tenue, Halymenia maculata,* (2 taxa)
	50.	Pulau Layang-Layangan, Labuan, Sabah	*Dasya iyengarii, Dasya longifila, Laurencia nangii, Padina boryana, Sargassum duplicatum* (5 taxa)
	51.	Pulau Papan, Labuan, Sabah	*Anotrichium tenue, Sargassum polycystum,* (1 taxa)
	52.	Pulau Rusukan Besar, Labuan, sabah	*Laurencia majuscula* (1 taxa)
	53.	Pulau Rusukan Kecil, Labuan, Sabah	*Halymenia durvillei* (1 taxa)
	54.	Suanganlada Beach, Pulau Labuan, Sabah	*Hormophysa cuneiformis, Sargassum cinereum, Sargassum duplicatum, Sargassum tenerrimum, Turbinaria conoides,* (5 taxa)

State	No	Location	Species Composition
	55.	Tanjung Aru, Labuan, Sabah	*Dictyota hauckiana, Colpomenia sinuosa, Gracilaria firma, Sargassum cinereum, Sargassum tenerrimum,* (5 taxa)
	56.	Victoria Off-Shore, Pulau Labuan, Sabah	*Colpomenia sinuosa, Dictyota hauckiana, Hydroclathrus clathratus, Hormophysa cuneiformis, Padina gymnospora, Sargassum cinereum, Sargassum tenerrimum* (7 taxa)
	57.	Pulau Talang-Talang Kecil, Semantan, Sabah	*Halymenia maculata,* (1 taxa)
	58.	Semporna, Sabah	*Caulerpa lentilifera, Caulerpa racemosa, Eucheuma sp., Eucheuma denticulatum (Eucheuma spinosum), Gracilaria sp., Gracilaria changii, Gracilaria verrucosa, Hormophysa cuneiformis, Laurencia sp., Kappaphycus sp., Kappaphycus alverazii (Eucheuma cottonii), Kappaphycus alvarezii var. tambalang, Kappaphycus malesianus, Kappaphycus striatus, Padina sp., Padina boryana, Padina gymnospora, Sargassum binderi, Sargassum polycystum, Solieria sp., Turbinaria conoides, Turbinaria ornata,* (22 taxa)
	59.	Lohok Butun, Semporna, Sabah	*Laurencia majuscula* (1 taxa)
	60.	Pulau Bum-Bum, Semporna, Sabah	*Caulerpa lentilifera, Eucheuma denticulatum, Kappaphycus alverazii (Eucheuma cottonii), Laurencia majuscula, Sargassum sp.,* (5 taxa)
	61.	Perusahaan Rumpai Laut Juni Kampung Sinhhamata, Pulau Bum-Bum, Semporna, Sabah	*Sargassum sp.* (1 taxa)
	62.	Pulau Salakan Semporna, Sabah	*Kappaphycus alvarezii* (1 taxa)
	63.	Sebangkat Island, Semporna, Sabah	*Eucheuma denticulatum, Kappaphycus alvarezii, Kappaphycus striatus,* (3 taxa)

State	No	Location	Species Composition
	64.	Pulau Selakan, Semporna, Sabah	*Caulerpa lentilifera, Eucheuma sp., Eucheuma denticulatum, Kappaphycus sp., Kappaphycus alverazii (Eucheuma cottonii). Laurencia majuscula,* (6 taxa)
	65.	Pulau Sipadan, Semporna, Sabah	*Amansia rhodantha*, (1 taxa)
	66.	Singgamata, Semporna, Sabah	*Sargassum sp.* (1 taxa)
	67.	Universiti Malaysia Sabah farms, Semporna, Sabah	*Kappaphycus alvarezii* (1 taxa)
	68.	Mini Estate, Universiti Malaysia Sabah (UMS), Semporna, Sabah.	*Kappaphycus alvarezii, Sargassum polycystum* (2 taxa)
	69.	Tawau, Sabah	*Caulerpa lentilifera, Caulerpa racemosa, Eucheuma sp., Eucheuma denticulatum (Eucheuma spinosum), Gracilaria sp., Kappaphycus sp., Kappaphycus alverazii (Eucheuma cottonii), Kappaphycus malesianus, Kappaphycus striatus, Solieria sp.,* (10 taxa)
	70.	Green leaf Synergy Sdn. Bhd., Tawau, Sabah, Malaysia	*Kappaphycus alvarezii* (1 taxa)
	71.	Tacara Sdn. Bhd., Tawau, Sabah	*Eucheuma cottonii* (1 taxa)
	72.	Malaysian Fishery Development Board, North East Borneo, Sabah	*Kappaphycus alvarezii* (1 taxa)
Sarawak	1.	Sarawak (Type Locality)	Delesseria adnata, *Laurencia papillosa, Melobesia membranacea, Catenella nipae, Hormophysa cuneiformis, Rosenvingea fastigiata, Sphacelaria caespitula*

State	No	Location	Species Composition
	2.	Batu Mandi, Bintulu, Sarawak	*Ahnfeltiopsis sp., Avrainvillea erecta, Avrainvillea obscura, Boodlea composita, Caulerpa sertularioides, Chondrophycus cartilagineus, Dictyopteris sp., Dictyopteris jamaicensis, Dictyota dichotoma, Galaxaura oblongata, Laurencia cartilaginea, Lobophora variegata, Padina australis, Padina boryana, Padina minor, Spatoglossum vietnamense, Halymenia sp., Halymenia dilatata, Halymenia durvillei, Halymenia floresii, Halymenia maculata, Hormophysa cuneiformis, Hydropuntia edulis, Ulva lactuca,* (24 taxa)
	3.	Golden Beach, Bintulu, Sarawak	*Acanthophora spicifera, Acetabularia major, Bryopsis hypnoides, Caulerpa racemosa var. peltata, Chondrophycus papillosus, Dictyota dichotoma, Gracilaria salicornia, Hydropuntia edulis, Hypnea cervicornis, Laurencia sp., Laurencia papillosa, Laurencia similis, Padina australis, Padina minor, Sargassum sp., Ulva intestinalis,* (16 taxa)
	4.	Kuala Nyalau, Bintulu, Sarawak	*Acanthophora spicifera, Bryopsis sp., Chaetomorpha sp., Chaetomorpha antennina, Gelidiella acerosa, Gracilaria salicornia, Hypnea cervicornis, Hypnea spicifera, Laurencia sp., Solieria sp., Ulva intestinalis, Valonia aegagropila,* (12 taxa)
	5.	Kampung Kuala Nyalau, Sarawak	*Acanthophora spicifera, Amphiroa fragilissima, Anadyomene plicata, Dictyota sp., Galaxaura oblongata, Gelidiella acerosa, Gracilaria salicornia, Laurencia papillosa, Leveillea jungermannioides, Lobophora variegata,* (10 taxa)
	6.	Kuala Similajau, Bintulu, Sarawak	*Acanthophora spicifera, Acetabularia major, Amphiroa fragilissima, Anadyomene plicata, Avrainvillea obscura, Bryopsis sp., Bryopsis hypnoides, Caulerpa sertularioides, Caulerpa racemosa var. peltata, Caulerpa peltata, Ceramium sp., Chaetomorpha sp., Chondrophycus papillosus, Cladophora prolifera, Dictyota sp., Dictyota dentata, Dictyota mertensii, Dictyota submaritima, Galaxaura oblongata,*

State	No	Location	Species Composition
			Gelidiella acerosa, Gracilaria salicornia, Hydropuntia edulis, Hypnea spicifera, Laurencia sp., Laurencia papillosa, Lobophora variegata, Padina antillarum, Padina boryana, Padina minor, Padina tetrastromatica, Pterocladia sp., Tricleocarpa fragilis, Laurencia papillosa, Laurencia similis, Sargassum sp., Scinaia furcellata, Ulva intestinalis, Valonia aegagropila (38 taxa)
	7.	Similajau National Park, Bintulu, Sarawak	*Acanthophora spicifera, Acetabularia major, Ahnfeltiopsis sp., Amphiroa fragilissima, Anadyomene plicata, Avrainvillea erecta, Avrainvillea obscura, Boodlea composita, Bostrychia tenella, Bryopsis sp., Bryopsis hypnoides, Caulerpa sertularioides, Caulerpa racemosa var. peltata, Centroceras clavulatum, Chaetomorpha sp., Chaetomorpha antennina, Cladophora sp., Cladophoropsis sp., Dictyopteris sp., Dictyopteris jamaicensis, Dictyota sp., Dictyota dentata, Dictyota dichotoma, Dictyota mertensii, Dictyota submaritima, Galaxaura oblongata, Gelidiella acerosa, Gracilaria salicornia, Halymenia sp., Halymenia dilatata, Halymenia durvillei, Halymenia floresii, Halymenia maculata, Hormophysa cuneiformis, Hydropuntia edulis, Hypnea cervicormis, Hypnea spicifera, Laurencia sp., Laurencia cartilaginea, Laurencia papillosa, Laurencia similis, Lobophora variegata, Pterocladia parva, Padina australis, Padina boryana, Padina minor, Padina tetrastromatica, Sargassum sp., Scinaia furcellata, Solieria sp., Spatoglossum vietnamense, Tolypiocladia glomerulata, Ulva intestinalis, Ulva lactuca, Valonia aegagropila,* (55 taxa)
	8.	Pantai Similajau, Bintulu, Sarawak	*Gracilaria arcuata, Gracilaria salicornia,* (2 taxa)
	9.	Pantai Tanjung Batu, Bintulu, Sarawak	*Acanthophora spicifera, Amphiroa fragilissima, Centroceras clavulatum, Chaetomorpha sp., Chondrophycus papillosus, Cladophora sp., Cladophoropsis sp., Gracilaria salicornia, Hydropuntia edulis, Hypnea cervicornis, Hypnea spicifera, Laurencia sp.,*

State	No	Location	Species Composition
			Laurencia papillosa, Laurencia similis, Padina australis, Padina minor, Sargassum sp., Tolypiocladia glomerulata, Ulva clathrata, Ulva intestinalis, (20 taxa)
	10.	Pantai Telekom, Bintulu, Sarawak	*Acanthophora spicifera, Acetabularia major, Anadyomene plicata, Bostrychia tenella, Bryopsis hypnoides, Centroceras clavulatum, Chaetomorpha sp., Chaetomorpha antennina, Chondrophycus papillosus, Cladophora prolifera, Cladophoropsis sp., Dictyota sp., Gracilaria salicornia, Hydropuntia edulis, Hypnea cervicornis, Hypnea spicifera, Laurencia sp., Laurencia similis, Laurencia papillosa, Padina australis, Padina minor, Padina tetrastromatica, Sargassum sp., Ulva intestinalis, Valonia aegagropila,* (25 taxa)
	11.	Asajaya, Kuching, Sarawak	*Enteromorpha sp., Gracilaria blodgettii, Gracilaria changii, Gracilaria coronopifolia, Laurencia sp.,* (5 taxa)
	12.	Muara Mengkuang, Kuching, Sarawak	*Gracilaria blodgetti* (1 taxa)
	13.	Pulau Salak, Kuching, Sarawak	*Gracilaria changii, Gracilaria coronopifolia* (2 taxa)
	14.	Pulau Satang Besar, Kuching, Sarawak	*Halymenia maculata, Laurencia majuscula,* (2 taxa)
	15.	Pulau Sampadi, Kuching, Sarawak	*Laurencia majuscula* (1 taxa)
	16.	Pulau Satang, Kuching, Sarawak	*Acanthophora spicifera, Acanthophora muscoides* (2 taxa)
	17.	Pulau Satang, Talang-Satang National Park, Kuching, Sarawak	*Acanthophora spicifera, Avrainvillea sp., Caulerpa serrulata, Halimeda sp., Halimeda discoidea, Halimeda macroloba, Halimeda opuntia, Halimeda tuna, Padina tetrastomatica, Udotea flabellum, Udotea javensis,* (11 taxa)

State	No	Location	Species Composition
	18.	Pulau Satang Besar, Kuching, Sarawak	*Acanthopora muscoides, Acanthopora spicifera, Amphiroa fragillisima, Avrainvillea erecta, Caulerpa serrulata, Cladophoropsis membranaceae, Colpomenia sinuosa, Dictyota bartayresii, Dictyota dichotoma, Halimeda discoidea, Halimeda macroloba, Halimeda opuntia, Halimeda tuna, Laurencia majuscula, Padina boryana, Padina tetrasomatica, Sargassum polycystum,* (17 taxa)
	19.	Tanjung Sipang, Kuching, Sarawak	*Caulacanthus ustulatus, Laurencia lageniformis,* (2 taxa)
	20.	Awat-Awat Village, Lawas, Sarawak	*Gracilaria arcuata* (1 taxa)
	21.	Lawas mangrove forests, Miri, Sarawak	*Caloglossa sp., Catenella sp., Enteromorpha spp., Rhizoclonium sp.,* (4 taxa)
	22.	Stream near Gunung Pueh, Lundu, Sarawak	*Delesseria beccarii* (1 taxa)
	23.	Tanjung Datu, Lundu, Sarawak	*Acanthophora spicifera, Anadyomene plicata, Boodlea composita, Cladophora forsskali, Dictyota beccariana, Dictyota dichotoma, Dictyota maxima, Dictyopteris woodwardia, Gracilaria edulis, Hydroclathrus clathratus, Laurencia flexillis, Laurencia lageniformis, Laurencia pannosa, Padina boryana, Sargassum acutifolium, Sargassum angustifolium,* (16 taxa)

24.	Mangrove area of Santubong, Sarawak	*Gracilaria changii* (1 taxa)
25.	Santubong, Sarawak	*Gracilaria blodgettii, Gracilaria changii, Gracilaria coronopifolia.* (3 taxa)
26.	Pulau Gador, Semantan, Sarawak	*Heterosiphonia crispella* (1 taxa)
27.	Pulau Talang-Talang Besar, Sarawak	*Dasya iyengarii, Heterosiphonia crispella* (2 taxa)

4.5.3 Seagrass species composition and distribution in Malaysia found in this desktop study

This study recorded seventeen (17) taxa of seagrass from three (3) families. Figure 17 shows the number of seagrass habitats and the number of publications recorded at those locations from 1993 to 2021. Different habitats of seagrass have been recorded in the Johor area, and it was the highest (37.2%), followed by Sabah (24.4%), Terengganu (19.2%), Sarawak (9.0%), Negeri Sembilan (2.6%), Pulau Pinang (2.6%), Kedah (1.3%), Melaka (1.3%), Pahang (1.3%) and Kelantan (1.3%). No data on seagrass were recorded for Perlis, Perak, and Selangor. Johor has the highest number of seagrass habitats investigated due to the increased interest in research related to dugong conservation issues that occurred in the Johor coastal area.

Table 4 summarizes the seagrass species composition and distribution reported in the coastal area of Malaysia from 1993 to 2021. Many of these seagrasses are found in the estuarine and intertidal areas, especially in the southern part of Peninsular Malaysia. However, we had difficulties finding information on the total coverage area of seagrass from all the articles that we had read. From this study, we found that Tanjung Andang shoal, Johor and Teluk Sepinong, Sandakan, Sabah, have the highest diversity of seagrass recorded in Malaysia comprising *Enhalus acoroides, Cymodocea rotundata, Cymodocea serrulata, Halodule pinifolia, Halodule uninervis, Halophila beccarii, Halophila decipiens, Halophila major, Halophila minor, Halophila ovalis, Halophila ovata, Halophila spinulosa, Syringodium isoetifolium, Ruppia maritima, Thalassia hemprichii, Thalassodendron ciliatum* (16 taxa). Out of 17 taxa recorded, *Zostera japonica* only can be found in Merambong shoal, Sungai Pulai, Johor. Table 5 shows the status of seagrass that has been found in Malaysian waters based on the IUCN Redlist. Figure 18 shows selected dominant seagrass usually found in Malaysian marine waters, and Figure 19 displays the maps of seagrass distribution in Peninsular Malaysia, Sabah, and Sarawak.

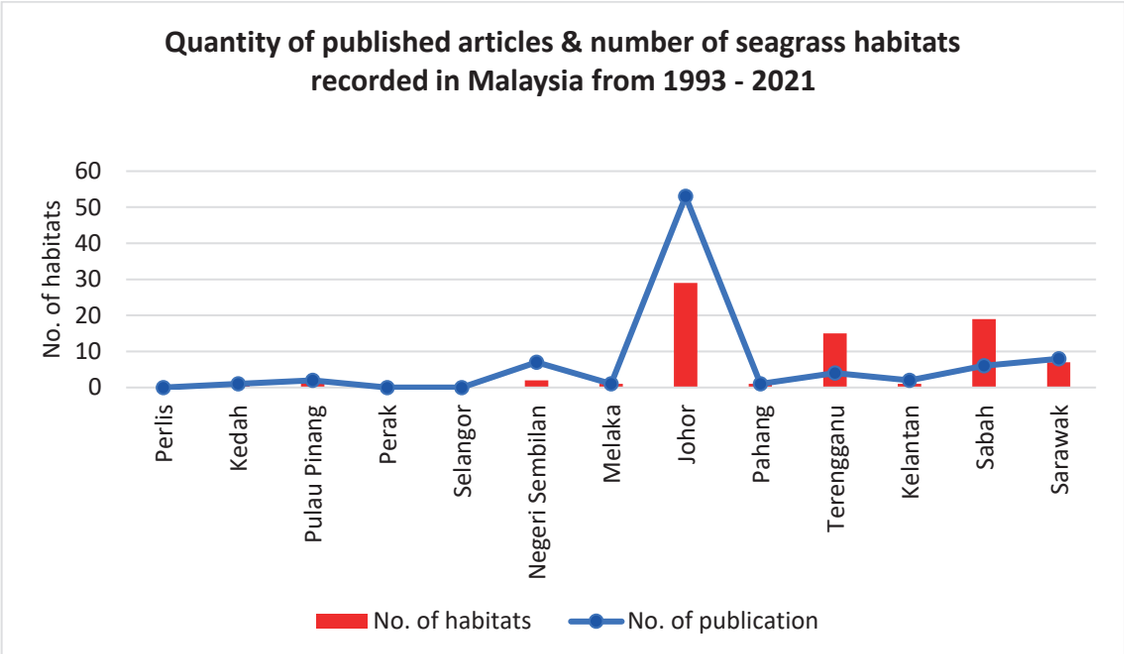


Figure 17: The number of published articles and seagrass habitats recorded in Malaysia from 1993 to 2021.

Table 5 : The status of seagrass that have been found in Malaysian waters based on the IUCN Redlist

Category	Seagrass Taxa	Status
Least Concern	*Cymodocea rotundata*	Stable
Least Concern	*Cymodocea serrulata*	Stable
Least Concern	*Halodule pinifolia*	Decreasing
Least Concern	*Halodule uninervis*	Stable
Least Concern	*Syringodium isoetifolium*	Stable
Least Concern	*Enhalus acoroides*	Decreasing
Least Concern	*Halophila beccarii*	Decreasing
Least Concern	*Halophila decipiens*	Stable
Least Concern	*Halophila minor*	Unknown
Least Concern	*Halophila ovalis*	Stable
Least Concern	*Halophila ovata*	Stable
Least Concern	*Halophila spinulosa*	Stable
Least Concern	*Ruppia maritima*	Stable
Least Concern	*Thalassia hemprichii*	Stable

a.

b.

c.

d.

a. *Enhalus* acoroides .
b.. *Halophila ovalis*

c.. *Halophila beccarii*
d..*Halophila spinulosa*

Figure 18: The dominant seagrass is usually found in Malaysian waters.

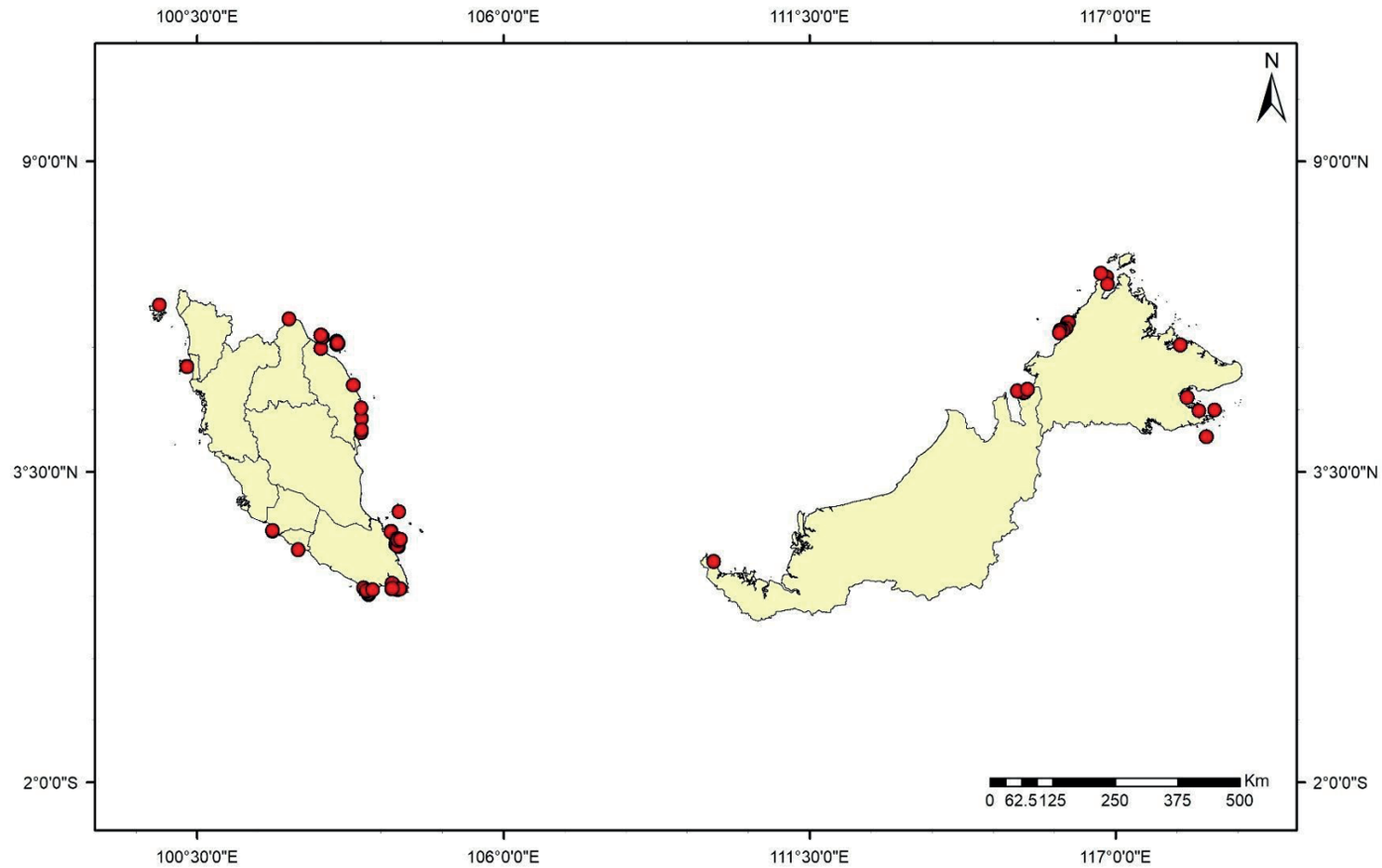


Figure 19: The map of seagrass distribution in Malaysia.

Table 4: Summary of seagrass species compositions at their habitats reported in Malaysian marine waters recorded from 1993- 2021

State	No	Location	Species Composition
Perlis		No data obtained	No data obtained
Kedah	1.	Tanjung Rhu, Langkawi, Kedah	*Halophila decipiens, Halophila major, Halophila minor, Halophila ovalis* (4 taxa)
Pulau Pinang	1.	Middle bank, Penang	*Halophila beccarii, Halophila decipiens, Halophila major, Halophila minor, Halophila ovalis* (5 taxa)
	2.	Pulau Gazumbo, Penang	*Halophila ovalis*
Perak		No data obtained	No data obtained
Selangor		No data obtained	No data obtained
Kuala Lumpur		No data obtained	No data obtained
Negeri Sembilan	1.	Teluk Kemang, Port Dickson, Negeri Sembilan	*Enhalus acoroides, Cymodocea rotundata, Cymodocea serrulata, Halodule pinifolia, Halodule uninervis, Halophila decipiens, Halophila major, Halophila minor, Halophila ovalis, Syringodium isoetifolium, Thalassia hemprichii,* (11 taxa)
	2.	Batu Tujuh, Port Dickson, Negeri Sembilan	*Cymodocea serrulata* (1 taxa)
Melaka	1.	Pulau Serimbun, Melaka	*Halophila decipiens, Halophila major, Halophila minor, Halophila ovalis* (4 taxa)
Johor	1.	Kong-Kong, Johor	*Enhalus acoroides, Halophila ovalis* (1 taxa)
	2.	Kampung Pasir Gogok, Johor	*Enhalus acoroides, Halophila ovalis, Halophila spinulosa* (3 taxa)
	3.	Kuala Sungai Santi, Johor	*Enhalus acoroides, Halophila ovalis* (2 taxa)

State	No	Location	Species Composition
	4.	Merambong shoal, Sungai Pulai, Johor	*Enhalus acaroides, Cymodocea rotundata, Cymodocea serrulata, Halodule pinifolia, Halodule uninervis, Halophila minor, Halophila ovalis, Halophila spinulosa, Syringodium isoetifolium, Thalassia hemprichii, Zostera japonica (11 taxa)*
	5.	Perigi Acheh (guard post), Johor	*Enhalus acoroides, Halophila ovalis,* (1 taxa)
	6.	Tanjung Andang shoal, Johor	*Enhalus acoroides, Cymodocea rotundata, Cymodocea serrulata, Halodule pinifolia, Halodule uninervis, Halophila beccarii, Halophila decipiens, Halophila major, Halophila minor, Halophila ovalis, Halophila ovata, Halophila spinulosa, Syringodium isoetifolium, Ruppia maritima, Thalassia hemprichii, Thalassodendron ciliatum (16 taxa)*
	7.	Tanjung Batu, Desaru Johor	*Enhalus acoroides, Cymodocea serrulata, Cymodocea rotundata, Halodule uninervis* (4 taxa)
	8.	Tanjung Kopok, Johor	*Halophila ovalis, Halophila spinulosa,* (1 taxa)
	9.	Tanjung Surat, Johor	*Halophila ovalis* (1 taxa)
	10.	Pulau Babi Besar, Sultan Iskandar Marine Parks, Johor and Tinggi islands	*Cymodocea serrulata, Halodule uninervis, Halophila ovalis, Syringodium isoetifolium.* (4 taxa)
	11.	Pulau Besar, Johor	*Cymodocea rotundata, Halodule uninervis, Halophila ovalis, Halophila spinulosa, Syringodium isoetifolium* (5 taxa)
	12.	Pulau Sibu, Johor	*Enhalus acoroides, Cymodocea rotundata, Cymodocea serrulata, Halodule pinifolia, Halodule uninervis, Halophila decipiens, Halophila major, Halophila minor, Halophila ovalis, Syringodium isoetifolium* (10 taxa)

State	No	Location	Species Composition
	13.	Pulau Sibu Hujung, Johor	*Cymodocea serrulata, Halodule uninervis, Halophila ovalis,* (3 taxa)
	14.	Pulau Sibu Tengah, Pulau Sibu, Johor	*Cymodocea rotundata, Cymodocea serrulata, Halodule uninervis, Halophila ovalis, Syringodium isoetifolium* (5 taxa)
	15.	Pulau Tinggi, Johor	*Cymodocea rotundata, Cymodocea serrulata, Halodule pinifolia, Halodule uninervis, Halophila decipiens, Halophila major, Halophila minor, Halophila ovalis, Halophila spinulosa, Syringodium isoetifolium, Thalassia hemprichii* (11 taxa)
	16.	Kampung Kota, Pulau Tinggi, Johor	*Cymodocea rotundata, Halodule uninervis, Halophila ovalis,* (3 taxa)
	17.	Kampung Pasir Panjang, Pulau Tinggi, Johor	*Cymodocea serrulata, Halophila ovalis, Halodule uninervis, Halophila decipiens, Syringodium isoetifolium* (5 taxa)
	18.	Kampung Sebirah Besar, Pulau Tinggi, Johor	*Cymodocea rotundata, Halodule uninervis* (2 taxa)
	19.	Kampung Sebirah Kecil, Pulau Tinggi, Johor	*Cymodocea rotundata, Cymodocea serrulata, Halodule pinifolia, Halodule uninervis, Halophila decipiens, Halophila ovalis, Halophila spinulosa, Syringodium isoetifolium* (8 taxa)
	20.	Kampung Tanjung Balang, Pulau Tinggi, Johor	*Enhalus acoroides, Cymodocea rotundata, Cymodocea serrulata, Halodule pinifolia, Halodule uninervis, Syringodium isoetifolium* (6 taxa)
	21.	Marine Park Jetty, Pulau Tinggi, Johor	*Cymodocea rotundata, Halodule uninervis* (2 taxa)
	22.	Pulau Ibol, Pulau Tinggi, Johor	*Halophila decipiens, Halophila ovalis* (2 taxa)
	23.	Tanjung Mali, Pulau Tinggi, Johor	*Halophila ovalis, Halophila spinulosa* (2 taxa)
	24.	Teluk Pinang, Pulau Tinggi, Johor	*Halophila decipiens, Halophila minor, Halophila ovalis* (3 taxa)

State	No	Location	Species Composition
	25.	Teluk Tigi, Pulau Tinggi, Johor	*Halodule uninervis, Halophila ovalis,* (2 taxa)
	26.	Sungai Pulai estuaries, Johor	*Cymodocea rotundata, Cymodocea serrulata, Enhalus acoroides, Halodule pinifolia, Halodule uninervis, Halophila beccarii, Halophila decipiens, Halophila major, Halophila minor, Halophila ovalis, Halophila spinulosa, Ruppia maritima, Syringodium isoetifolium, Thalassia hemprichii, Thalassodendron ciliatum* (15 taxa)
	27.	Sungai Duku, Sungai Pulai estuaries, Johor	*Enhalus acoroides, Halophila ovalis, Halophila spinulosa, Syringodium isoetifolium* (4 taxa)
	28.	Seluyong shoal, Sungai Pulai, Johor	*Halodule uninervis, Halophila ovalis* (big-leaved)*, Halophila ovalis* (small-leaved), *Halophila spinulosa.* (3 taxa)
	29.	Sungai Bahan, Johor	*Halophila decipiens, Halophila ovalis, Halophila spinulosa, Enhalus acoroides* (4 taxa)
Pahang	1.	Pulau Tioman, Pahang	*Halophila decipiens, Halophila major, Halophila minor, Halophila ovalis,* (4 taxa)
Terengganu	1.	Merchant, Terengganu	*Halophila minor, Halophila ovalis, Halodule pinifolia* (3 taxa)
	2.	Gong Batu, Setiu, Terengganu	*Halodule pinifolia, Halophila ovalis* (2 taxa)
	3.	Kemaman, Terengganu	*Halophila beccarii* (1 taxa)
	4.	Kemasik, Terengganu,	*Halodule pinifolia* (1 taxa)
	5.	Paka, Terengganu	*Halophila beccarii, Halodule pinifolia* (2 taxa)
	6.	Telaga Simpul, Terengganu	*Halophila beccarii, Halodule pinifolia* (2 taxa)

State	No	Location	Species Composition
	7.	Pulau Redang, Terengganu	*Halophila decipiens, Halophila minor, Halodule pinifolia* (3 taxa)
	8.	Chagar Hutang, Pulau Redang, Terengganu	*Halophila decipiens* (1 taxa)
	9.	Pasir Panjang, Pulau Redang, Terengganu	*Halodule pinifolia,* (1 taxa)
	10.	Sungai Redang estuary, Pulau Redang, Terengganu	*Halophila decipiens, Halophila minor* (2 taxa)
	11.	Teluk Dalam, Pulau Redang, Terengganu	*Halodule pinifolia,* (1 taxa)
	12.	Pulau Perhentian, Terengganu	*Enhalus acoroides, Halodule pinifolia, Halophila decipiens, Halophila minor, Halophila ovalis* (5 taxa)
	13.	Channel in front of Coco Hut, Pulau Perhentian, Terengganu	*Halophila minor* (1 taxa)
	14.	Channel in front of Department of Fisheries, Pulau Perhentian, Terengganu	*Halodule pinifolia; Halophila decipiens; Halophila minor; Halophila ovalis* (4 taxa)
	15.	Tanjung Batu Lepir, Pulau Perhentian Besar, Terengganu	*Enhalus acoroides;* (1 taxa)
	16.	Kg. Tanjung Aur (Rajawali), Pulau Perhentian Kecil, Terengganu	*Halophila minor.* (1 taxa)
Kelantan	1.	Pengkalan Nangka, Kelantan	*Halodule pinifolia, Halophila beccarii,* (2 taxa)
Sabah	1.	Bak-bak, Tun Mustapha Marine Park, Sabah	*Enhalus acoroides, Cymodocea rotundata, Cymodocea serrulata, Halodule uninervis, Halodule pinifolia, Halophila ovalis, Synngodium isoetifolium, Thalassia hempnchii* (8 taxa)

State	No	Location	Species Composition
	2.	Limau-limauan, Tun Mustapha Marine Park, Sabah	*Enhalus acoroides, Cymodocea rotundata, Halodule uninervis, Halophila ovalis, Halophila pinifolia, Thalassia hemprichii* (6 taxa)
	3.	Sepang Bay, Sabah	*Enhalus acoroides, Cymodocea rotundata, Cymodocea serrulata, Halodule pinifolia, Halodule uninervis, Halophila minor, Halophila ovalis, Thalassia hempnchii* (8 taxa)
	4.	Sungai Salut, Sabah	*Enhalus acoroides, Cymodocea rotundata, Cymodocea serrulata, Halodule pinifolia, Halodule uninervis, Halophila ovalis, Thalassia hempnchii* (7 taxa)
	5.	Sungai Mengkabong, Sabah	*Enhalus acoroides, Halophila ovalis, Thalassia hempnchii* (2 taxa)
	6.	Tanjung Mengayau, Sabah	*Enhalus acoroides, Cymodocea rotundata, Cymodocea serrulata, Halodule uninervis Halophila ovalis, Thalassia hempnchii* (6 taxa)
	7.	Teluk Sepinong, Sandakan, Sabah	*Enhalus acoroides, Cymodocea rotundata, Cymodocea serrulata, Halodule pinifolia, Halodule uninervis, Halophila beccarii, Halophila decipiens, Halophila major, Halophila minor, Halophila ovalis, Halophila ovata, Ruppia maritima, Syringodium isoetifolium , Thalassia hemprichii, Thalassodendron ciliatum* (16 taxa)
	8.	Universiti Malaysia Sabah-Outdoor Development Center (UMS-ODEC) Beach, Kota Kinabalu, Sabah	*Enhalus acoroides, Cymodocea rotundata, Halodule uninervis, Halophila ovalis, Thalassia hemprichii.* (5 taxa)
	9.	Pulau Bohay Dulang, Sabah	*Enhalus acoroides, Halophila ovalis, Thalassia hempnchii* (3 taxa)
		Pulau Gaya, Sabah	*Enhalus acoroides, Cymodocea rotundata, Cymodocea serrulata, Halodule pinifolia, Halodule uninervis, Halophila decipiens, Halophila minor, Halophila ovalis, Halophila spinulosa, Thalassia hempnchii.* (10 taxa)

State	No	Location	Species Composition
	10.	Gaya Bay, Gaya Island, Sabah	*Enhalus acoroides, Cymodocea rotundata, Cymodocea serrulata, Halodule uninervis, Halophila ovalis* (5 taxa)
	11.	Kuari Bay, Pulau Gaya, Sabah	*Halodule uninervis, Cymodocea rotundata, Cymodocea serrulata* (3 taxa)
	12.	Marine Ecological Research Centre (MERC), Gaya Island, Sabah	*Enhalus acoroides, Cymodocea rotundata, Cymodocea serrulata, Halodule uninervis, Halophila ovalis* (5 taxa)
	13.	Police beach, Pulau Gaya, Sabah	*Halodule uninervis, Cymodocea rotundata, Cymodocea serrulata, Halophila ovalis, Thalassia hemprichii,* (5 taxa)
	14.	Pulau Maganting, Sabah	*Halodule uninervis, Halophila minor, Halophila ovalis, Thalassia hempnchii,* (4 taxa)
	15.	Pulau Sapi, Sabah	*Thalassia hemprichii* (1 taxa)
	16.	Pulau Selingan, Sabah	*Halodule pinifolia, Halophila decipiens, Halophila minor, Halophila ovalis* (4 taxa)
	17.	Pulau Sipadan, Sabah	*Cymodocea rotundata, Halodule pinifolia, Halophila ovalis, Thalassia hempnchii* (4 taxa)
	18.	Pulau Sulug, Sabah	*Halophila decipiens* (1 taxa)
	19.	Pulau Taiwan, Sabah	*Cymodocea rotundata, Halodule uninervis, Halophila minor, Halophila ovalis* (4 taxa)

State	No	Location	Species Composition
Sarawak	1.	Punang Sari, Sarawak	*Enhalus acoroides, Cymodocea rotundata, Halodule pinifolia, Halodule uninervis, Halophila beccarii, Halophila decipiens, Halophila minor, Halophila ovalis, Thalassia hemprichii* (9 taxa)
	2.	Pantai Sari, Sarawak	*Halophila beccarii* (1 taxa)
	3.	Lawas, Sarawak	*Enhalus acoroides, Cymodocea rotundata, Halodule pinifolia, Halodule uninervis, Halophila beccarii, Halophila minor, Halophila ovalis, Thalassia hemprichii* (8 taxa)
	4.	Sungai Bangkulit, Lawas, Sarawak	*Enhalus acoroides, Cymodocea rotundata, Halodule pinifolia, Halodule uninervis, Halophila beccarii, Halophila minor, Halophila ovalis, Thalassia hemprichii* (8 taxa)
	5.	Awat-awat, Lawas, Sarawak	*Enhalus acoroides, Cymodocea rotundata, Halodule pinifolia, Halodule uninervis, Halophila beccarii, Halophila minor, Halophila ovalis, Thalassia hemprichii* (8 taxa)
	6.	Sungai Bintulu, Sarawak	*Halophila beccarii* (1 taxa)
	7.	Pulau Talang- Talang, Semantan, Sarawak	*Halophila decipiens* (1 taxa)

4.5.4 Mangrove species composition and distribution in Malaysia found in this desktop study

(i) Mangrove distribution in Malaysia

In Malaysia, Sabah holds the largest area of mangroves as represented by 62% followed by Sarawak (22%) and Peninsular Malaysia (18%) (Table 6). In Peninsular Malaysia, the largest extent of mangrove area was recorded in Perak with 44,990 ha, Selangor 20,853 ha and Johor 26,818 ha (Table 7). However, the mangrove area is dramatically declining over 17 years (as in 2017). Sarawak has shown the most reduced mangrove area with 38%, followed by Sabah 35% and Peninsular Malaysia 27%.

Table 6: Malaysia's mangrove forest coverage (Omar & Misman, 2020)

Region	Mangroves 1990 (ha)	Mangroves 2000 (ha)	Mangroves 2017 (ha)
Peninsular Malaysia	116,746	114,353	110,953
Sabah	385,630	382,448	378,195
Sarawak	147,936	145,263	139,890
Total	650,311	642,063	629,038

Table 7: Extents of mangroves in Malaysia for 2017 (Omar & Misman, 2020)

Region	Mangroves Area (ha)
Perlis	49
Kedah	7,725
Penang	1,967
Perak	44,990
Selangor	20,853
Negeri Sembilan	1,557
Melaka	1,241
Johor	26,818
Pahang	3,759
Terengganu	1,571
Kelantan	422

(ii) Location according to state for mangrove research conducted

Research on Malaysian mangroves was widely conducted throughout the Malaysian country. This includes various topics of research and aims at different purposes. However, most of the studies were found on the west coast of Peninsular Malaysia (52%) than on the East coast of Peninsular Malaysia (36%). Sabah and Sarawak recorded a minor study with 12% of the total studies (Figure 20). Selangor represents the highest study on the west coast of Peninsular Malaysia, with 27 studies conducted, followed by Perak (24) and Kedah (11). On the east coast of Peninsular Malaysia, Terengganu was the most studied, with 23 studies, followed by Johor (11) and Kelantan (10) (Figure 21).

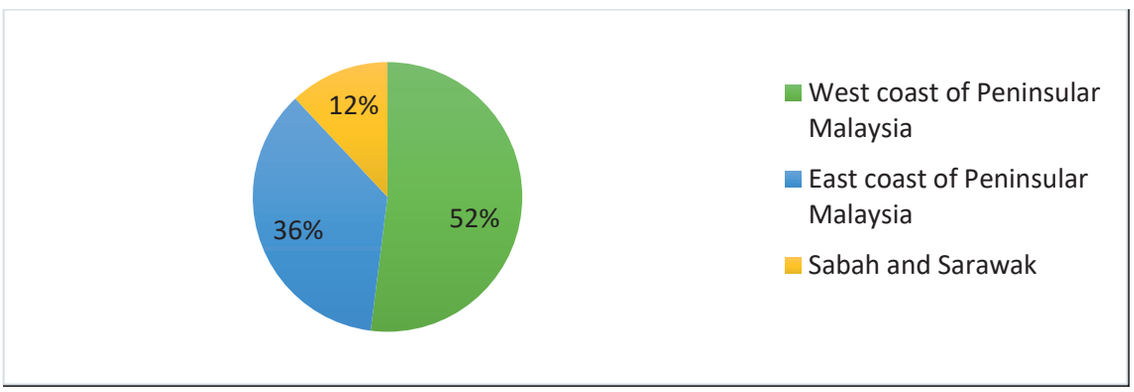


Figure 20: Mangrove research location across the Malaysian State

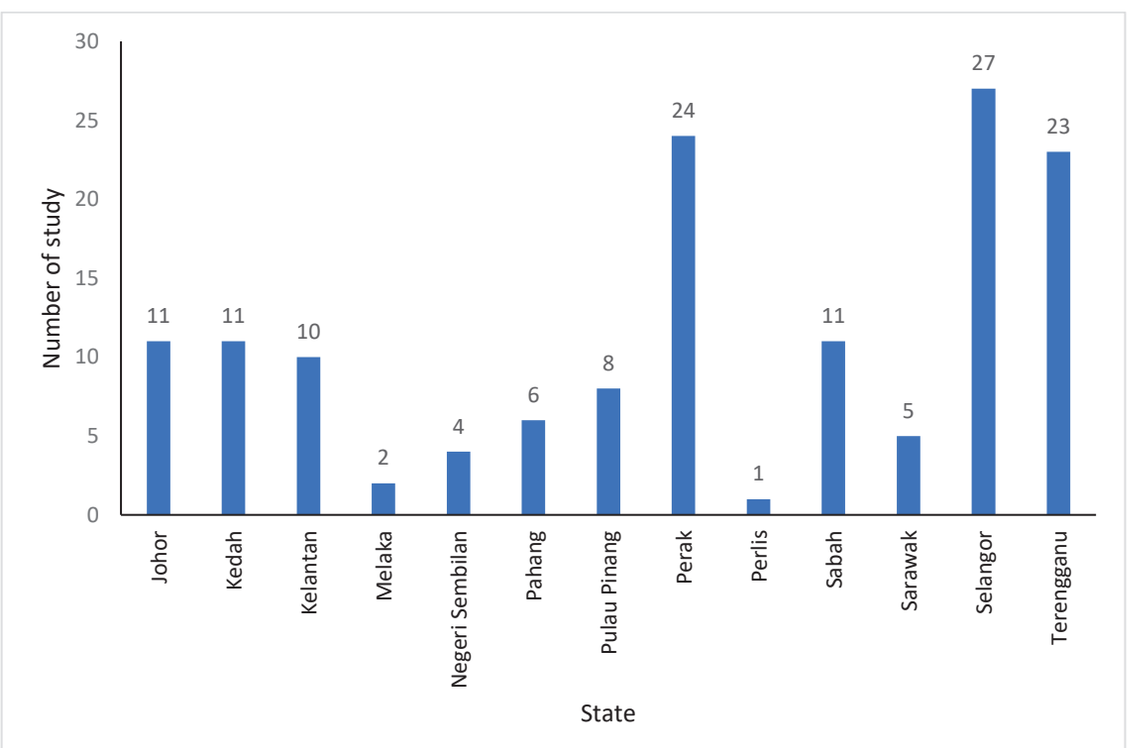


Figure 21: Location of mangrove study in the Malaysian state

(iii) Location of mangrove collected

In this study, we have found that most of the study reports were reported from West Coast of Peninsular Malaysia rather than the east coast of Peninsular Malaysia. Sabah and Sarawak represented the minor study reported (Figure 22).

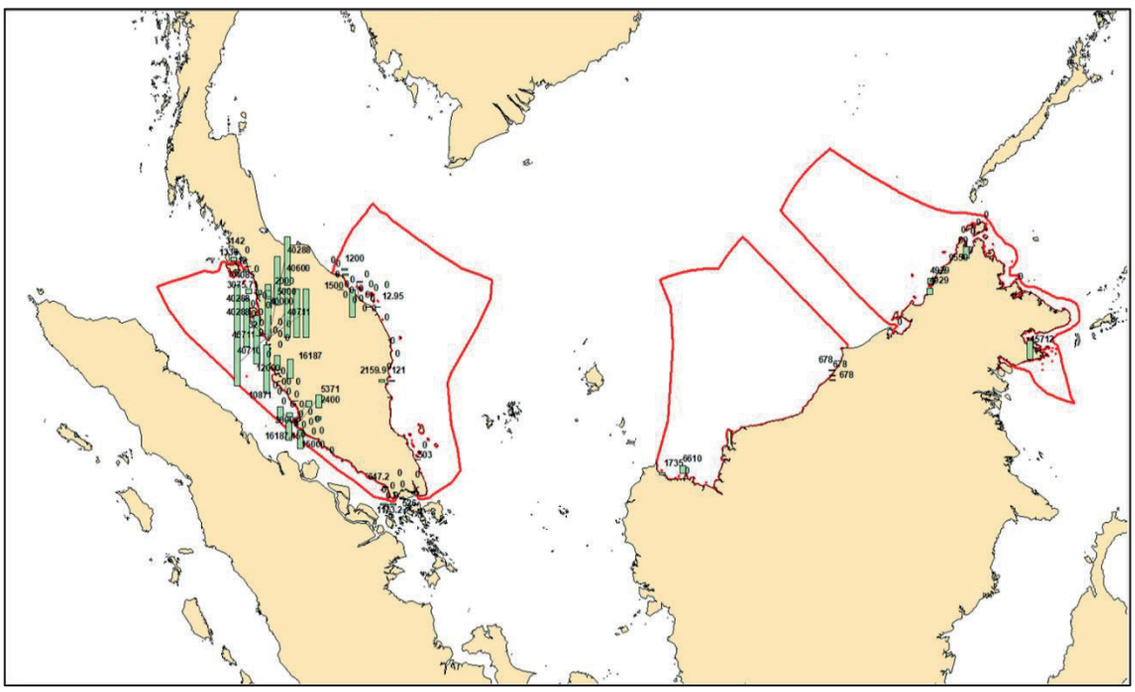


Figure 22: Distribution of mangrove study in Malaysia

(iv) Types of mangrove forest habitats

In Malaysia, mangroves are primarily found in estuaries or the lower stream. The early classification of mangrove forest type in Malaysia was referred to by Watson (1928) as the classification based on the inundation class. However, from this study new category for mangrove forest type has been established and used to describe mangrove forest settings in Malaysian mangroves (Figure 23, Figure 24 & Table 8). The latest classification is according to the geomorphological setting where mangroves can be classified as follows:

i. Lagoon : mangrove that is located in semi-enclosed water body that is separated from the sea by a barrier i.e sand bar

ii. Coastal : mangroves that is located along the coastline fronting directly to the sea

iii. Estuarine : mangrove that is located at the river mouth where the tides meet the river

iv. Riverine : mangrove that is located along the riverbank restricted to the brackish water

v. Delta : mangrove that is located at a mouth of a river that contain large amount of sediment deposit

vi. Island : mangroves that is located at the island that comprise of sandy beaches and rocky shores

From this study, most of the mangrove was carried out in riverine, represented by 25%, followed by delta and lagoon, setting 18.6% of each. Meanwhile, island, coastal and estuarine were recorded for 16%, 13%, and 8%, respectively. The list of mangrove forest-type settings is shown in Table 8.

(v) List of Mangrove species inventory

In this study, we managed to document 199 mangrove species' belongings to 58 families. From the list, 40 species are the exclusive mangrove species, 150 non-exclusive mangrove species, four associate and five hybrid mangrove species were recorded according to the location of each state (Table 9). The dominant mangrove species found during this study is referred to in Figure 25.

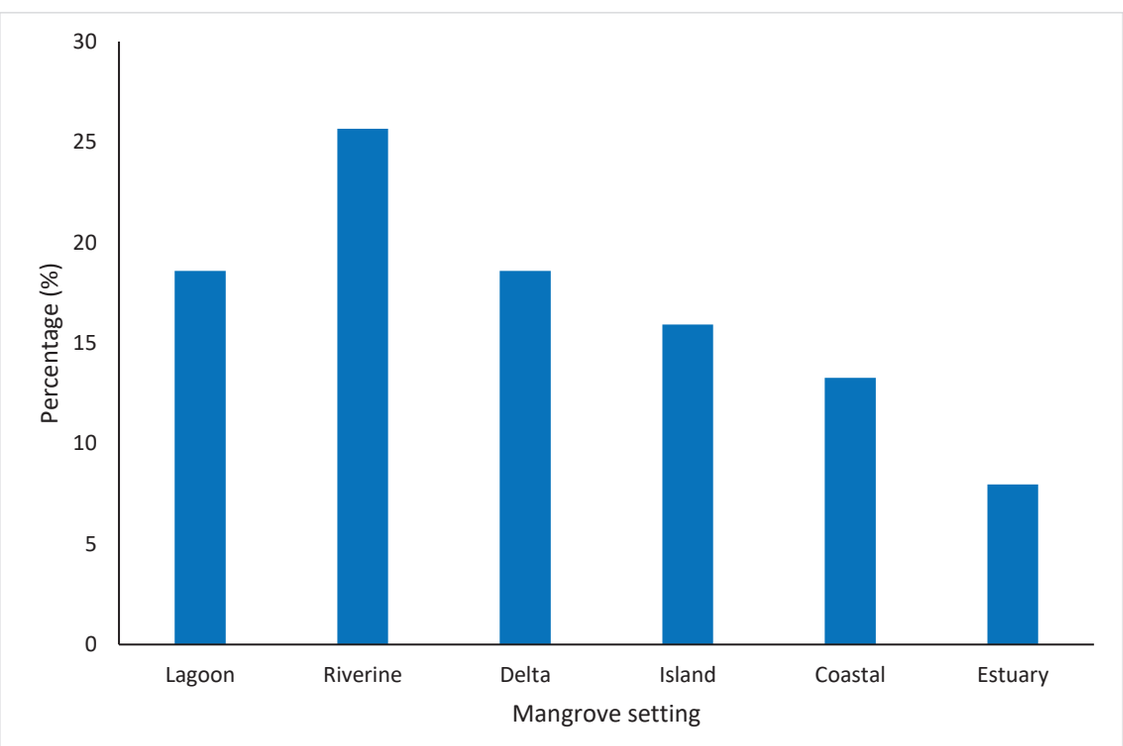


Figure 23: Mangrove study according to the mangrove forest habitat

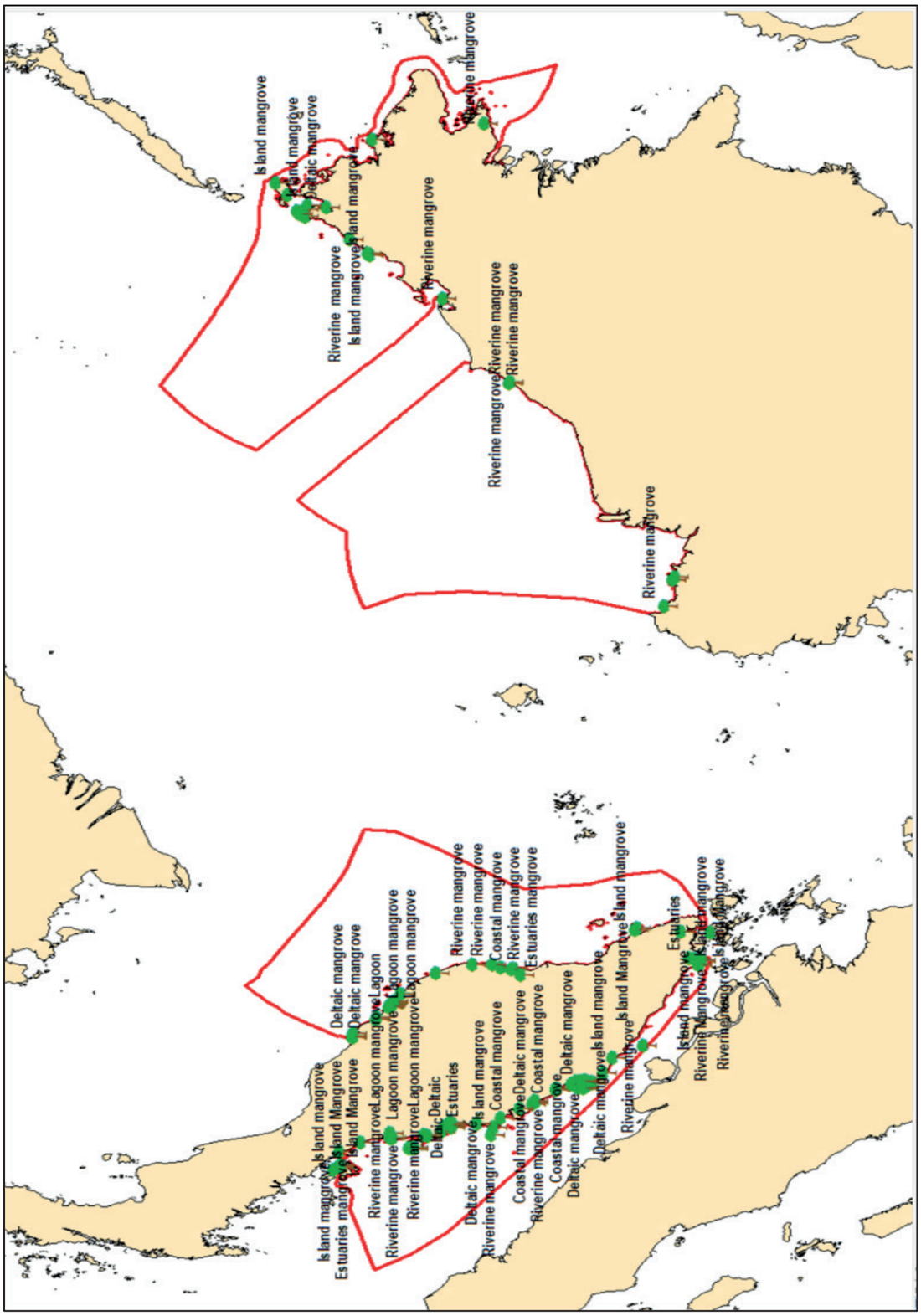


Figure 24: Mangrove forest-type setting in a Malaysian mangrove

Table 8: Mangrove forest habitat in Malaysian mangrove

Lagoon	Riverine	Delta	Island	Coastal	Estuary
• Merchang Lagoon, Terengganu	• Merbok, Kedah	• Kuala Sepetang, Perak	• Kilim Geoforest, Kedah	• Kampung Tanjung Kepah, Lekir, Perak	• Matang Mangrove Forest, Perak
• Pulau Besar, Merang, Terengganu	• Sg Merbok, Kedah	• Matang Mangrove Forest, Perak	• Kisap, Kedah	• Kuala Selangor Nature Park, Selangor	• Klang, Selangor
• Pulau kecil, Merang, Terengganu	• Kuala Sepetang, Perak	• Pulau Carey, Selangor	• Pulau Langkawi, Kedah	• Pantai Kelanang, Morib, Selangor	• Kuala Ibai, Terengganu
• Pulau Besar, Setiu Lagoon, Terengganu	• Matang Mangrove Forest Reserve (MMFR), Perak	• Pulau Che Mat Zain, Selangor	• Pulau Pangkor, Perak	• Sungai Haji Dorani, Selangor	• Setiu Lagoon, Terengganu
• Pulau Busung, Setiu Lagoon, Terengganu	• Kuala Selangor	• Pulau Indah, Klang, Selangor	• Carey Island, Selangor	• Tanjung Piai, Johor	• Setiu Wetlands, Terengganu
• Pulau Che Hamid, Setiu Lagoon, Terengganu	• Kuala Selangor Nature Park, Selangor	• Pulau Ketam, Selangor	• Telok Gong, Pulau Klang, Selangor	• Kudat, Sabah	• Delta Tumpat, Kelantan
• Pulau Che Him, Setiu Lagoon, Terengganu	• Rembau-Linggi Estuary, Negeri Sembilan	• Pulau Klang, Selangor	• Pulau Ketam, Klang, Selangor		• Tok Bali, Kelantan
• Pulau Gemia, Setiu Lagoon, Terengganu	• Kampung Johor Lama, Johor	• Telok Gong, Selangor	• Pulau Sibu, Johor		
• Pulau Layat, Setiu Lagoon, Terengganu	• Kong-Kong, Johor	• Delta Tumpat, Kelantan	• Pulau Kukup, Johor		
• Pulau Rhu, Setiu Lagoon, Terengganu	• Balok River, Pahang	• Pulau Che Minah, Tumpat, Kelantan	• Pulau Banggi, Sabah		
• Pulau Semut, Setiu Lagoon, Terengganu	• Cherating, Pahang	• Kota Marudu bay, Sabah	• Pulau Gaya, Sabah		

Lagoon	Riverine	Delta	Island	Coastal	Estuary
• Pulau Sutung, Setiu Lagoon, Terengganu	• Sg Chukai, Kemaman, Terengganu		• Pulau Manukan, Sabah		
• Pulau Telaga Tujuh, Setiu Lagoon, Terengganu	• Sg Kertih, Kemaman Terengganu				
• Pulau Tok Ba, Setiu Lagoon, Terengganu	• Awat-awat, Sarawak				
• Pulau Tok Haji, Setiu Lagoon, Terengganu	• Sematan, Sarawak				
• Pulau Ubi, Setiu Lagoon, Terengganu	• Sibuti, Sarawak				
• Setiu Lagoon, Terengganu	• Pangkalan Madai, Kunak, Sabah				
• Setiu Wetlands, Terengganu	• Pangi Ujung, Kunak, Sabah				
• Tok Bali, Kelantan	• Semporna, Sabah • Sulaman lake, Sabah • Sungai Garama, Beaufort, Sabah • Sungai ISME, Sandakan, Sabah • Sungai Klias, Beaufort, Sabah • Sungai Lalasun, Sandakan, Sabah • Sungai Mattangar in Beluran				

Table 9 : Summary of mangroves species compositions at their habitats reported in Malaysian marine waters recorded from 1986- 2022

State	No	Location	Species Composition
Perlis	1.	No data obtained	No data obtained
Kedah	1.	Kilim, Pulau Langkawi, Kedah	*Avicennia marina, Avicennia officinalis, Hydnocarpus ilicifolius, Pentaspadon curtisii, Pentaspadon motley, Pentaspadon velutinus, Spondias pinnata, Schefflera heterophylla, Radermachera pinnata, Radermachera stricta, Spathodea campanulate, Terminalia triptera, Cycas siamensis , Diospyros ismailii, Diospyros ferrea, Elaeocarpus griffithii, Erythroxylum cuneatum, Macaranga sp., Mallotus brevipetiolatus, Mallotus dispar, Flacourtia rukam, Fagraea curtisii, Vitex pinnata, Cinnamomun sp., Lagerstroemia floribunda, Sonneratia alba, Heritiera littoralis, Microcos sp., Pentace sp., Pterospermum lanceifolium, Sterculia angustifolia, Sterculia lancaviensis, Memecylon edule, Memecylon edule, Memecylon pauciflorum, Aglaia cucullate, Xylocarpus granatum, Xylocarpus moluccensis, Xylocarpus rumphii, Ficus deltoidei, Ficus rumphii, Ficus superba, Streblus laxiflorus, Syzgium sp., Phyllanthus pulcher, Xanthophyllum affine, Xanthophyllum discolor ,Bruguiera cylindrica, Bruguiera sexangular, Ceriops zippelliana, Ceriops tagal, Rhizophora apiculate, Rhizophora mucronate, Rhizophora stylosa, Psychotria angulate, Murraya paniculata* (57 taxa)
	2.	Sungai Kisap, Pulau Langkawi, Kedah	*Avicennia officinalis, Xylocarpus granatum, Xylocarpus moluccensis, Bruguiera gymnorrhiza, Bruguiera parviflora, Ceriops tagal, Rhizophora apiculate, Rhizophora mucronata.* (8 taxa)
	3.	Sungai Merbok, Kedah	*Acanthus ebracteatus, Acanthus ilicifolius, Avicennia alba, Avicennia marina, Avicennia officinalis, Avicennia rumphiana, Nypa fruticans, Phoenix paludosa, Dolichandrone spathacea, Lumnitzera littorea, Lumnitzera racemose, Excoecaria agallocha, Cynometra iripa, Pemphis acidula, Sonneratia alba, Sonneratia caseolaris, Sonneratia griffithii, Sonneratia ovata, Brownlowia argentata, Brownlowia tersa, Camptostemon philippinense, Heritiera fomes , Heritiera globose, Heritiera littoralis, Aglaia cucullate, Xylocarpus granatum, Xylocarpus moluccensis, Osbornia octodonta, Aegiceras corniculatum, Aegiceras floridum, Acrostichum speciosum, Bruguiera cylindrica, Bruguiera gymnorrhiza, Bruguiera hainesii, Bruguiera parviflora, Bruguiera sexangular, Bruguiera x rhynochopetala,*

State	No	Location	Species Composition
			Ceriops zippelliana, Ceriops tagal, Kandelia candel, Rhizophora x lamarckii, Rhizophora apiculate, Rhizophora sp., Rhizophora stylosa, Scyphiphora hydrophyllacea. (45 taxa)
Pulau Pinang	1.	Kuala Sungai Burung, Balik Pulau, Pulau Pinang	*Avicennia alba, Avicennia marina, Avicennia officinalis, Avicennia rumphiana, Cocos nucifera, Nypa fruticans, Chromolaena odorata, Pluchea indica, Terminalia catappa, Ipomoea illustris, Ipomoea reptans, Dioscorea alata, Excoecaria agallocha, Derris trifoliata, Leucaena leucocephala, Flagellaria indica, Fagraea fragrans, Clerodendrum villosum, Sonneratia ovata, Heritiera littoralis, Talipariti tiliaceum, Thespesia populnea, Xylocarpus granatum, Xylocarpus moluccensis, Ficus retusa, Dendrolobium crumenatum, Drynaria quercifolia, Colubrina asiatica., Bruguiera cylindrica, Bruguiera gymnorrhiza, Bruguiera parviflora, Rhizophora apiculate, Rhizophora mucronate, Pometia pinnata* (34 taxa)
	2.	Kuala Sungai Pinang, Balik Pulau, Pulau Pinang	*Avicennia alba, Avicennia marina, Avicennia officinalis, Avicennia rumphiana, Nypa fruticans, Excoecaria agallocha, Sonneratia ovata, Xylocarpus granatum, Xylocarpus moluccensis, Acrostichum aureum, Bruguiera cylindrica, Bruguiera gymnorrhiza, Bruguiera parviflora, Rhizophora apiculata* (14 taxa)
	3.	Pantai Acheh, Balik Pulau, Pulau Pinang	*Acanthus ilicifolius, Avicennia marina, Pluchea indica, Terminalia catappa, Derris trifoliata, Xylocarpus granatum, Acrostichum aureum, Bruguiera cylindrica,* (8 taxa)
	4.	Pulau Burung, Nibong Tebal, Pulau Pinang	*Avicennia marina, Avicennia officinalis, Excoecaria agallocha, Sonneratia alba, Sonneratia ovata, Talipariti tiliaceum, Bruguiera parviflora, Ceriops tagal, Rhizophora apiculate, Rhizophora mucronata* (10 taxa)
Perak	1.	Kuala Gula, Taiping, Perak	*Avicennia marina, Avicennia officinalis* (2 taxa).
	2.	Kuala Sepetang, Perak	*Acanthus ilicifolius, Avicennia alba, Avicennia marina, Avicennia officinalis, Nypa fruticans, Oncosperma tigillarium, Lumnitzera racemose, Excoecaria agallocha, Intsia bijuga, Sonneratia alba, Sonneratia caseolaris, Sonneratia ovata, Xylocarpus granatum, Xylocarpus moluccensis, Ficus macrocarpa, Acrostichum speciosum, Bruguiera cylindrica, Bruguiera gymnorrhiza, Bruguiera hainesii, Bruguiera parviflora, Bruguiera sexangular, Ceriops tagal, Rhizophora apiculate, Rhizophora mucronata* (29 taxa)

State	No	Location	Species Composition
	3.	Lekir, Manjung, Perak	*Avicennia alba, Sonneratia alba, Rhizophora apiculata* (3 taxa)
	4.	Pantai Remis, Tanjung Hantu, Perak	*Avicennia officinalis* (1 taxa)
	5.	Pulau Pangkor, Perak	*Avicennia alba, Sesuvium portulacastrum, Buchanania arborescens, Cerbera manghas, Hoya coronaria, Ochrosia oppositifolia, Wollastonia biflora, Chromolaena odorata, Garcinia hombroniana, Lumnitzera littorea, Terminalia catappa, Ipomoea pes-caprae, Erythroxylum cuneatum, Suregada multiflora, Caesalpinia bonduc, Dendrolobium umbellatum, Derris trifoliata, Intsia bijuga, Pongamia pinnata, Fagraea fragrans, Scaevola taccada, Premna serratifolia, Vitex pinnata, Cassytha filiformis, Neolitsea zeylanica, Sonneratia alba, Heritiera littoralis, Talipariti tiliaceum, Thespesia populnea, Xylocarpus granatum, Ficus superba, Syzygium grande, Chionanthus ramiflorus, Cymbidium finlaysonianum, Breynia racemose, Ischaemum muticum, Drynaria sparsisora, Colubrina asiatica, Bruguiera cylindrica, Ceriops tagal, Rhizophora apiculata, Morinda umbellata, Scyphiphora hydrophyllacea, Pouteria obovate, Stachytarpheta indica, Ximenia americana* (46 taxa)
Selangor	1.	Carey Island, Selangor	*Avicennia alba, Avicennia marina, Avicennia officinalis, Santiria griffithii, Excoecaria agallocha, Sonneratia alba, Talipariti tiliaceum, Xylocarpus granatum, Xylocarpus moluccensis, Bruguiera cylindrica, Bruguiera gymnorrhiza, Bruguiera parviflora, Ceriops tagal, Kandelia candel, Rhizophora apiculata, Rhizophora mucronata* (16 taxa)
	2.	Kapar Forest Reserve, Selangor	*Avicennia alba, Avicennia marina, Avicennia officinalis, Sonneratia alba, Xylocarpus granatum, Bruguiera parviflora, Rhizophora apiculate, Rhizophora mucronata* (8 taxa)
	3.	Kuala Selangor Nature Park, Selangor	*Avicennia alba, Avicennia officinalis, Calophyllum inophyllum, Excoecaria agallocha, Sonneratia alba, Sonneratia caseolaris, Sonneratia ovata, Talipariti tiliaceum, Bruguiera parviflora, Rhizophora apiculata, Rhizophora mucronata* (11 taxa)
	4.	Pulau Klang, Selangor	*Avicennia marina, Excoecaria agallocha, Sonneratia alba, Sonneratia caseolaris, Xylocarpus granatum, Xylocarpus moluccensis, Bruguiera cylindrica, Bruguiera gymnorrhiza,*

State	No	Location	Species Composition
			Bruguiera hainesii, Bruguiera parviflora, Bruguiera sexangula, Ceriops tagal, Rhizophora apiculata, Rhizophora mucronata (14 taxa)
	5.	Pulau Kelang Forest Reserve, Selangor	*Avicennia alba, Avicennia officinalis* (2 taxa)
	6.	Pantai Kelanang, Morib, Selangor	*Rhizophora apiculata* (1 taxa)
	7.	Pulau Ketam, Selangor	*Avicennia alba, Avicennia marina, Sonneratia alba, Xylocarpus moluccensis, Bruguiera cylindrica, Bruguiera gymnorrhiza, Bruguiera parviflora, Ceriops tagal, Rhizophora apiculata, Rhizophora mucronata* (10 taxa)
	8.	Pantai Remis, Selangor	*Xylocarpus granatum* (1 taxa)
	9.	Sungai Haji Dorani, Selangor	*Avicennia alba, Avicennia marina, Avicennia officinalis, Sesuvium portulacastrum, Cocos nucifera, Nypa fruticans, Lumnitzera racemosa, Excoecaria agallocha, Sonneratia alba, Talipariti tiliaceum, Xylocarpus moluccensis, Aegiceras corniculatum, Bruguiera cylindrica, Bruguiera sexangula, Rhizophora mucronata, Scyphiphora hydrophyllacea*. (16 taxa)
	10.	Sungai Klang, Selangor	*Bruguiera parviflora, Avicennia marina*. (2 taxa)
	11.	Teluk Gedong, Selangor	*Avicennia alba, Avicennia marina, Avicennia officinalis, Sonneratia alba, Xylocarpus granatum, Bruguiera cylindrica, Bruguiera parviflora, Ceriops tagal, Rhizophora apiculata, Rhizophora mucronata* (10 taxa)
	12.	Telok Gong, Selangor	*Avicennia alba, Avicennia marina, Avicennia officinalis, Excoecaria agallocha, Sonneratia alba, Sonneratia caseolaris, Talipariti tiliaceum, Xylocarpus granatum, Xylocarpus moluccensis, Bruguiera gymnorrhiza, Bruguiera parviflora, Ceriops tagal, Rhizophora mucronata, Rhizophora apiculata* (14 taxa)

State	No	Location	Species Composition
Negeri Sembilan	1.	Pulau Burong, Port Dickson, Negeri Sembilan	*Rhizophora apiculata, Rhizophora mucronata* (2 taxa)
	2.	Rembau-Linggi Estuary, Negeri Senbilan	*Nypa fruticans , Sonneratia sp.* (2 taxa)
	3.	Tanjung Sepat, Port Dickson, Negeri Sembilan	*Avicennia marina, Excoecaria agallocha, Sonneratia alba, Talipariti tiliaceum, Xylocarpus granatum, Bruguiera parviflora, Rhizophora apiculata, Rhizophora mucronata* (8 taxa)
Melaka	1.	Merlimau, Melaka	*Avicennia marina, Avicennia officinalis, Sonneratia alba, Bruguiera cylindrica, Bruguiera parviflora, Ceriops tagal, Rhizophora apiculata, Rhizophora mucronata* (8 taxa)
Johor	1.	Kampung Johor Lama, Kota Tinggi, Johor.	*Talipariti tiliaceum, Xylocarpus granatum, Rhizophora mucronata,* (3 taxa)
	2.	Kong Kong Laut, Johor	*Acanthus ebracteatus, Avicennia officinalis, Lumnitzera littorea, Sonneratia alba, Talipariti tiliaceum, Xylocarpus granatum, Ceriops tagal, Rhizophora apiculata, Rhizophora mucronata* (9 taxa)
	3.	Pulau Kukup, Johor	*Acanthus ebracteatus, Acanthus ilicifolius, Avicennia alba, Avicennia marina, Avicennia officinalis, Avicennia rumphiana, Cerbera odollam, Nypa fruticans, Asplenium nidus, Lumnitzera littorea, Lumnitzera racemosa, Excoecaria agallocha, Intsia bijuga, Sonneratia alba, Sonneratia caseolaris, Sonneratia ovata, Heritiera littoralis, Talipariti tiliaceum, Xylocarpus granatum, Xylocarpus moluccensis, Xylocarpus rumphii, Aegiceras corniculatum, Acrostichum speciosum, Bruguiera cylindrica, Bruguiera gymnorrhiza, Bruguiera hainesii, Bruguiera parviflora, Bruguiera sexangula, Ceriops zippelliana, Ceriops tagal, Rhizophora x lamarckii, Rhizophora apiculata, Rhizophora mucronata, Rhizophora x anamalayana, Scyphiphora hydrophyllacea, Merope angulata* (36 taxa)

State	No	Location	Species Composition
	4.	Pulau Sibu, Johor	*Avicennia alba, Avicennia marina, Avicennia rumphiana, Nypa fruticans, Dolichandrone spathacea, Lumnitzera littorea, Diospyros ferrea, Excoecaria agallocha, Dendrolobium umbellatum, Derris trifoliata, Intsia bijuga, Leucaena leucocephala, Sonneratia alba, Heritiera littoralis, Talipariti tiliaceum, Xylocarpus granatum, Xylocarpus moluccensis, Xylocarpus rumphii, Acrostichum speciosum, Bruguiera cylindrica, Bruguiera gymnorrhiza, Ceriops tagal, Rhizophora apiculata, Rhizophora mucronata, Rhizophora stylosa, Rhizophora x anamalayana, Scyphiphora hydrophyllacea.* (27 taxa)
	5.	Sungai Pulai, Johor	*Acanthus ebracteatus, Acanthus ilicifolius, Avicennia alba, Avicennia marina, Avicennia officinalis, Avicennia rumphiana, Cerbera odollam, Nypa fruticans, Asplenium nidus, Lumnitzera littorea, Lumnitzera racemosa, Excoecaria agallocha, Intsia bijuga, Sonneratia alba, Sonneratia caseolaris, Sonneratia ovata, Heritiera littoralis, Talipariti tiliaceum, Xylocarpus granatum, Xylocarpus moluccensis, Aegiceras corniculatum, Acrostichum speciosum, Bruguiera cylindrica, Bruguiera gymnorrhiza, Bruguiera parviflora, Bruguiera sexangula, Ceriops zippelliana, Ceriops tagal, Rhizophora x lamarckii, Rhizophora apiculata, Rhizophora mucronata, Rhizophora x anamalayana, Scyphiphora hydrophyllacea, Merope angulata* (34 taxa)
	6.	Tanjung Piai, Johor	*Acanthus ebracteatus, Acanthus ilicifolius, Avicennia alba, Avicennia marina, Avicennia officinalis, Avicennia rumphiana, Cerbera odollam, Nypa fruticans, Asplenium nidus, Lumnitzera littorea, Lumnitzera racemosa, Excoecaria agallocha, Intsia bijuga, Sonneratia alba, Sonneratia caseolaris, Sonneratia ovata, Heritiera littoralis, Talipariti tiliaceum, Xylocarpus granatum, Xylocarpus moluccensis, Aegiceras corniculatum, Acrostichum speciosum, Bruguiera cylindrica, Bruguiera gymnorrhiza, Bruguiera parviflora, Bruguiera sexangula, Ceriops zippelliana, Ceriops tagal, Rhizophora x lamarckii, Rhizophora apiculata, Rhizophora mucronata, Rhizophora stylosa, Rhizophora x anamalayana, Scyphiphora hydrophyllacea, Merope angulata* (35 taxa)

State	No	Location	Species Composition
Pahang	1.	Cherating Estuary, Pahang	*Avicennia officinalis, Nypa fruticans, Sonneratia alba, Xylocarpus granatum, Xylocarpus moluccensis, Pandanus atrocarpus, Acrostichum aureum, Bruguiera gymnorrhiza, Bruguiera parviflora, Ceriops tagal, Rhizophora apiculata, Rhizophora mucronata* (12 taxa)
	2.	Kuantan, Pahang	*Avicennia marina, Sonneratia alba, Bruguiera gymnorrhiza, Rhizophora mucronata* (4 taxa)
	3.	Sungai Balok, Pahang	*Avicennia alba, Avicennia marina, Avicennia officinalis, Lumnitzera littorea, Lumnitzera racemosa, Drosera heterophylla, Excoecaria agallocha, Sonneratia alba, Sonneratia caseolaris, Talipariti tiliaceum, Xylocarpus granatum, Bruguiera cylindrica, Bruguiera parviflora, Rhizophora apiculata, Rhizophora mucronata, Merope angulata* (16 taxa)
Terengganu	1.	Kampung Mangkuk, Setiu Terengganu	*Casuarina equisetifolia, Syzygium grande, Rhizophora apiculata* (3 taxa)
	2.	Merang, Terengganu	*Avicennia alba, Anacardium occidentale, Melanochyla fulvinervis, Canarium sp., Calophyllum inophyllum, Casuarina equisetifolia, Garcinia forbesii, Fagraea fragrans, Vitex sp., Alseodaphne albifrons, Talipariti tiliaceum, Melaleuca leucadendron, Syzygium grande, Syzgium sp., Bruguiera cylindrica, Bruguiera gymnorrhiza, Rhizophora apiculata, Pouteria obovata, Pouteria malaccensis* (19 taxa)
	3.	Merchang estuary, Marang Terengganu	*Avicennia alba, Avicennia rumphiana, Cocos nucifera, Casuarina sp., Lumnitzera racemosa, Derris trifoliata, Vitex rotundifolia, Talipariti tiliaceum, Pandanus odoratissimus, Bruguiera cylindrica, Ceriops zippelliana, Rhizophora apiculata* (12 taxa)
	4.	Setiu lagoon, Terengganu	*Acanthus ilicifolius, Aganope heptaphylla, Asplenium nidus, Avicennia alba, Avicennia rumphiana, Caesalpinia crista, Calamus erinaceus, Calophyllum rupicola, Casuarina equisetifolia, Cerbera manghas , Cerbera odollam, Cocos nucifera, Cynometra iripa, Dalbergia candenatensis, Dendrolobium umbellatum, Derris trifoliata, Diospyros ferrea, Dischidia nummularia, Dolichandrone spathacea, Excoecaria agallocha, Fimbristylis ferruginea, Finlaysonia obovate, Garcinia hombroniana, Ipomoea pes-caprae, Lumnitzera littorea, Lumnitzera racemose, Neolitsea zeylanica, Nypa fruticans , Olax psittacorum, Oncosperma tigillarium, Pongamia pinnata, Premna serratifolia, Salacia chinensis,*

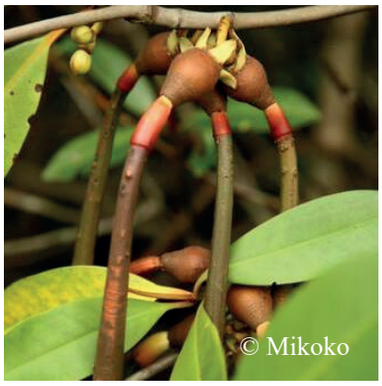
State	No	Location	Species Composition
			Scaevola taccada, Secamone elliptica, Sesuvium portulacastrum, Sonneratia alba, Sonneratia caseolaris, Syzygium kunstleri, Syzygium gratum, Talipariti tiliaceum, Terminalia catappa, Vatica pauciflora, Volkameria inermis, Wollastonia biflora, Flagellaria indica, Barringtonia racemose, Heritiera littoralis,Taeniophyllum pusillum, Pandanus tectorius, Glochidion littorale, Spinifex littoreus, Zoysia matrella, Pyrrosia piloselloides, Aegiceras corniculatum, Bruguiera cylindrica, Bruguiera gymnorrhiza, Bruguiera x hainesii, Carallia brachiate, Ceriops zippelliana, Ceriops tagal, Rhizophora apiculate, Rhizophora mucronate, Hydnophytum formicarum, Myrmecodia tuberosa, Allophylus cobbe, Pouteria obovate, Ximenia americana (67 taxa)
	5.	Setiu Wetlands, Terengganu	*Acanthus ebracteatus, Acanthus ilicifolius, Acrostichum speciosum , Aegiceras corniculatum, Avicennia alba, Avicennia officinalis , Avicennia sp., Avicennia rumphiana, Bruguiera cylindrica, Bruguiera gymnorrhiza, Bruguiera sexangular, Bruguiera x rhynochopetala, Bruguiera x hainesii, Ceriops tagal, Ceriops zippelliana, Dendrobium crumenatum, Derris trifoliata, Excoecaria agallocha, Finlaysonia obovate, Heritiera littoralis, Intsia bijuga, Lumnitzera littorea, Lumnitzera racemose, Nypa fruticans, Phoenix paludosa, Rhizophora apiculate, Rhizophora mucronate, Rhizophora x anamalayana, Scyphiphora hydrophyllacea, Sonneratia sp., Sonneratia alba, Sonneratia caseolaris, Sonneratia lanceolata, Sonneratia x hainanensis, Sonneratia ovata, Talipariti tiliaceum, Xylocarpus granatum, Xylocarpus moluccensis* (37 taxa)
	6.	Sungai Chukai, Kemaman Terengganu	*Nypa fruticans, Lumnitzera littorea, Excoecaria agallocha, Xylocarpus granatum, Bruguiera gymnorrhiza, Ceriops zippelliana, Rhizophora apiculata* (7 taxa)
	7.	Sungai Kertih, Kemaman Terengganu	*Bruguiera cylindrica, Rhizophora apiculata, Kandelia candel, Avicennia alba, Nypa fruticans, Excoecaria agallocha, Sonneratia caseolaris, Heritiera littoralis, Rhizophora mucronata, Bruguiera gymnorrhiza, Bruguiera parviflora, Xylocarpus granatum, Talipariti tiliaceum.* (13 taxa)
	8.	Universiti Malaysia Terengganu, Terengganu	*Avicennia alba , Rhizophora apiculata* (2 taxa)

State	No	Location	Species Composition
Kelantan	1.	Delta Tumpat, Kelantan	*Acanthus ilicifolius, Acrostichum aureum, Avicennia alba, Avicennia marina, Bruguiera gymnorrhiza, Cocos nucifera, Derris trifoliata, Nypa fruticans, Rhizophora apiculate, Rhizophora mucronate, Sonneratia caseolaris* (11 taxa)
	2.	Sungai Semerak, Tok Bali, Kelantan	*Aegiceras corniculatum, Bruguiera cylindrica, Bruguiera parviflora, Bruguiera sexangular, Ceriops zippelliana, Derris trifoliata, Heritiera littoralis, Rhizophora apiculate, Talipariti tiliaceum.* (9 taxa)
Sabah	1.	Banggi Island, Sabah	*Sonneratia alba, Xylocarpus granatum, Ceriops tagal, Rhizophora apiculata, Rhizophora mucronata* (5 taxa)
	2.	Kota Marudu, Marudu Bay, Sabah	*Avicennia alba, Avicennia marina, Excoecaria agallocha, Intsia bijuga, Sonneratia alba, Heritiera littoralis, Xylocarpus moluccensis, Bruguiera gymnorrhiza, Bruguiera parviflora, Ceriops zippelliana, Rhizophora apiculata, Rhizophora mucronata, Rhizophora sp*. (13 taxa)
	3.	Kudat Mainland, Sabah	*Lumnitzera littorea, Sonneratia alba, Xylocarpus granatum, Bruguiera cylindrica, Bruguiera gymnorrhiza, Rhizophora apiculata, Rhizophora mucronata, Rhizophora stylosa* (8 taxa)
	4.	Sandakan, Sabah	*Bruguiera gymnorrhiza, Bruguiera sexangula* (2 taxa)
	5.	Semporna Mangrove Forest, Sabah	*Avicennia marina, Mangifera sp., Casuarina equisetifolia, Lumnitzera littorea, Lumnitzera racemosa, Excoecaria agallocha, Jatropha sp., Derris sp., Millettia pinnata, Barringtonia asiatica, Pemphis acidula, Sonneratia caseolaris, Talipariti tiliaceum, Xylocarpus granatum, Bruguiera cylindrica, Bruguiera parviflora, Ceriops tagal, Rhizophora apiculata, Rhizophora mucronata, Rhizophora stylosa, Morinda cirtifolia, Scyphiphora hydrophyllacea* (22 taxa)
	6.	Sulaman Lake Forest Reserve, Sabah	*Avicennia alba, Ceriops zippelliana, Rhizophora apiculata, Rhizophora mucronata* (4 taxa)
	7.	Tunku Abdul Rahman Park, Sabah	*Lumnitzera littorea, Lumnitzera racemosa, Heritiera littoralis, Xylocarpus moluccensis, Bruguiera cylindrica, Bruguiera hainesii, Rhizophora apiculata, Scyphiphora hydrophyllacea* (8 taxa)

State	No	Location	Species Composition
Sarawak	1.	Awat-Awat, Lawas, Sarawak	*Nypa fruticans, Lumnitzera littorea, Lumnitzera racemosa, Sonneratia alba, Sonneratia caseolaris, Xylocarpus granatum, Bruguiera parviflora, Rhizophora apiculata, Rhizophora mucronata* (9 taxa)
	2.	Kuching Wetlands National Park, Sarawak	*Avicennia alba, Avicennia marina, Excoecaria agallocha, Xylocarpus granatum, Bruguiera parviflora, Ceriops zippelliana, Ceriops tagal, Rhizophora apiculata, Rhizophora mucronata* (9 taxa)
	3.	Wildlife Sanctuary, Sibuti, Sarawak	*Nypa fruticans, Phoenix paludosa, Excoecaria agallocha, Intsia bijuga, Thespesia populnea, Xylocarpus granatum, Xylocarpus moluccensis, Acrostichum speciosum, Rhizophora apiculata* (9 taxa)

(v) Dominant mangrove species information

a.



b.

c.

d.

e.

f.

g.

h.

i.

j.

k.

l.

m

n.

o.

p.

q.

r.

s.

t.

u.

v.

w.

x.

y.

z.

aa.

a. Rhizophora apiculata	*b. Rhizophora mucronata*	*c. Rhizophora stylosa*
d. Bruguiera gymnorhiza	*e. Bruguiera cylindrica*	*f. Bruguiera sexangula*
g. Bruguiera hainesii	*h. Bruguiera parviflora*	*i. Kandelia candel*
j. Avicennia alba	*k. Avicennia marina*	*l. Avicennia officinalis*
m. Lumnitzera littorea	*n. Lumnitzera racemosa*	*o. Aegiceras corniculatum*
p. Aegiceras floridum	*q. Acrostichum aureum*	*r. Acrostichum speciosum*
s. Sonneratia alba	*t. Sonneratia caseolaris*	*u. Sonneratia ovata*
v. Xylocarpus granatum	*w. Xylocarpus moluccensis*	*x. Xylocarpus rumphii*
y. Ceriops zippeliana	*z. Ceriops tagal*	*aa. Heritiera littoralis*

Figure 25: The dominant mangrove species found during this study.

(vi) IUCN Redlist

In terms of mangrove conservation status species, there are four mangrove species listed under Critically Endangered (CR), four species endangered (EN), three species of vulnerable (VU), and five near threatened (NT) (Figure 26). The summary of mangrove species under the IUCN Redlist can be found in Table 10 & Table 11.

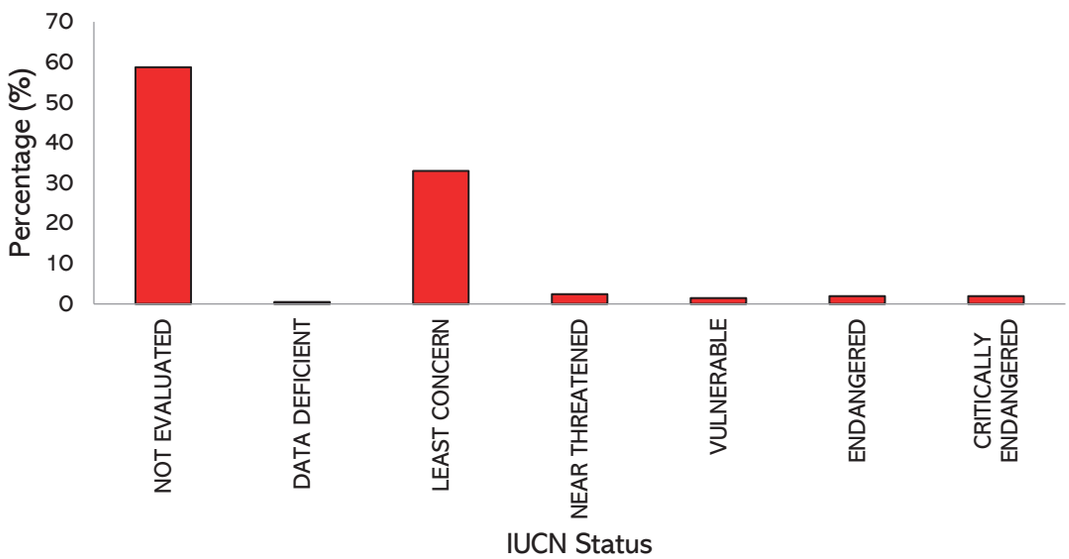


Figure 26: Mangrove IUCN Status

Table 10: Mangrove conservation status

IUCN Red List Category		Number of species
Not Evaluated	NE	121
Data Deficient	DD	1
Least Concern	LC	68
Near Threatened	NT	5
Vulnerable	VU	3
Endangered	EN	4
Critically Endangered	CR	4
	Total	206

Table 11: The mangrove species under IUCN red list category in a Malaysian mangrove

Family	Scientific Name	Common Name	Exclusivity	IUCN Status
Acanthaceae	*Acanthus ebracteatus*	Jeruju	Exclusive	Least Concern
	Acanthus ilicifolius	Jeruju putih	Exclusive	Least Concern
	Acanthus volubilis	Jeruju	Exclusive	Least Concern
	Acanthus sp.	Jeruju	Exclusive	Not Evaluated
	Avicennia alba	Api-api putih	Exclusive	Least Concern
	Avicennia marina	Api-api jambu	Exclusive	Least Concern
	Avicennia marina var. acutissima	Api-api jambu	Exclusive	Not Evaluated
	Avicennia officinalis	Api-api ludat	Exclusive	Least Concern
	Avicennia spp.	Api-api	Exclusive	Not Evaluated
	Avicennia rumphiana (Avicennia lanata)	Api-api bulu	Exclusive	Vulnerable
Apocynaceae	*Finlaysonia obovata*	Kalak kambing	Exclusive	Not Evaluated
Combretaceae	*Lumnitzera littorea*	Teruntum Merah	Exclusive	Not Evaluated
	Lumnitzera racemosa	Teruntum puteh	Exclusive	Least Concern
Euphorbiaceae	*Excoecaria agallocha*	Buta-buta	Exclusive	Not Evaluated
Fabaceae	*Intsia bijuga*	Merbau Ipil, Merbau Ayer, Ipil, Kwila, Kayu Besi	Exclusive	Near Threatened
Lythraceae	*Sonneratia alba*	Perepat	Exclusive	Least Concern
	Sonneratia caseolaris	Berembang	Exclusive	Least Concern
	Sonneratia griffithii	Gadabu	Exclusive	Critically Endangered
	Sonneratia lanceolata	Gadabu	Exclusive	Least Concern
	Sonneratia x hainanensis	-	Exclusive	Critically Endangered
	Sonneratia hybrids/sp nov.	-	Exclusive	Not Evaluated
	Sonneratia ovata	Gedabu	Exclusive	Near Threatened
	Sonneratia spp.	Gadabu	Exclusive	Not Evaluated
Malvaceae	*Heritiera fomes*	Sundari	Exclusive	Endangered
	Heritiera globosa	Dungun	Exclusive	Endangered
	Heritiera littoralis	Dungun	Exclusive	Least Concern

Family	Scientific Name	Common Name	Exclusivity	IUCN Status
Meliaceae	*Xylocarpus granatum*	Nyireh bunga	Exclusive	Least Concern
	Xylocarpus moluccensis/ Xylocarpus mekongensis	Nyireh batu	Exclusive	Least Concern
	Xylocarpus rumphii	Nyireh laut	Exclusive	Not Evaluated
Primulaceae	*Aegiceras corniculatum*	Kuku helang	Exclusive	Least Concern
	Aegiceras floridum	Teruntum	Exclusive	Near Threatened
	Acrosthicum aureum	Piai raya	Exclusive	Not Evaluated
	Acrostichum speciosum	Piai laut	Exclusive	Least Concern
Rhizophoraceae	*Bruguiera cylindrica*	Berus putih	Exclusive	Least Concern
	Bruguiera gymnorrhiza	Tumu merah	Exclusive	Least Concern
	Bruguiera hainesii	Bakau mata buaya	Exclusive	Critically Endangered
	Bruguiera parviflora	Lenggadai	Exclusive	Least Concern
	Bruguiera sexangula	Tumu putih	Exclusive	Least Concern
	Bruguiera sp	Tumu	Exclusive	Not Evaluated
	Bruguiera x rhynochopetala	-	Exclusive	Not Evaluated
	Bruguiera x hainesii	Bakau mata buaya	Exclusive	Not Evaluated
	Ceriops decandra/ Ceriops zipelliana	Tengar	Exclusive	Least Concern
	Ceriops tagal	Tengar	Exclusive	Least Concern
	Kandelia candel	Pisang pisang, Berus berus, Beras beras, Pulut pulut	Exclusive	Least Concern
	Rhizophora apiculata	Bakau minyak	Exclusive	Least Concern
	Rhizophora mucronata	Bakau belukap	Exclusive	Least Concern
	Rhizophora sp.	Bakau	Exclusive	Not Evaluated
	Rhizophora stylosa	Bakau kurap	Exclusive	Least Concern

4.6 Threats faced by marine plants in Malaysia

Based on this desktop study, we found that very few articles have discussed the issues related to the threats faced by marine plants especially for seaweed and seagrass in the Malaysian marine waters area. Table 12 summarizes the essential biotic and abiotic stresses that limit the distribution and abundance of marine plants reported in Malaysia.

Table 12: Important stresses which limit the distribution and abundance of marine plants

Stress	Vulnerability
Salinity change	• Mechanical and biological disturbance. Increased respiratory load and decreased productivity.
Temperature change	• Change in reproduction patterns and growth.
Wave-action	• Sediment-movement • Blow-outs (depressions)
Anaerobiosis	• Epiphytes • Anoxic water
Nutrient limitation	• Lack of trace elements • Lack of Nitrogen and Phosphate
Epiphytes	• Smothering, shading, anoxia • Decreased productivity
Light / shade	• Lower productivity • Shading by epiphytes
Infection	• Die-back or decreased fitness
Herbivory	• Removal of critical parts
Physical damage	• Propeller damage to leaves and uprooting • Seaweed and seagrass harvesting
Climate change	• Changes in seasonal variation and abiotic stress influence the marine plant's growth

4.6.1 Threats faced by marine microalgae in Malaysia

(a) Environmental stress can reduce the growth and diversity of microalgae

Stress conditions such as nutrient limitation, high irradiance, high sea surface temperature, and chemical contamination can reduce the photosynthetic pigments such as chlorophyll a, carotenoids, and phycobiliprotein production in marine microalgae (Chu, 2002).

(b) Water discoloration due to harmful algal blooms (HABs)

The exact mechanism that triggers the bloom of dinoflagellates leading to the red tide phenomenon and the production of toxins in shellfish is unknown. However, it is believed that disturbance in ecological balance in the sea due to dumping materials, dredging, blasting of sea-bed, and construction or natural substrata disturbance may trigger such phenomenon. In recent years much construction work, blasting of the coastal sea bed for collection of corals, reclamation, and exploration for oil and gas have been carried out in the sea along the West Coast of Sabah.

It must also be noted that shellfish may even become poisonous long before the bloom of dinoflagellates becomes sufficiently high to produce red patches in the sea. Therefore, it is necessary to test shellfish for toxicity at regular intervals. Diagnosing and preventing red tide-associated diseases require physicians, public health authorities, and the Fisheries Department's awareness of the problem.

As Anton (2008) reported, the dinoflagellate blooms can recur in the exact location for consecutive years, and more detailed studies are required to understand these events' dynamics and causal factors. Such information will be needed to sustain fishery resources and mitigate future blooms.

(d) Shellfish contamination

Few cases of suspected food poisoning due to the consumption of clams have been reported since 1976, such as coastal villagers from Kampong Maruntum; a coastal district of Sipitang; Pulau Mantanani, Kota Belud, and other areas in Sabah as reported by Roy (1977). These unfortunate phenomena triggering the bloom of dinoflagellates have posed a real public health hazard and an economic problem for the fishermen and the fishing industry. Therefore, the Fisheries and Medical Departments have to organize and implement a monitoring system to determine the shellfish's toxin content and prevent consumption of shellfish whenever toxin content appears higher than the safe level; levels above eight prg per 100 g of shellfish meat are considered unsafe.

4.6.2 Threats faced by seaweed in Malaysia

(a) Seasonal diseases

In Malaysia, seaweed diseases is generally focused on those affecting *Eucheuma* sp and *Kappaphycus* sp, particularly the 'ice-ice' disease phenomenon. Largo et al., 1995, reported that the main environmental conditions that influenced the outbreak are low salinity and low light intensity. The 'ice-ice' disease affects not only growth bur also its appearance and, possibly, carrageenan product quality.

(b) Market price fluctuation

As reported by (Wamucii, 2023), the export and import price of seaweed in Malaysia over the last five years has been quite varied. The total values in export for seaweed in Malaysia were USD1784 (2016), USD 2917 (2017), USD 2562 (2018) and USD 4008 (2019). Mohd Mahmud and Nitty, 2020) reported that, the uncertainty in the price of dried seaweed marked by "price boom". It is a situation where a rapid increase in price in several cycles and followed by a crash. Usually, this happens when the market is flooded with money from China. The impact of the risk is also felt by customers as they now will have to compete with a higher price, but with little capital. This phenomenon usually will be followed by a seaweed market crash.

(c) Seaweed diversity is low relative to other areas. There are many areas in the habitats that have been poorly investigated.

(d) Turbid waters and extremely poor visibility due to sedimentation

Turbidity are the most visible indicators of water quality. These suspended particles can come from soil erosion, runoff, discharges, stirred bottom sediments or algal blooms. Clear water is usually considered an indicator of healthy water and excessive suspended sediment can impair water quality for aquatic and human life. Turbidity can also inhibit photosynthesis by blocking sunlight. Halted or reduced photosynthesis means a decrease in plant survival and decreased dissolved oxygen output. The higher the turbidity levels, the less light that can reach the lower levels of water. This reduces plant productivity at the bottom of an ocean, Without the needed sunlight, seaweed and seagrasses below the water's surface will not be able to continue photosynthesis and may die.

(e) Degraded coral reef and rocky shore

Seaweed is usually grown well in the coral reef ecosystems. However, the coral reef ecosystems have undergone phase shifts to alternate, degraded assemblages because of the combined human activities of unsustainable overfishing, intensive tourism, urbanization, sedimentation, declining water quality, pollution and primarily from the direct and indirect impacts of climate change. Most coral ecologists confirm that coral

reef degradation has increased dramatically during the last three decades due to enhanced anthropogenic disturbances and their interaction with natural stressors (El-Naggar, 2019).

(f) Low seaweed density around the islands is the relatively sizeable tidal amplitude, seasonal variation, and difference in habitats, in addition to the vulnerability to grazing, especially by a sea urchin.

(g) The low spring tides create an extremely harsh environment for plants due to desiccation and intense solar radiation.

(h) For seaweed cultivation in Sabah, stocking density, culture period, and water depth affect the growth rate, carrageenan content, and molecular weight of *Kappaphycus striatumol* (Hurtado et al., 2008). For *Kappaphycus* sp, crops decline in some regions due to sourcing of seedlings from single, selected genetic stocks considered to have initially higher yield potential but which resulted in strain fatigue or loss of vigor. Other reasons for reducing the seaweed cultivation industry in Sabah are price fluctuation, the unrecognized dried seaweed market, and security issues.

4.6.3 Threats faced by seagrass in Malaysia

(a) Low abundance & diversity

The limited intertidal distribution of seagrass could be affected by other environmental factors, i.e., substratum, current movement, or other factors (Abu Hena, 2001).

The changes in seagrass depth distribution may change the result of water quality due to runoff impacts (Muta Hara, 2003)

The variations in seagrass biomass depended on the species type and their environmental conditions, such as water quality and circulation, sediment status, and nutrient content. Sediment depth & water depth are also- essential factors in controlling seagrass biomass (Abu Hena, 2004)

(b) High water contamination

Water quality has a significant impact on seagrass. Changes in water quality, such as increased nutrient concentrations, suspended solids, and heavy metals, can negatively affect seagrass abundance, growth and health. Nutrient pollution, can lead to seagrass

decline over time. Seagrasses play a crucial role in filtering nutrients and particles from the water column, helping to maintain water quality (Shaikah, 2009; Bjock, et al, 2008).

(c) Land reclamation

Coastal reclamation has been identified as a major contributor to seagrass habitat loss, leading to physical damage, excessive sedimentation, and increased turbidity (Adharini et al., 2022; Duarte, 2002; Japar Sidik et al., 2016; Nadiarti et al., 2012;Unsworth et al., 2018)

(d) Coral reef destruction

Environmental stressors such as eutrophication, over-fishing, sedimentation and physical damage from boating activities have reduced the resilience of the world's tropical coral reef and seagrass ecosystems (Orth et al., 2006; Hoegh-Guldberg et al., 2007; Hughes et al., 2017). Because seagrass meadows in tropical bays and lagoons are largely dependent on the sheltered conditions within the shadow of fringing coral reefs, it logically follows that declines in coral reefs will be matched by a decline in seagrass meadows, as was shown in modelling studies (Saunders et al., 2014; Keyzer et al., 2020).

(e) Sediment burial

Seagrasses in shallow coastal waters are subjected to various stresses, such as burial. Clonal organisms may respond to burial in very different ways depending on how firmly integrated they are through horizontal rhizomes. Sediment burial strongly affected seagrass' survival, biomass, and shoot density. Despite the range in species size, 8 cm is a critical burial depth to which these seagrasses respond either by losing shoots and reducing biomass or both (Ooi, 2011).

4.6.4 Threats faced by mangroves in Malaysia

This study reported 7 types of mangrove threats (Figure 27). The most significant threats were recorded for coastal development in mangrove forests, as represented by 14 cases, followed by aquaculture practices and overharvesting with 13 and 11 cases respectively. The rest of the threats are less than 10 cases, for example, natural phenomena, pollution, coastal development and ecological disturbance. The detail of each case i.e classification of threats with the location reported from the study were elaborated in Table 13.

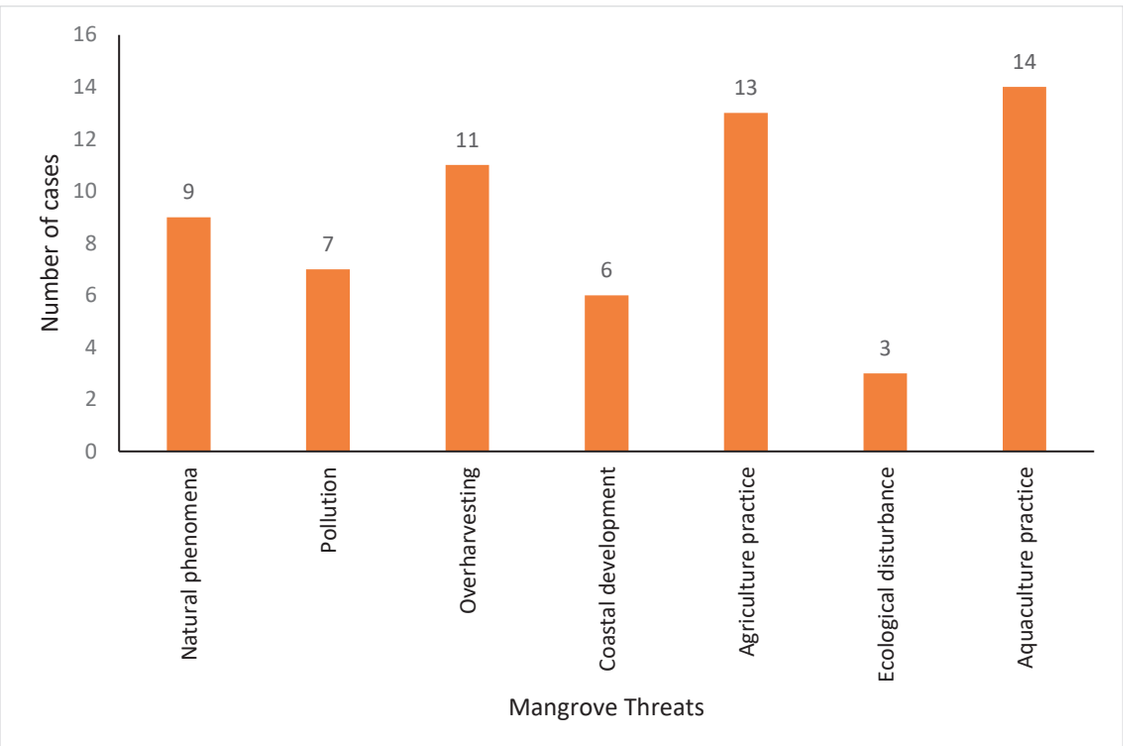


Figure 27: Mangrove threats in Malaysia

Table 13: List of mangrove threats in Malaysia

Mangrove threats	Remark	Location	
Natural phenomena	Coastal erosion, storm surges, tropical storm, sea level rise, lightning strike	**Johor**	Pulau Sibu
		Kedah	Kisap Forest Reserve, Merbok Mangrove Reserve
		Selangor	Pulau Che Mat Zin, Pulau Indah, Sungai Haji Dorani, Carey island, Kuala Selangor Nature Park
		Terengganu	Setiu Wetlands
Pollution	Oil pollution, mixed wastewater, microplastic, marine debris, heavy metal contamination & overusing of fertiliser in palm cultivation activity	**Johor**	Pulau Sibu
		Selangor	Pulau Che Mat Zin, Pulau Indah, Carey island, Pantai Kelanang
		Perak	Matang Mangrove Forest Reserve
		Terengganu	Setiu Wetlands
Overharvesting	Charcoal production, logging	**Kedah**	Kisap Forest Reserve, Merbok Mangrove Forest, Kuala Kedah
		Selangor	Teluk Gong, Pulau Ketam, Pulau Klang, Sungai Haji Dorani, Carey island
		Sabah	Kota Marudu Mangrove Forest
		Johor	Kampung Johor Lama
		Negeri Sembilan	Rembau-Linggi Estuary
Coastal development	Housing, sand dredging activity, development of port, jetty for boat landing	**Kedah**	Merbok Mangrove Forest
		Kelantan	Delta Tumpat
		Terengganu	Setiu Wetlands
		Pahang	Kuantan
		Selangor	Kuala Selangor Nature Park, Sg. Haji Dorani
Agriculture practice	Oil palm plantation	**Kelantan**	Delta Tumpat
		Johor	Kampung Johor Lama
		Negeri Sembilan	Rembau-Linggi Estuary
		Kedah	Merbok Mangrove Forest

Mangrove threats	Remark		Location
		Perak	Matang Mangrove Forest Reserve
		Sabah	Semporna Mangrove Forest, Sungai Lalasun & Sungai ISME in Sandakan, Sungai Mattangar in Beluran, Sungai Garama & Sungai Klias in Beaufort, and Pangkalan Madai & Pangi Ujung in Kunak
Ecological disturbance	Introduction of invasive species to the area, over-exploitation, endangered species	**Kelantan**	Delta Tumpat
		Selangor -	Sungai Haji Dorani
		Kedah	Merbok Mangrove Forest, Kuala Kedah
Aquaculture practice	Shrimp farming, fish farming, oyster farming	**Pahang**	Cherating estuary
		Negeri Sembilan	Rembau-Linggi Estuary
		Selangor	Sungai Haji Dorani, Carey island
		Terengganu	Setiu Wetlands
		Kedah	Merbok Mangrove Forest
		Sabah	Semporna Mangrove Forest, Sungai Lalasun & Sungai ISME in Sandakan, Sungai Mattangar in Beluran, Sungai Garama & Sungai Klias in Beaufort, and Pangkalan Madai & Pangi Ujung in Kunak,

5.0 GAP ANALYSIS

5.1 Information Gaps and Needs for Future Research

Table 14 summarizes the information gaps found in this desktop study.

No	Issues	Information gaps
1.	A limited number of publications were obtained via desktop study before the year 2000	Before 2000, most data were published as hardcopy books and conference proceedings.
2.	Marine plants research application in biodiversity study	Less than 10% of the total publications are focused on biodiversity studies in microalgae, seaweed, and seagrass, except for the mangroves. Most of the biodiversity study was conducted before 1990, and many research grants were provided to the researcher to complete the marine plant survey. Therefore, starting from the year 2001, the actual status of the marine plant diversity at the current time is unknown.
3.	Source of marine microalgae used for research	The majority (80%) of the microalgae samples used for the research were obtained from the university algae culture collection, and only 20% were collected from the field collection. Therefore, the status of the microalgae diversity in their original habitats is unknown.
4.	Location of marine plants collected and investigated	Most of the area surveys for marine microalgae were focused on the Sabah coastal area due to the HABs problems but not in another location in Malaysia. For the seaweed and seagrass, the research location was focused on the area that has high seaweed and seagrass biodiversity from published papers but not in another coastal region, especially in the fishing prohibited areas that are used as a nursery ground for juvenile fishes or marine parks Limited mangrove biodiversity data from Sabah and Sarawak due to the permit requirement to access the sources
5.	Data on species abundance	For microalgae, there is a lack of data reported on the cell density of the microalgae in their habitats. The same trend was observed for the seaweed and seagrass species abundance.

No	Issues	Information gaps
6.	Data on coverage area	A lack of data on coverage area was reported for the seaweed and seagrass
7.	Data on water quality	A lack of data on the status of water quality in seaweed and seagrass habitats was reported in the published articles.
8.	Marine plants research application in climate change issues	Marine plants including seaweed, seagrass and mangrove studies for climate change mitigation are still lacking and need more attention and further study need to be carried out effectively.
9.	Sources of mangrove use in research	This study only managed to document the data from the fieldwork survey. Limited research has deposited the voucher specimen to the herbarium for future reference
10.	Mangrove mapping study	The mangrove mapping study is an urgent study to get the current status of the remaining Malaysian mangrove area - due to the accelerating development of the coast, which is causing mangrove destruction
11.	List of mangrove species inventory	Limited data for mangrove hybrid throughout Malaysian mangrove forest
12.	Dominant mangrove species	Limited data on mangrove community structure to determine the dominant mangrove species. This study is urgent to identify the dominant species of the area before more mangrove destruction for coastal development
13.	Mangrove forest type/habitat	Lacking data for island mangrove, more study is needed to fill this research gap
14.	Mangrove threats	A more comprehensive study on mangrove mapping is needed to ensure the main destruction of mangroves, whether due to land use changes/land conversion or aquaculture.

6.0 DISCUSSION & SUGGESTIONS

6.1 Identification of Potential Areas to be protected for MPAs with the creation of marine ecological corridors.

Based on the microalgae, seaweed, seagrass and mangrove biodiversity data analyzed from this study, here we are providing information on the linkages of the marine plants (microalgae, seaweed, seagrass and mangrove) ecosystem as a service provider to the local coastal inhabitants and other users. These habitats were chosen as suggested, and existing MPA areas were based on the highest diversity of marine plants recorded in the area (Table 15) and the map of the suggested MPAs is shown in Figure 28.

Importance and roles of marine plants

Seaweed, seagrass beds, and mangroves forest serve as feeding, breeding, and nursery grounds for various marine organisms, especially fishery species of commercial importance. Seaweed, seagrass beds, and coral reefs supply more than one-fifth of the fish caught in East Asia (McManus 1988). Invertebrates associated with seaweed, seagrass beds, and mangroves include shrimps, cucumbers, sea urchins, crabs, scallops, mussels, and snails. Commercial species like Siganus (rabbitfish) and Penaeus merguiensis feed on seagrasses (Fortes 1995, Chong & Sasekumar 1981).

Seaweed and seagrasses with spreading rhizomes and roots hold the sandy-muddy substratum together, preventing erosion and smothering of benthic species. Species like Enhalus and Thalassodendron with long strap-like leaves form good wave breakers, and extensive beds protect shorelines exposed to solid waves (Phang 2000). Even smaller species, such as Halodule pinifolia (Sidik et al. 1999) and Halophila spp (Erftemeijer et al. 1999), are suitable substrate stabilizers as they can survive in areas of shifting substrate and intense wave action.

The marine plants' ecosystem harbours entire food chains and serves as food for the zooplankton, invertebrates, dugong, and several species of turtles and fish. Commercial seaweed species such as *Caulerpa lentilefera*, *Kappaphycus* sp, and large seagrass, *Enhalus* fruits are sold in markets in Kota Kinabalu, Sabah, as food for the local population. In Southeast Asia, seaweed and seagrass are used in many ways: as packing material, paper, children's toys, compost for fertilizer, fodder, and baskets and mats (Fortes, 1995). They may also potentially be used as biofilters and as a source of biochemicals. All these roles make seaweed and seagrass meadows the most valuable ecosystems regarding the value-added benefits of their services. Seaweed and seagrasses also contribute significantly to the oxygenation of the seas and carbon sequestration, reducing the effects of global warming (Phang, 2000). Their role in the oceanic carbon budget is proportionally more significant than expected from their cover

or primary production alone, for seagrasses are estimated to contribute 12% of the net ecosystem production in the ocean (Duarte & Cebrian 1996).

Marine plants support major detritus-based food chains in many coastal waters, providing nutrients for several invertebrates and fish (Phillips and McRoy, 1980, Larkum et al., 1989). The two most-cited large herbivores which regularly include seagrass in their diets are the dugong, *Dugon dugon*, and the green turtle, *Chelonia mydas*. Both animals can digest the fibrous cellulose of the seagrass in their diet.

This study managed to compile a mangrove biodiversity study for the mangroves in Malaysia. Over 37 years, the analysis showed that most topics are related to mangrove Biodiversity along the Malaysian coastline, including Sabah and Sarawak. From the reports, the presence of Malaysian mangrove species was listed and enumerated alongside their distribution across the Malaysian state. The West coast of Peninsular Malaysia has recorded the highest study, particularly in Selangor and Perak, while Terengganu was the most studied on the east coast of Peninsular Malaysia. However, the data from Sabah and Sarawak are limited, and perhaps mangrove researchers can access the data for compilation in the future.

In Malaysia, there are 38 exclusive mangrove species, 57 non-exclusive mangrove species and 9 are associate species (Japar 1994). Previous work in more than 60 years for example Wyatt -Smith (1960), Liew (1980) and Chai (1982) managed to record 31 exclusive mangrove species, 51 species non-exclusive. In this study, there were 45 exclusive mangrove species and 150 non-exclusive mangrove species were obtained from the compilation of Malaysian mangrove studies. This study recorded slightly higher exclusive species since there were few studies that could identify the mangrove species to the genus level only. Therefore, the real number of mangrove species is hindered due to the lack of expertise in mangrove plant identification. Additionally, the occurrence of hybrid species in Malaysian mangrove is increasing therefore the updated checklist for Malaysian mangrove species is an urgency for further work.

In 1928, Watson categorised mangrove forest types according to the tide's inundation classes. However, from this compilation study, we managed to classify Malaysian mangrove forest types according to their geomorphological setting. For example, lagoon mangrove, riverine mangrove, deltaic mangrove, coastal mangrove, and island mangrove. Among these, the riverine mangrove was the most studied by Malaysian researchers perhaps it was the common mangroves that can be found along the Malaysian coastline.

This study also analyzed the mangrove threats in Malaysia, and we found that aquaculture practices are the main threat to Malaysian mangroves. Most of the activities are the development of fish and shrimp ponds and fish cage culture. This problem is getting worse for mangrove forests as the pond was abandoned after several years, which has diminished the mangrove forest area. The second most increased threat was agriculture practice. The oil plantation was reported as the main crop that was planted

in coastal area and responsible for 38.2% mangrove area loss in Malaysia (Richard and Fries 2016). Overharvesting of mangrove trees for charcoal production and for timber is also considerably high with 11 cases and the natural phenomena for example coastal erosion also recorded several cases in Malaysian coastline which also contribute to the mangrove collapse.

6.2 Suggestion

As a result of analyzing the data obtained from this desktop study, the following recommendations are suggested.

(a) Monitoring

Monitoring work needs to be performed on (i) water quality and (ii) the marine plants' habitats for species composition and abundance. A workable monitoring plan could be for special interest groups, for example, local schools and non-governmental organizations (NGOs), to adopt a seaweed and seagrass meadow and monitor it according to predefined standard methods. This will increase awareness and encourage ownership of the ecosystems while providing data integral to the ecosystem's management.

(b) Landuse and Coastal Erosion

Coastal ecosystems are often put at risk by what goes on in the adjacent terrestrial zone. Land use development needs to be monitored and managed with a view of the impacts these may have on the fringing seaweed and seagrass meadows. If proper land development measures are not implemented, coastal erosion can severely damage the marine flora. Therefore, the management of zones beyond the perimeter of seaweed, seagrass, and coastal ecosystem must also be considered. However, this may involve the integration and cooperation of multiple parties inside and along a specific watershed area, making this a challenging issue to resolve successfully.

(c) Awareness and education

Local ecosystem users should know the correct rules of conduct in a marine plant ecosystem. Trawling, dredging, and anchoring should be prohibited in a seaweed and seagrass meadow. Care should also be taken to reduce physical damage by boat propellers, especially during low tide. To achieve this, proper identification of the local stakeholders must exist, and how best to reach out to them.

(d). Transplantation

For the plan, seaweed and seagrass transplantation should be conducted to restore damaged ecosystems. However, such work requires basic research beforehand to understand selected species' phenology, ecology, and life cycle. This necessarily translates into the involvement of a research institution to design and conduct research in all the relevant areas.

(e) Future studies

This preliminary study provides a brief insight into the marine plants' ecosystem of the Peninsular Malaysia, Sabah and Sarawak. However, we would recommend conducting future studies in the following areas:

(i) Marine plants phenology and ecology

Phenology studies the timing of recurring biological events, the causes of their timing of biotic and abiotic forces, and the interrelation among phases of the same or different species. Phenological events include seasonal variations in leaf growth biomass, shoot density, reproduction and recruitment, and the timing of fertility and reproduction. These events need to be understood to hypothesize better the capacity of a specific seaweed and seagrass ecosystem to support marine organisms, especially an endangered species like the dugong population. The link between aquatic plants' phenological events and environmental parameters, such as physical water quality data, nutrient levels, and tidal patterns, must be studied in greater depth if threat identification and management become necessary.

(ii) Marine plants recovery

Seaweed and seagrass mortality and recovery rates in response to environmental pressure such as nutrient limitation, low light conditions, epiphytic colonization, and herbivory, for example, provide insights into the resilience of the seaweed and seagrass ecosystem. Knowledge of these will allow better management of the ecosystem.

(iii) Culture collection

A culture collection of marine microalgae, seaweed, and seagrasses should be set up in a laboratory environment to facilitate research on the life cycle of selected species. These propagated specimens may also form the basis for seagrass transplanting and replanting work, where juveniles are grown to an optimal size in the controlled environment of a laboratory and then planted in damaged ecosystems that require recolonization.

(iv) Further surveys

Further surveys need to be carried out to map and characterize marine plant habitats in Peninsular Malaysia, Sabah, and Sarawak. If considering the entire marine plants of Malaysia, then the coastline of Sabah and Sarawak should be studied in detail before any definitive conclusions are drawn about the diversity and biogeography of aquatic plants in Malaysia.

For future research in mangrove biodiversity, it is recommended to use the established database for Malaysian mangrove study. The database can include the following:

i) collection of mangrove related study in Malaysia, including journal articles, books, proceedings, technical reports, etc

ii) herbarium- to preserve and keep the mangrove specimen for future reference

Table 15: Identification of Potential Areas to be protected for MPAs

No	Marine Plants Area	Associated habitats	Importance of the area	Threats
1.	Sungai Merbok estuary	Sub-tidal	(i) Association of marine microalgae, seaweeds, seagrasses and mangroves for the fisheries industry	(i) Oil pollution (ii) sediment movement
2.	Middle bank, Penang	Sub-tidal	(i) Association of seaweeds and seagrasses and associated fauna	(i) Oil pollution (ii) Wind-blown waves, sediment movement
3.	Teluk Kemang, Negeri Sembilan	Coral reef flats	(i) Association of seaweeds, seagrasses, mangroves, and associated fauna (ii) Biodiversity (corals, gastropods, seaweeds, seagrasses, microalgae, mangroves, zooplankton, fishes, etc.) (iii) Traditional capture fisheries (iv) Area for scientific study	(i) Sedimentation due to coastal development (e.g. hotels, resorts, restaurants) (ii) Sand mining, oil pollution, e.g., tarballs (iii) Public recreational area (iv) Wind-blown waves, sediment movement
4.	Tanjung Adang-Merambong, Johor	Sub-tidal shoals	(i) Association of seaweeds, seagrasses, mangroves, and associated fauna (ii) Biodiversity (gastropods, seaweeds, fishes, microalgae, zooplankton, etc.) (iii) Traditional capture fisheries support local coastal communities	(i) Land reclamation for port facilities causes sedimentation and burial of seagrass beds and destroys a shoal (ii) Transportation avenues

No	Marine Plants Area	Associated habitats	Importance of the area	Threats
5.			(iv) Gleaning site for gastropods and bivalves (v) Nursery ground for invertebrates and vertebrates (vi) A feeding ground for dugongs and birds (vii) Area for scientific study	
6.	Pulau Besar, Pulau Sibu, Pulau Sibu Tengah, Pulau Tinggi, Johor Pulau Tioman, Pahang Pulau Langkawi, Kedah Pulau Besar, Melaka	Sub-tidal, off-shore island	(i) Biodiversity (seaweeds, seagrass, microalgae, fishes, zooplankton, gastropods, etc.) (ii) Shoreline stabilization (iii) Traditional capture fisheries supporting local coastal population (iv) Pristine area for scientific study (v) Turtle and dugong feeding ground (vi) Area for scientific study	(i) Transportation avenues (ii) Tourism (iii) Wind-blown waves, shifting of sand during the north-east monsoon
7.	Telaga Simpul, Pantai Bari Kecik, Pantai Chendering, Terangganu	Inter-tidal	(i) Biodiversity (seaweeds, seagrass, microalgae, fishes, zooplankton, gastropods, etc.) (ii) Shoreline stabilization against wave and tidal currents	(i) Sand mining for shoreline stabilization against the north-east monsoon (ii) Digging activities for polychaetes

	Marine Plants Area	Associated habitats	Importance of the area	Threats
			(iii) Traditional capture fisheries (iv) Polychaete collection by the locals for fish baits	(iii) Wind-blown waves, shifting of sand during the north-east monsoon
8.	Pantai Kemasik, Pantai kuala Abang, Tanjung Jara, Terengganu	Semi-enclosed lagoon and shoal	(i) Biodiversity (seaweeds, seagrass, microalgae, fishes, zooplankton, gastropods, etc.) (ii) Traditional capture fisheries supporting local coastal communities (iii) Gleaning site for bivalves (iv) Breeding ground for bivalves	(i) Transportation avenues (ii) Pull the net (iii) Sand dredging and mining for flood control (iv) Freshwater, wind-blown waves, shifting of sand during the north-east monsoon
9.	Merchang, Terengganu	Semi-enclosed lagoon	(i) Biodiversity (seaweeds, seagrass, microalgae, mangroves, fishes, zooplankton, gastropods, etc.) (ii) Traditional capture fisheries supporting local coastal population (iii) Area for scientific study	(i) Transportation avenues (ii) oil pollution, e.g., tarballs (iii) Freshwater, wind-blown waves, shifting of sand during the north-east monsoon
10.	Gong Batu, Setiu, Terengganu	Semi-enclosed lagoon	(i) Site for fish (Lates calcifer, Epinephelus sexfasciatus) cage culture (ii) Site for nine interconnected ecosystem– home for mangrove true species & hybrids, freshwater plant	(i) Transportation avenues (ii) Sand dredging and mining for flood control

No	Marine Plants Area	Associated habitats	Importance of the area	Threats
			species, *Melaleuca* species, Peat swamp species, beach species,	(iii) Freshwater from rain during north-east monsoon
11.	Pulau Redang, Pulau Perhentian Besar, Pulau Perhentian Kecil,	Sub-tidal	(i) Marine Park protected (ii) Traditional capture fisheries supporting local coastal communities (iii) Turtle sanctuary	(i) Illegal fishing (ii) Tourism
12.	Pulau Bidong Laut, Terengganu		(iv) Area for scientific study	(iii) Wind-blown waves, shifting of sand, and erosion during the north-east monsoon
13.	Kuala Semerak, Pengkalan Nangka, Kelantan	Semi-enclosed lagoon	(i) Traditional capture fisheries supporting local coastal population (ii) Site for fish (Lates calcarifer, Epinephelus sexfasciatus) cage culture (iii) Gleaning site (Geloina coaxans, Meretrix meretrix, Hiatula solida) (iv) Migrant bird (Egretta garzetta) feeding ground	(i) Pull the net (ii) Digging activities for the collection of Hiatula solida, Meretrix meretrix (iii) Sand dredging and mining for flood controls and land based-development (iv) Freshwater from rain during the north-east monsoon

No	Marine Plants Area	Associated habitats	Importance of the area	Threats
14.	Taman Tuanku Abdul Rahman Marine Parks, Pulau Gaya, Pulau Manukan, Pulau Mantanani, Pulau Tiga, Sabah	Sub-tidal, off-shore island	(i) Marine park protected for the conservation of local fauna and flora (ii) Biodiversity (seaweeds, seagrass, microalgae, fishes, zooplankton, gastropods, etc.) (iii) Area for scientific study (iv) Site for monitoring of seagrass communities on the effect of global warming (v) Dugong feeding ground	(i) Illegal fishing, fish bombing (ii) Illegal collection of invertebrates, e.g., sea cucumbers, sea urchins, seaweeds (Caulerpa sp.), gastropods (iii) Tourism
15.	Sepangar bay, Kota Kinabalu Coastal area, Sabah	Inter-tidal	(i) Biodiversity (seaweeds, seagrass, microalgae, fishes, zooplankton, gastropods, etc.) (ii) Shoreline stabilization (iii) Traditional capture fisheries supporting local coastal population (iv) Gleaning site for bivalves, gastropods, sea cucumbers, macroalgae (v) Collection of peanut worms for fish baits	(i) Digging activities for peanut worms (ii) Wind-blown waves, shifting of sand, and erosion during south-west monsoon

No	Marine Plants Area	Associated habitats	Importance of the area	Threats
16.	Pulau Selingan, Pulau Bakungan Kecil, Sabah	Sub-tidal, off-shore islands	(i) Marine park protected (ii) Biodiversity (seaweeds, seagrass, microalgae, fishes, zooplankton, gastropods, etc.) (iii) Turtle sanctuary, totally protected	(i) Illegal fishing, fish bombing
17.	Bak-bak & Limau-limauan, Tun Mustapha Marine Park, Teluk Sepinong, Sandakan, Sabah	Sub-tidal, off-shore islands	(i) Marine park protected (ii) Biodiversity (seaweeds, seagrass, microalgae, fishes, zooplankton, gastropods, etc.) (iii) Turtle sanctuary, totally protected	(i) Illegal fishing, fish bombing
18.	Punang-Sari-Lawas river estuary, Sarawak	Inter-tidal	(i) Biodiversity (seaweeds, seagrass, microalgae, fishes, zooplankton, gastropods, etc.) (ii) Traditional capture fisheries (smoked fish, Ilisha elongata or locally known as Tahai) supporting the local coastal population (iii) Gleaning site (Meretrix meretrix) (iv) Feeding ground for dugong and birds	(i) Digging activities for the collection of Meritrix meretrix (ii) Wind-blown waves, shifting of sand and

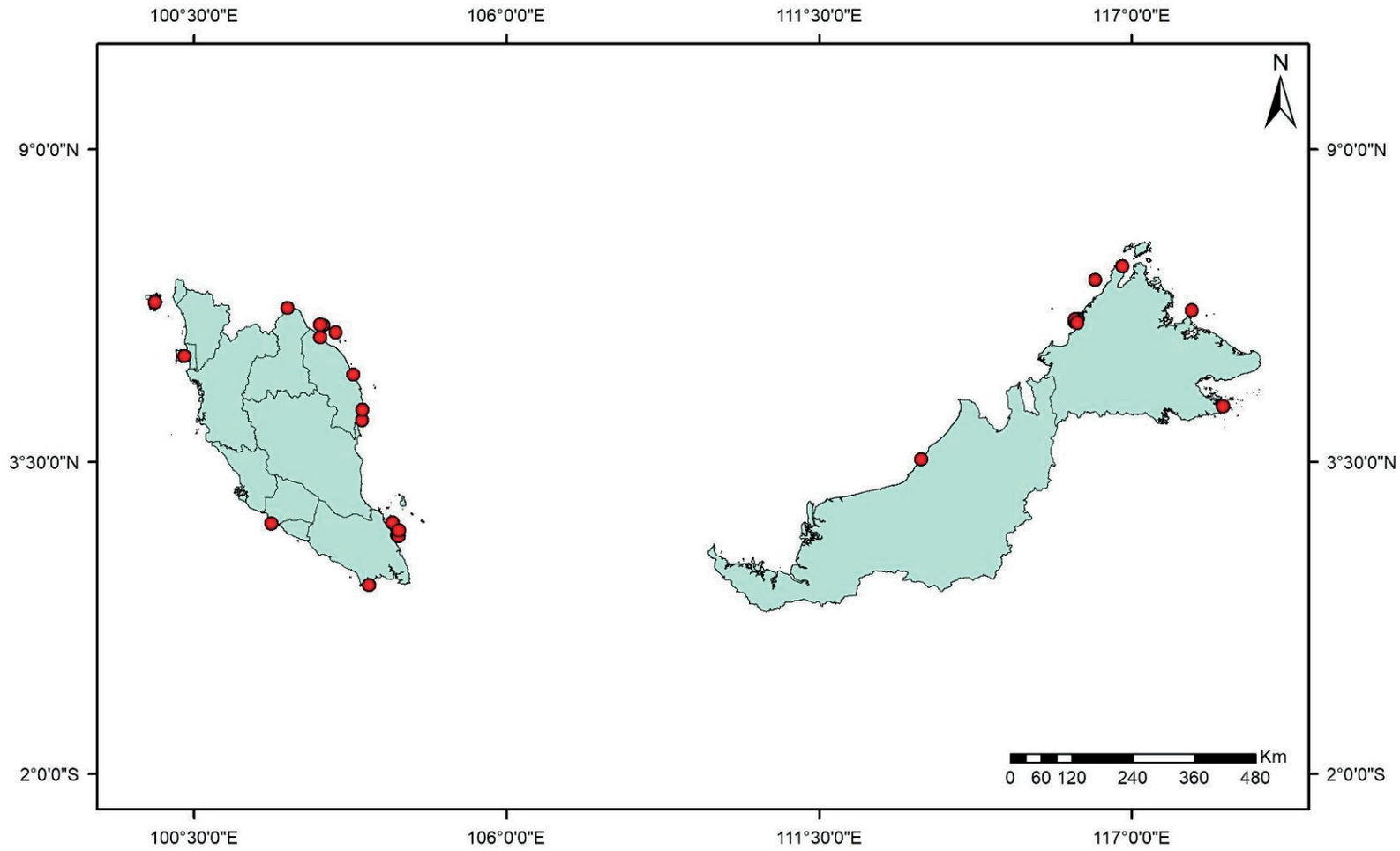


Figure 28: The maps of Potential Areas to be protected for MPAs

7.0 CONCLUSION

Malaysian coastline and marine waters are witnessing rapid development. The baseline data on aquatic plants, including microalgae, seaweed, seagrass, and mangrove diversity and resources, would help understand changes that may arise from physical changes in the environment, pollution load, and climate change. Through careful planning and strategic adaptive management systems, it is possible to mitigate the impact on coastline and marine waters and sustainably use of ecosystem services.

8.0 REFERENCES

Abdul, H. N., Naqqiuddin, M.A., Zulkifli, S.Z., Abu Hena, M.K., Omar, H. & Ismail, A. (2016). Phytoplankton diversity in tiger shrimp pond in Merlimau, Malacca. *Proceedings Malaysia Ecology Seminar 2016, Putrajaya International Convention Centre*. (pp 223.)

Abdul-Hamid, H., Mohamad-Ismail, F. N., Mohamed, J., Samdin, Z., Abiri, R., Tuan-Ibrahim, T. M., Mohammad, L. S., Jalil, A. M., Jalil, A. M., & Naji, H. R. (2022). Allometric Equation for Above ground biomass estimation of mixed mature mangrove forest. *Forests. 13* (2), 325.

Abdul Khalil, H.P.S., Tye, Y.Y., Ismail, Z., Leong, J.Y., Saurabh, C.K., Lai, T.K., Chong, E.W.N., Aditiawati, P., Md. Tahir, P. & Dungani R. (2017). Oil Palm Shell Nanofiller in Seaweed-based Composite Film: Mechanical, Physical, and Morphological Properties. *BioResources Journal, 12* (3),5996-6010.

Abdul Khalil, H.P.S., Chong, E.W.N., Owolabi, F.A.T., Asniza, M., Tye, Y.Y., Tajarudin, H.A., Paridah, M.T. & Rizal, S. (2018). Microbial-induced CaCO3- filled seaweed-based film for green plasticulture application. *Journal of Cleaner Production. 199,* 150-163.

Abdul Qudus B Aroyehun, Shariza Abdul Razak, Kishneth Palaniveloo, Thilahgavani Nagappan, Nur Suraiza Nabila Rahmah, Gan Wee Jin, Dinesh Kumar Chellappan, Jestin Chellian and Anil Philip Kunnath (2020). Bioprospecting Cultivated Tropical Green Algae,*Caulerpa racemosa* (Forsskal) J. Agardh: A Perspective on Nutritional Properties, Antioxidative Capacity and Anti-Diabetic Potential. *Foods, 9* (9), 1313

Abdullah, N.S., Naim, M.A., Mohd-Nor, N., and Zainal Abidin, Z.A. (2020). Diversity of cultivable bacteria by strategic enrichment isolated from farmed edible red seaweed, Gracilaria sp. *Journal Clean WAS, 4* (1), 17-20.

Abu Bakar, N.A., Ibrahim, T.A.T., Shalan, N.A.M., and Mohamed, S. (2017). Changes in rats' breast tumor ultrastructure and immune and messenger RNA responses caused by dietary Seaweed (*Kappaphycus alvarezii*) extract. *Journal of Microscopy and Ultrastructure, 5,* 70–81.

Abu Hena, M. K., Misri, K., Japar Sidik, B., Hishamuddin, O., & Hidir, H. (2001). Photosynthesis of seagrass *Cymodocea serrulata* (Magnoliophyta /Potamogetonales / Cymodoceaceae) in field and laboratory. *Indian Journal of Marine Sciences, 30* (4), 253-256

Abu Hena, M. K., Misri, K., Japar Sidik, B., Hishamuddin, O., & Hidir, H. (2001). Photosynthetic and respiration responses of Dugong grass *Thalassia hemprichii* (Ehrenberg) Aschers. at Teluk Kemang seagrass bed, Malaysia. *Pakistan Journal of Biological Sciences. 4* (12), 1487-1489.

Abu Hena, M.K., Misri, K., Japar Sidik, B., Hishamuddin, O. & Hidir, H. (2004). A preliminary study of the biological aspects of an intertidal seagrass *Thalassia hemprichii* (Ehrenberg) Ascherson in Port Dickson, Malaysia. *Pakistan Journal of Biological Sciences. 7*(10), 1801-1807.

Abu Hena, M.K., Ismail, J., Idris, M.H. & Bhuiyan, M.K.A (2016). Seagrasses from Lawas, Sarawak, Malaysia: Diversity and Ecosystem Approaches. *Poster. International Fisheries Symposium, IFS 2016, Phu Quoc Island, Vietnam.*

Abu Hena, M.K., Muta Harah, Z., Japar Sidik, B., Bhuiyan, M.K.A & Nesarul, H.M. (2016). Seagrasses ecosystems in Malaysian waters: Climate change impacts and fisheries outlook. *Poster. Water security and climate change. Challenges and opportunities in Asia. Institute of Technology, Bangkok 29-Nov - 1 Dec 2016.*

Adam, M.F., Zakaria, R.M., Fry, B., Chong, V.C., Then, Y.H.A., Brown, C.J., & Lee, S.Y. (2018). Loss and recovery of carbon and nitrogen after mangrove clearing. *Ocean & Coastal Management, 161*, 117-126.

Adenan, N.S. (2012). Lipid Production in Marine Microalgae Under Different Salinity, Temperature and Nutrient Levels. *Doctoral dissertation, Universiti Putra Malaysia*.

Adenan, N.S., Yusoff, F.M., Medipally, S.R., & Shariff, M. (2016). Enhancement of lipid production in two marine microalgae under different levels of nitrogen and phosphorus deficiency. *Journal of Environmental Biology, 37*(4), 669.

Affandi, N.A.M., Kamali, B.M.R., Tamin, N.M., & Hashim, R. (2010). Early growth and survival of *Avicennia alba* seedlings under excessive sedimentation*. Scientific Research and Essays, 5* (18), 2801-2805.

Ahmad, F., Sulaiman, M.R., Saimon, W., Yee C.F., & Matanjun, P., (2012). Proximate compositions and total phenolic contents of selected edible seaweed from Semporna, Sabah, Malaysia. *Borneo Science, 31*, 85-96.

Ahmad S. (2006). Seaweed industry in Sabah, east Malaysia. In: Phang, S.M., Critchley A.T. and Ang P.O. Jr (eds.). *Advances in Seaweed Cultivation and Utilization in Asia*. University of Malaya Maritime Research Centre Publication, Malaysia, (pp 41-52).

Ahmad, Z., Kassim, Z., Shaari, R., Amin, A.M., Shammodin, M.S., Rosli, N.S.M., Hasnan, H. H., Shammodin, N., & Jinah, M.I.H.M. (2020). Mapping mangrove distribution in Kong Kong Laut, Masai, Johor, using remote sensing. *Malayan Nature Journal, 72*(4), 545–550.

Ahmad, Z., Mohamad Suharni, M. L., Taib, S. N. A., & Shammodin, M. S. (2019). Impact of coastal development on mangrove distribution in Cherating Estuary, Pahang, Malaysia. *Malaysian Journal of Fundamental and Applied Sciences, 15*(3), 456–461. https://doi.org/10.11113/mjfas.v15n3.1091

Ahmad-Kamil, E.I., Ramli, R., Jaaman, S.A., Bali, J., & Al-Obaidi, J.R. (2013). The effects of water parameters on monthly seagrass percentage cover in Lawas, East Malaysia. *The Scientific World Journal,* Article ID 892746, pp 1-8.

Akhir, M.S.A.M., Amir, A.A., & Mokhtar, M. (2017). Nutrients and Pollutants Removal in Small-Scale Constructed Wetland in Frangipani Resort Langkawi, Malaysia. *Nature Environment and Pollution Technology, 16* (2), 569.

Al-Asif, A., Hamli, H., Abu Hena, M.K., Idris, M.H., Gerusu, G.J., Ismail, J. & Karim, N.U. (2020). Benthic macrofaunal assemblage in seagrass-mangrove complex and

adjacent ecosystems of Punang-Sari Estuary, Lawas, Sarawak, Malaysia. *Biodiversitas. 21*(10): 4606-4615.

Ali, M.K.M., Wong, J.V.H., Sulaiman, J., Juli, J.L., and Md. Yasir, S. (2014). Improvement of Growth and Mass of *Kappaphycus Striatum var. Sacol* by Using Plant Density Study at Selakan Island in Semporna Malaysia. *International Conference on Biological, Chemical and Environmental Sciences (BCES-2014) June 14-15, 2014 Penang, Malaysia*

Ali, M.K.M., Critchley, A.T., and Hurtado, A.Q., (2019). Micropropagation and sea-based nursery growth of selected commercial *Kappaphycus* species in Penang, Malaysia. *Journal of Applied Phycology*. https://doi.org/10.1007/s10811-019-02003-4

Ali, M. A., Abd Halim, M. H., Masnan, S. S. K., & Saidin, M. M. (2021). The Biological Diversity of Sungai Merbok in Fulfill Requirement of Criteria for Natural Tourism. *Quantum Journal of Social Sciences and Humanities, 2*(4), 53-66.

Amin, N. M., & Hasan, F. A. (2003). Setiu Wetlands: Tranquility Amidst Plenty. Kolej Universiti Sains dan Teknologi Malaysia.

Aminah, H., Ahmad Fauzi, M. S., Hamzah, M. & Mohd Nasir, H. (2008). Penghasilan bahan tanaman nyireh batu (*Xylocarpus moluccensis*) melalui kutipan anak benih liar. In: *Prosiding Seminar Pemuliharaan Hutan Persisiran Pantai Negara 2008: Hasil Penyelidikan Dan Aplikasinya Kepada Tanaman Serta Kesedaran Komuniti* (pp. 127-130)

Amir, A. A. (2012). Canopy gaps and the natural regeneration of Matang mangroves. *Forest Ecology and Management, 269,* 60-67.

Amir, A. A. (2018). Protecting our mangroves and coastal wetlands. *New Straits Times.* https://www.nst.com.my/opinion/columnists/2018/12/437325/protecting-our-mangroves-and-coastal-wetlands.

Amri, A.Y., Sim, J.O.L., Phang, S.M., Hussin, A., Rosman, F.R. & Fauzi, R. (2005). Dugongs In Peril: The Conservation and Protection of Dugongs in Johor, Malaysia. *Technical Report. A joint project by TITAN Chemicals Corp Bhd, United Nations Development Programme & University Malaya Maritime Research Centre*, (pp. 110)

Amri, A.Y., Sim, J.O.L., Phang, S.M., Hussin, A., Rosman, F.R. & Fauzi, R. (2005). Phase II Dugongs In Peril: The Conservation and Protection of Dugongs in Johor, Malaysia & Part I: Seagrass Survey Report July 2008. *Technical Report. A joint project by TITAN Chemicals Corp Bhd & University Malaya Maritime Research Centre,* (pp. 1-58)

Andy, R.M., Aminuddin, M., Walter, L., & Nurul, N. S., (2008). A Study on Mangrove Diversity at Kudat Mainland and Bangi Island, Sabah Malaysia. In: *Prosiding Seminar Pemuliharaan Hutan Persisiran Pantai Negara 2008: Hasil Penyelidikan Dan Aplikasinya Kepada Tanaman Serta Kesedaran Komuniti* (pp. 139-150)

Anis, S. (2012). Study of Species Composition and Stand Structure of Mangrove Forest at Pulau Kecil and Western of Pulau Besar in Merang, Terengganu. *Undergraduate thesis, Bachelor of Science in Marine Science, Faculty of Maritime Studies and Marine Science, Universiti Malaysia Terengganu, Terengganu*. (pp 1-136)

Anton, A., Teoh, P. L., Mohd-Shaleh, S. R., & Mohammad-Noor, N. (2008). First occurrence of *Cochlodinium* blooms in Sabah, Malaysia. *Harmful algae, 7*(3), 331-336.

Ariffin, S.A., Ramasamy, K., Davis, P., Mani, V., and Adbulla, M.A. (2014). Safety of Malaysian marine endophytic fungal extract S2 from a brown seaweed *Turbinaria conoides*. *Journal of Coastal Life Medicine, 2* (7), 527-534.

Arina, N.; Chandran, R., Hidayah, N., Zainee, N.F.A., Prathep,A., Rozaimi, M. (2020). Coralline macroalgae contribution to ecological services of carbon storage in a disturbed seagrass meadow. *Marine Environmental Research, 162,* Article number 105156.

Arina, N., Ashikin, C.N., Hidayah, N., Fairoz, M. & Rozaimi, M. (2020). Data on sediment nitrogen loadings and nitrogen in the biomass of seagrasses from Sungai Pulai estuary (Johor, Malaysia). *Data in brief. 28*, Article number 104979

Aroyehun, A.Q., Palaniveloo, K., Ghazali, F., Idid, M.R., Abdul Razak, S. (2019). Effects of Seasonal Variability on the Physicochemical, Biochemical, and Nutritional Composition of Western Peninsular Malaysia *Gracilaria manilaensis*. *Molecules MDPI, 24* , Article number 3298.

Arshad, A., Japar Sidik, B., Muta Hara, Z., Yusof, S. & Ghaffar, M. A. (2006). Fish communities from seagrass bed of Merchang Lagoon, Terengganu, Peninsular Malaysia. *Coastal Marine Science. 30* (1), 268-275.

Arshad, A., Jimmy, A., Nurul Amin, S.M., Japar Sidik, B. & Muta Hara, Z. (2008) Length-weight and length-length relationships of five fish species collected from seagrass beds of the Sungai Pulai estuary, Peninsular Malaysia. *Journal Applied Ichthyology. 24*, 328–329

Arshad, A., Nurul Amin, S.M, Osman, N., Che Cob, Z. & Saad, C.R. (2010). Population Parameters of Planktonic Shrimp, *Lucifer intermedius* (Decapoda: Sergestidae) from Sungai Pulai Seagrass Area Johor, Peninsular Malaysia. *Sains Malaysiana. 39* (6), 877-882.

Arshad, A., Ara, R., Amin, S.M.N., Effendi, M., Zaidi, C.C. & Mazlan, A.G. (2011). Influence of environmental parameters on shrimp post-larvae in the Sungai Pulai seagrass beds of Johor Strait, Peninsular Malaysia. *Scientific Research and Essays. 6* (26), 5501-5506.

Ashton, E.C., & Macintosh, D.J. (2002). Preliminary assessment of the plant diversity and community ecology of the Sematan mangrove forest, Sarawak, Malaysia. *Forest Ecology and Management, 166*(1–3), 111–129. https://doi.org/10.1016/S0378-1127(01)00673-9

Ashton, E.C., Hogarth, P.J., & Ormond, R. (1999). Breakdown of mangrove leaf litter in a managed mangrove forest in Peninsular Malaysia. In: Diversity and function in mangrove ecosystems. Springer, Dordrecht. (pp. 77-88).

Asmida, I., Noor Akmal, A.B., Ahmad, I., & Sarah Diyana, M. (2017). Biodiversity of Macroalgae in Blue Lagoon, the Straits of Malacca, Malaysia and Some Aspects of Changes in Species Composition. *Sains Malaysiana, 46* (1): 1–7.

Asri, A., Masson, V.L., Montalescot, V., Lim, P.E., Nor, A.M., Hussin, H., & Shaxson, L. (2021). The role of migrants in the Malaysian seaweed value-chain. *Marine Policy, 134*:104812.

Assaw, S., Rosli, N.L., Mat Azmi, N.A., Mazlan, N.W., & Ismail, N. (2018). Antioxidant and antibacterial activities of polysaccharides and methanolic crude extracts of local edible red seaweed *Gracilaria* sp. *Malays. Appl. Biol., 47*(4), 135–144.

Azian, M., Ismail, H. & Mohd Afendi, H. (2009). *Laporan jawatankuasa teknikal mengenai penyelidikan dan pembangunan (R&D): Program penanaman bakau dan spesies-spesies yang sesuai di pesisiran pantai negara bagi tahun 2007. Kepong, Selangor: Institut Penyelidikan Perhutanan Malaysia.*

Azim, N. H., Subki, A., & Balia Yusof, Z. N. (2018). Abiotic stresses induce total phenolic, total flavonoid and antioxidant properties in Malaysian indigenous microalgae and cyanobacterium. *Malaysian Journal of Microbiology, 14* (1), 25-33

Aziz, S.M.A. (2018). Potential of Malaysia seaweed extracts in inhibiting *Ganoderma boninese* and identification of their antifungal compound. *Thesis Master of Science, Universiti Putra Malaysia.*

Azman, B.A.R., Ramlan, O., Wan-Lotfi, W.M., Zaidi, C.C. & Othman, B.H.R. (2008). Seagrass biodiversity of Pulau Tinggi, Johor. *Research and Information Series of Malaysian Coasts (2nd Series). Malaysia marine ecosystem: Opportunities & Recent Researchers.* (pp 53-57.)

Azman, M. S., Sharma, S., Shaharudin, M. A. M., Hamzah, M. L., Adibah, S. N., Zakaria, R. M., & MacKenzie, R. A. (2021). Stand structure, biomass and dynamics of naturally regenerated and restored mangroves in Malaysia. *Forest Ecology and Management, 482*, 118852.

Azmi, A.A., Yoshida, T., Toda, T., Ross, O.H. & Cob, Z.C. (2016). Comparison of zooplankton abundance and community in seagrass and non-seagrass areas of Merambong shoal. In: *The 2016 UKM FST Postgraduate Colloquium, AIP Conference Proceedings, 1784*, 060002-1-060002-7.AIP Publishing.

Azmi, N.F., Ghaffar, M.A & Cob, Z.C. (2018). Apicomplexa-like parasites in some gastropods from Merambong seagrass bed, Johor Straits, Malaysia. *Turkish Journal of Fisheries and Aquatic Sciences. 19* (2): 89-97.

Azmil, A.R., Wan Juliana, W.A., Razali, M.S., Shahir, S., Al-Hadi, M., & Firdaus, N.A. (2012). *Flora bakau Pulau Pangkor. Hutan Pulau Pangkor Perak: Pengurusan Hutan Persekitaran Fizikal dan Kepelbagaian Biologi Siri Kepelbagaian Biologi Hutan*, 19, 19-128.

Baba, B.M., Wan Mustapha, W.A. & Lim, S.J. (2018). Effect of extraction methods on the yield, fucose content and purity of fucoidan from *Sargassum* sp. obtained from Pulau Langkawi, Malaysia. *Malaysian Journal of Analytical Sciences, 22*(1), 87 – 94

Baharuddin, N.N.D.E., Aziz, N.S., Sohif, H.N., Karim, W.A.A., Al-Obaidi, J.R., & Basiran, M. (2016). Marine microalgae flocculation using plant: the case of *Nannochloropsis oculata* and *Moringa oleifera*. *Pak J Bot, 48* (2), 831-840.

Bajury, D.M., Rawi, M.H., Sazali, I.H., Abdullah, A., & Sarbini, S.R. (2017). Prebiotic evaluation of red seaweed (*Kappaphycus alvarezii*) using invitro colon model. *International Journal of Food Sciences and Nutrition, 68,* (7), 821-828,

Banerjee, S., Hew, W.E., Khatoon, H., Shariff, M., & Yusoff, F.M. (2011). Growth and proximate composition of tropical marine *Chaetoceros calcitrans* and *Nannochloropsis oculata* cultured outdoors and under laboratory conditions. *African Journal of Biotechnology. 10*(8), 1375-1383.

Begum, H., Khatoon, H., Yusoff, F.M., & Shariff, M. (2020). Production and Purity of Phycobiliproteins from Selected Marine and Freshwater Cyanobacteria Subjected to Different Drying Methods. *Asian Fisheries Science, 33*, 258-265.

Bhuyar, P., Ab.Rahim, M.H., Yusoff, M.M., Maniam, G.P. & Govindan, N. (2019). A selective microalgae strain for biodiesel production in relation to higher lipid profile. *Maejo International Journal of Energy and Environmental Communication, 1*(1), pp.8–14.

Bhuyar, P., Rahim., M.H., Sundararaju, S., Maniam, G.P., and Govindan, N., (2020). Antioxidant and antibacterial activity of red seaweed; *Kappaphycus alvarezii* against pathogenic bacteria. *Global J. Environ. Sci. Manage. 6* (1), 47-58. DOI: 10.22034/gjesm.2020.01.04

Bhuyar, P., Dang, D.H, Mandia, E., Ab.Rahim, M.H., Maniam, G.P. & Govindan, N. (2020). Salinity reduction from poly-chem-industrial wastewater by using microalgae (*Chlorella* sp.) collected from coastal region of peninsular Malaysia. *The Yale journal of biology and medicine, 1,* 1-14.

Bhuyar, P., Dang, D.H, Mandia, E., Ab.Rahim, M.H., Maniam, G.P. & Govindan, N. (2020). Desalination of polymer and chemical industrial wastewater by using green photosynthetic microalgae, *Chlorella* sp. *Maejo International Journal of Energy and Environmental Communication, 1,* 9-19.

Bhuyar, P., Ab.Rahim, M.H., Maniam, G.P., Ramaraj, R. & Govindan, N. (2020). Exploration of bioactive compounds and antibacterial activity of marine blue-green microalgae (*Oscillatoria* sp.) isolated from coastal region of west Malaysia. *SN Applied Sciences. 2*. 1906. 10.1007/s42452-020-03698-8.

Bhuyar, P., Yusoff, M.M., Ab.Rahim, M.H., Sundararaju, S., Maniam, G.P. & Govindan, N. (2020). Effect of plant hormones on the production of biomass and lipid extraction for biodiesel production from microalgae *Chlorella* sp. *Journal of microbiology, biotechnology and food sciences, 9*, 671-674. 10.15414/jmbfs.2020.9.4.671-674.

Bhuyar, P., Sundararaju, S., Ab.Rahim, M.H., Maniam, G.P. & Govindan, N . (2021). Enhanced productivity of lipid extraction by urea stress conditions on marine microalgae *Coelastrum* sp. for improved biodiesel production. *Bioresource Technology Reports, 15*. 100696. 10.1016/j.biteb.2021.100696.

Bin, Y.C., Hong, L.S., Ibrahim, Y.S., Bachok, Z. & Anuar, S.T. (2021). Dynamic Fatty Acid Profile of Asian Sea Bass (*Lates calcarifer*) From Setiu Wetlands, East Coast Peninsular Malaysia. *Malaysian Journal of Analytical Sciences, 25*, 53-61.

Bong, S.C., & Loh, S.P. (2013). A study of fatty acid composition and tocopherol content of lipid extracted from marine microalgae, *Nannochloropsis oculata* and *Tetraselmis suecica*, using solvent extraction and supercritical fluid extraction. *International Food Research Journal, 20* (2).

Chan, C.X., Teo, S.S., Ho, C.L., Othman, R.Y., & Phang, S.M. (2004). Optimisation of RNA extraction from *Gracilaria changii* (Gracilariales, Rhodophyta). *Journal of Applied Phycology, 16*, 297–301.

Chan, S.W., Mirhosseini, H., Taip, F.S., Ling, T.C., & Tan, C.P. (2013). Comparative study on the physicochemical properties of k-carrageenan extracted from *Kappaphycus alvarezii* (doty) doty ex Silva in Tawau, Sabah, Malaysia and commercial k-carrageenans. *Food Hydrocolloids, 30,* 581-588.

Chan, P.T., Matanjun, P., Md Yasir, S., & Tan, T.S. (2014). Antioxidant activities and polyphenolics of various solvent extracts of red seaweed, *Gracilaria changii. J. Appl. Phycol.* DOI 10.1007/s10811-014-0493-1

Chan, P.T & Matanjun, P. (2017).Chemical composition and physicochemical properties of tropical red seaweed, *Gracilaria changii*. *Food Chemistry. 221* , 302-310

Chandra, I.A., Seca, G., Noraini, R., Ahmad, M.M.P., Osumanu, H.A., Hazandy, A.H., & Nik, M.A.M. (2015). Soil carbon storage in dominant species of Mangrove Forest of Sarawak, Malaysia. International *Journal of Physical Sciences, 10*(6), 210–214. https://doi.org/10.5897/ijps2014.4183

Chang, V.S. & Teo, S.S. (2016). Evaluation of heavy metal, antioxidant and anti-tyrosinase activities of red seaweed (*Eucheuma cottonii*). *International Food Research Journal 23*(6), 2370-2373.

Chang, V.S., Okechukwu, P.N., & Teo, S.S. (2017). The properties of red seaweed (*Kappaphycus alvarezii*) and its effect on mammary carcinogenesis. *Biomedicine & Pharmacotherapy, 87*, 296–301.

Chang, Y.S., Cheah, Y.T., Lyly, L.H.T., Ishak, N.I.I., Ng, Y.S., Ahmad, A.L., & Ooi, B.S. (2021). Microalgal exopolymeric substances fouling in submerged vacuum membrane distillation and its mitigation via enhanced air bubbling. *Desalination, 508*, 115047.

Che Cob, Z., Arshad, A., Wan Muda, W. L. & Mazlan, A.G. (2008). Gastropod and Bivalve Mollusks Associated with The Seagrass Bed at Merambong Shoal, Johor Straits, Malaysia. In: Mohamed, C.A.R, Sahrani, f.k., Ali, M.M, Che Cob, Z. & Ahmad, N. (Eds.). *Malaysia Marine Ecosystem: The studies of Johor Darul Takzim East Coast*. (pp 89-100).

Che Cob, Z., Arshad, A., Bujang, J.S., Bakar, Y., Simon, K.D. & Mazlan, A.G. (2012). Habitat preference and usage of *Strombus canarium* Linnaeus, 1758 (Gastropoda: Strombidae) in Malaysian seagrass beds. *Italian Journal of Zoology*. 1-9.

Che Cob, Z., Arshad, A., Bujang, J.S., & Ghaffar, M.A. (2014). Spatial and temporal variations in *Strombus canarium* (Gastropoda: Strombidae) abundance at Merambong seagrass bed, Malaysia. *Sains Malaysiana, 43* (4): 503-511.

Chee, S.Y., Wong, P.K. & Wong, C.L. (2011). Extraction and characterisation of alginate from brown seaweeds (Fucales, Phaeophyceae) collected from Port Dickson, Peninsular Malaysia. *Journal of Applied Phycology, 23*,191-196.

Chen, J.T., Mustafa, E.M., Vello, V., Lim, P., Sulaiman, N.N., Majid, N.A., Phang, S.M., Md. Tahir, P. & Liew, K. (2016). Preliminary assessment of Malaysian micro-algae strains for the production of biojet fuel. *IOP Conference Series: Materials Science and Engineering, 152* (1), 012042).

Chew, Y.L., Lim, Y.Y., Omar, M. & Khoo, K.S. (2008). Antioxidant activity of three edible seaweeds from two areas in South East Asia. *LWT, 41,* 1067–1072.

Chik, M.N., & Yahya, L. (2012). Comparison of carbon fixation abilities of selected marine microalgae species. *PERINTIS eJournal, 2*.

Chik, M., Yahya, L., Boosroh, M., & Shamsudin, L. (2012). Scanning of microalgae species for biological CO_2 fixation at a Malaysian coastal coal-fired power station. *OIDA International Journal of Sustainable Development, 4* (3), 19-28.

Chik, M.N. (2017). Isolation, purification and identification of microalgae from coal-fired Power Plant Environment. *Malaysian Journal of Analytical Science, 21*(2), 460–469.

Chin, G.J.W.L., Mohamad, M.Z., Maili, S., Yong, W.T.L., & Rodrigues, K.F. (2017). ISSR-PCR Fingerprinting of *Kappaphycus* and *Eucheuma* (Rhodophyta, Gigartinales) Seaweed Varieties From Sabah, Malaysia. *Transactions on Science and Technology, 4*(3), 420 - 425.

Chin, Y.X., Chen, X., Cao, W.X., Sharifuddin, Y., Green, B.D., Lim, P.E., Xue, C.H., & Tang, Q.J. (2020). Characterization of seaweed hypoglycemic property with integration of virtual screening for identification of bioactive compounds. *Journal of Functional Foods, 64*, 103656.

Chong, J. F., Fadhullah, W., Lim, V., & Lee, C. K. (2019). Two-stage cultivation of the marine microalga *Chlorella salina* for starch and carbohydrate production. *Aquaculture International, 27* (5), 1269-1288.

Chong, T.Y., Chean, S.A., Ong, C.T., Wong, L,Y., Goh, C.R., Tan, I.S., Foo, H.C.Y., Lam, M.K., & Lim, S. (2020). Techno-economic evaluation of third-generation bioethanol production utilizing the macroalgae waste: A case study in Malaysia*. Energy, 210*:118491.

Chu, W. L., Alwi, A., & Phang, S.M (2002). Phycoerythrin Production by a Marine *Oscillatoria* (Cyanophyta). *Malaysian Journal of Science, 21*, 69-75.

Chu, W. L. (2012). Biotechnological applications of microalgae. *IeJSME, 6*(1), S24-S37.

Chu W.L., Norazmi Mohamed & Phang S.M. (2003). Fatty-acids composition of some Malaysian seaweeds. *Malaysian Journal of Science. 22* (2), 21-27.

Daily Express Online - Sabah's Leading News Portal, (2019). Toxic algae in Kuala Penyu: Avoid shellfiish. [online] .Available at:

http://www.dailyexpress.com.my/news/144416/ toxic-algae-in-kuala-penyu-avoid-shellfish/ [Accessed 5 September 2019].

Datu Eranza, D.R., Bahron, A., Alin, J., Roslinah, M., & Malusirang, S.R. (2017). On-going assessment of issues in the seaweed farming industry in Sabah, Malaysia. *Journal of the Asian Academy of Applied Business, 4*, 49-60.

Ding, G.T. & Salihon, J. (2011). The Optimisation of levels of the variables pH and concentration of ferric chloride for harvesting marine microalgae by flocculation. In: *Proceedings of the International Conference on Food Engineering and Biotechnology (IPCBEE).*Vol. 9. IACSIT Press, Singapore.

Du, J., Hu, W., Nagelkerken, I., Sangsawang, L., Loh, K.H., Ooi, J.L.S., Liao, J., Zheng, X., Qiu, S. & Chen, B. (2020). Seagrass meadows provide multiple benefits to adjacent coral reefs through various microhabitat functions. *Ecosystem Health and Sustainability.* DOI: 10.1080/20964129.2020.1812433

Earl Roscoe, J.R., Wil Cluny, Abg. Ahmad. A. M. & Ricky, J. A. (2019). Lesson Learned from Mangrove Rehabilitation in Sarawak. In: *Proceeding of The National Seminar on Mangrove and Coastal Forest 2019* (pp. 22-31).

Ebrahimi Nigjeh, S., Yusoff, F.M., Mohamed Alitheen, N.B., Rasoli, M., Keong, Y.S., & Omar, A.R.B. (2013). Cytotoxic effect of ethanol extract of microalga, *Chaetoceros calcitrans*, and its mechanisms in inducing apoptosis in human breast cancer cell line. *BioMed Research International*.

EL-Turk, M., Abdullah, R., Zakaria, R.M., & Bakar, N.K.A. (2019). Heavy metal contamination in mangrove sediments in Klang estuary, Malaysia: Implication of risk assessment. Estuarine. *Coastal and Shelf Science, 226*, 106266.

Esa, F.A., Harith, M.N., & Hassan, R. (2012). Preliminary Morphological Study on Seaweed *Acanthophora* spp. of Satang Island. *Conference Paper, Universiti Malaysia Sarawak.*-DOI: 10.13140/2.1.1527.3603

Esa, F.A., Hassan, R. & Harith, M.N. (2012). Preliminary Seaweed Assemblages of Satang Island. In: *Proceedings- The 12th Symposium of the Malaysian Society of Applied Biology 2012.*

Esa, F.A., Harith, M.N., and Hassan, R. (2013). Diversity and Abundance of Seaweed at Satang Besar Island, Sarawak. *The 7th International Symposium on Kuroshio Science, Pontianak, Indonesia, 21-23.*

Fairoz, M., Rozaimi, M. & Nastasia, W. F. (2018). Records of sea star (*Echinodermata, Asteroidea*) diversity in a disturbed tropical seagrass meadow. *Arxius de Miscel· lània Zoològica. 16*, 243-254.

Fakhrulddin, I.M., Japar Sidik, B. & Muta Harah, Z. (2013). *Halophila beccarii* Aschers (Hydrocharitaceae) responses to different salinity gradient. *Journal of Fisheries and Aquatic Science. 8* (3), 462-471.

Farahin, A. W., Natrah, I., Nagao, N., Yusoff, F. M., Shariff, M., Banerjee, S., & Toda, T. (2021). Tolerance of *Tetraselmis tetrathele* to high ammonium nitrogen and its effect

on growth rate, carotenoid and fatty acids productivity. *Frontiers in bioengineering and biotechnology, 9*, 19.

Faridah, M. & Ibrahim, Yusof & Baharuddin, Nursalwa & Abd Rahman Azmi, Alyza & Borkhan, Hafiz. (2017). *Invertebrates of Setiu Wetlands.* Penerbit UMT.

Faridah-Hanum, I., Kudus, K.A., & Saari, N.S. (2012). Plant diversity and biomass of Marudu bay mangroves in Malaysia. *Pakistan Journal of Botany, 44* (2), 151–156.

Faridah-Hanum, I., & Latiff, A. (2019). *Rhizophora* Biomass of Mangrove Swamp Forests and Its Utilization in Energy and Industrial Production: The Case of Malaysia. In: Ecophysiology, Abiotic Stress Responses and Utilization of Halophytes (pp. 365-381). Springer, Singapore.

Faridah-Hanum, I., Yusoff, F. M., Fitrianto, A., Ainuddin, N. A., Gandaseca, S., Zaiton, S., & Harun, N. Z. N. (2019). Development of a comprehensive mangrove quality index (MQI) in Matang Mangrove: Assessing mangrove ecosystem health. *Ecological Indicators, 102*, 103-117.

Fauzi, N.F.M., Min, T.H., & Hashim, A.M. (2020). Assessment of Mangrove Replanting Site at Kg Tanjung Kepah, Lekir, Perak. *IOP Conference Series: Earth and Environmental Science, 549* (1), 012054.

Fauziee, N.A.M., Chang, L.S., Wan Mustapha, W.A., Nor, A.R.M. & Lim, S.J. (2021). Functional polysaccharides of fucoidan, laminaran and alginate from Malaysian brown seaweeds (*Sargassum polycystum, Turbinaria ornata* and *Padina boryana*). *International Journal of Biological Macromolecules, 167,* 1135–1145.

Fortes, M.D., Ooi, J.L.S., Tan, Y.M., Prathep, A., Bujang, J. S., & Yaakub, S. M. (2018). Seagrass in Southeast Asia: a review of status and knowledge gaps, and a road map for conservation. *Botanica Marina, 61*(3): 269-288.

Freeman, A.S., Short, F.T., Isnain, I., Razak, F.A., & Coles, R.G. (2008). Seagrass on the edge: land-use practices threaten coastal seagrass communities in Sabah, Malaysia. *Biological Conservation, 141*(12), 2993-3005.

Fuad, N., Omar, R., Kamarudin, S., Harun, R., Idris, A., & Azlina, W.W. (2018). Effective use of tannin-based natural biopolymer, AFlok-BP1 to harvest marine microalgae *Nannochloropsis* sp*. Journal of environmental chemical engineering, 6*(4), 4318-4328.

Fudholi, A, Othman, M.Y., Ruslan, M.H., Yahya, M., Zaharim, A & Sopian (2011). Design and Testing of Solar Dryer for Drying Kinetics of Seaweed in Malaysia. *Recent Researches in Geography, Geology, Energy, Environment and Biomedicine*. ISBN: 978-1-61804-022-0.

Fukuyo, Y., Kodama, M., Omura, T., Furuya, K., Furio, E. F., Cayme, M., Lim, P.T, Dao, V.H., Kotaki, Y, Matsuoka, K., Iwataki, M., Sriwoon, R. & Lirdwitayaprasit, T. (2011). Ecology and oceanography of harmful marine microalgae (Project-2). In: Nishida, S., Fortes, M.D & Miyazaki, N. (eds). Chapter 3. *Coastal marine science in Southeast Asia—Synthesis Report of the Core University Program of the Japan Society for the Promotion of Science: Coastal Marine Science (2001–2010). TERRAPUB*, Tokyo, 23-48.

Gan M.H., Orosco C.A. & Maya Sofia M.K.A. (2008). Checklist of Terengganu seaweeds: With emphasis on East Coast Peninsular Expedition I, 2005. In : Phang S.M., Lewmanomont K. & Lim, P.E. (eds.). Taxonomy of Southeast Asian Seaweeds.. *Monograph Series 2, Institute of Ocean and Earth Sciences, University of Malaya, Kuala Lumpur.* (pp. 159-178).

Gan, S.Y., Azman, B.A.R., Yoshida, T., Majid, A.M., Toda, T., Takahashi, K. & Othman, B.H.R. (2010). Comparison of day and night mysid assemblages in a seagrass bed by using emergence traps, with key to species occurring at Pulau Tinggi, Malaysia. *Coastal Marine Science. 34* (1), 74-81.

Ghazaly, M.M. & Abdullah, Maizah & Radif, N.S.A.M. & Ghazali, Y.S. & Tajuddin, S.F. & Pauzi, N.H.A. & Razali, R.M. (2019). An insight on the flora species and meiofauna distribution at Pantai Kelanang mangrove forest, Morib, Selangor. *Malaysian Applied Biology, 48,* 215-220.

Goessens A., Satyanarayana B., Mohd. Lokman H., Sulong I., & Dahdouh-Guebas, F (2013). Forest composition and structure in the mangroves at Matang, West Peninsular Malaysia, after a century of sustainable management. In: *Prosiding Seminar Kebangsaan Pemuliharaan Hutan Persisiran Pantai Negara 2013: Pemeliharaan dan Pemuliharaan Hutan Pesisiran Pantai Untuk Kesejahteraan Masyarakat* (pp. 208-210).

Goessens, A., Satyanarayana, B., Van der Stocken, T., Quispe Zuniga, M., Mohd-Lokman, H., Sulong, I., & Dahdouh-Guebas, F. (2014). Is Matang Mangrove Forest in Malaysia sustainably rejuvenating after more than a century of conservation and harvesting management?. *PloS one, 9* (8), e105069.

Goh, C.S., & Lee, K.T. (2010). A visionary and conceptual macroalgae-based third-generation bioethanol (TGB) biorefinery in Sabah, Malaysia as an underlay for renewable and sustainable development. *Renewable and Sustainable Energy Reviews, 14*, 842–848.

Goh, S.H., Yusoff, F.M., & Loh, S. P. (2010). A comparison of the antioxidant properties and total phenolic content in a diatom, *Chaetoceros* sp. and a green microalga, *Nannochloropsis* sp. *Journal of Agricultural Science, 2* (3), 123.

Goh, S. H., Alitheen, N. B. M., Yusoff, F. M., Yap, S. K., & Loh, S. P. (2014). Crude ethyl acetate extract of marine microalga, *Chaetoceros calcitrans*, induces Apoptosis in MDA-MB-231 breast cancer cells. *Pharmacognosy Magazine, 10* (37), 1.

Gopalakrishnan, L., Satyanarayana, B., Chen, D., Wolswijk, G., Amir, A. A., Vandegehuchte, M. B., & Dahdouh-Guebas, F. (2021). Using historical archives and landsat imagery to explore changes in the mangrove cover of Peninsular Malaysia between 1853 and 2018. *Remote Sensing, 13* (17), 3403.

Goto, M., Nagao, N., Yusoff, F.M., Kamarudin, M.S., Katayama, T., Kurosawa, N., & Toda, T. (2018). High ammonia tolerance on growth rate of marine microalga *Chlorella vulgaris*. *Journal of Environmental Biology, 39*(5), 843-848.

Govindan, N. et al. (2019). Statistical optimization of lipid production by the diatom *Gyrosigma* sp. grown in industrial wastewater. *Journal of Applied Phycology, 32*. 10.1007/s10811-019-01971-x.

Hamdan, O., Khairunnisa, M. R., Ammar, A. A., Mohd Hasmadi, I., & Khali Aziz, H. (2013). Mangrove carbon stock assessment by optical satellite imagery. *Journal of Tropical Forest Science, 25* (4), 554–565.

Hamdan, O., Aziz, H. K., & Hasmadi, I. M. (2014). L-band ALOS PALSAR for biomass estimation of Matang Mangroves, Malaysia. *Remote Sensing of Environment, 155*, 69-78.

Hamzah, T.N.T., Lee, S.Y., Hidayat, A., Terhem, R., Faridah-Hanum, I., & Mohamed, R. (2018). Diversity and characterization of endophytic fungi isolated from the tropical mangrove species, *Rhizophora mucronata*, and identification of potential antagonists against the soil-borne fungus, *Fusarium solani*. *Frontiers in microbiology, 9,* 1707.

Hamzah, M.L., Amir, A.A., Maulud, K.N.A., Sharma, S., Mohd, F.A., Selamat, S.N., & Begum, R.A. (2020). Assessment of the mangrove forest changes along the Pahang coast using remote sensing and GIS technology. *Journal of Sustainability Science and Management, 15* (5), 43-58.

Hamzah, S.R., Anuar, S.T., Khalik, W.M.A.W.M., Kolandhasamy, P., & Ibrahim, Y.S. (2021). Ingestion of microplastics by the estuarine polychaete, *Namalycastis* sp. in the Setiu Wetlands, Malaysia. *Marine pollution bulletin, 170*, 112617.

Hashim, R., Kamali, B., Tamin, N. M., & Zakaria, R. (2010). An integrated approach to coastal rehabilitation: mangrove restoration in Sungai Haji Dorani, Malaysia. *Estuarine, Coastal and Shelf Science, 86*(1), 118-124.

Hashim, M., Sani, D.A. & Yahya, N.N. (2021). Appraisal of seagrass aboveground biomass changes using satellite data within the tropical coastline of Peninsular Malaysia. *Geocarto International*. DOI: 10.1080/10106049.2021.1917007.

Heck, K.L., Nadeau, D.A. & Thomas, R. (2003). The nursery role of seagrass beds, Gulf of Mexico. *Science, 15*, 50-54.

Hidayah, N., Tahirin, S.A., Fairoz, M. & Rozaimi, M. (2019). Carbon stock and δ13C data of sediment samples collected from a tropical seagrass meadow in Malaysia. *Plant Science Today. 6* (2), 132-136.

Hii, S.L., Lim, J.Y., Ong, W.T., & Wong, C.L. (2016). Agar from Malaysian red seaweed as potential material for synthesis of bioplastic film. *Journal of Engineering Science and Technology, 7*, 1-15.

Hussin, H., & Khoso, A. (2017). Seaweed cultivation and coastal communities in Malaysia: an Overview. *Asian Fisheries Sciences, 30*, 87-100.

Ho, N.A.J. (2018). Fish communities in adjacent seagrass and coral reefs in Babi Besar Island and Tinggi Island, Malaysia. *Thesis Master of Science, Institute of Biological Sciences, Faculty of Science, University of Malaya, Kuala Lumpur*.

Ho, N.A.J., Ooi, J.L.S., Affendi,Y.A.& Chong, V.C. (2018). Influence of habitat complexity on fish density and species richness in structurally simple forereef seagrass meadows. *Botanica Marina. 61* (6), 547-557.

Hong, L.C., Hemati, Z., & Zakaria, R. (2017). Carbon stock evaluation of selected mangrove forests in peninsular Malaysia and its potential market value. *Journal of Environmental Science and Management, 20* (2).

Hookham, B., Shau-Hwai, A.T., Dayrat, B., & Hintz, W. (2014). A baseline measure of tree and gastropod biodiversity in replanted and natural mangrove stands in Malaysia: Langkawi Island and Sungai Merbok. *Tropical Life Sciences Research, 25* (1), 1–12.

Hossain, M., Othman, S., Bujang, J.S., & Kusnan, M. (2008). Net primary productivity of *Bruguiera parviflora* (Wight & Arn.) dominated mangrove forest at Kuala Selangor, Malaysia. *Forest ecology and management, 255* (1), 179-182.

Hossain, M.S., Bujang, J.S., Zakaria, M.H., & Hashim, M. (2014). The application of remote sensing to seagrass ecosystems: an overview and future research prospects. International *Journal of Remote Sensing, 36* (1), 61-114.

Hossain, M.S., Bujang, J. S., Zakaria, M. H. & Hashim, M. (2015). Assessment of the impact of Landsat 7 Scan Line Corrector data gaps on Sungai Pulai Estuary seagrass mapping. *Applied Geomatics. 7* (3), 189-202.

Hossain, M.S., Bujang, J.S., Zakaria, M.H. & Hashim, M. (2015). Assessment of Landsat 7 Scan Line Corrector-off data gap-filling methods for seagrass distribution mapping. *International Journal of Remote Sensing. 36* (4), 1188-1215.

Hossain, M.S., Japar Sidik, B., Muta Harah, Z. (2015). Landsat image enhancement techniques for subtidal and intertidal seagrass detection and distribution mapping in the coastal waters of Sungai Pulai estuary, Malaysia*. Coastal Marine Science. 38* (1), 27-41.

Hossain, M.S., Bujang, J.S., Zakaria, M.H., & Hashim, M. (2015). Application of Landsat images to seagrass areal cover change analysis for Lawas, Terengganu and Kelantan of Malaysia. *Continental Shelf Research, 110* , 124-148.

Hussin, R., Hossin, A., & Kunjuraman, V. (2017). Strengthening Fishing Community and Capacity Building through Seaweed Mini Estate System in Sabah, Malaysia. *Int. J. of Soc. Policy and Society*, 8-23

Ibnu Rasid, E.N., Mohamad, S.E., Jamaluddin, H., & Salleh, M.M. (2014). Screening factors influencing the production of astaxanthin from freshwater and marine microalgae. *Applied biochemistry and biotechnology, 172* (4), 2160-2174.

Ibrahim, Y.S., Azmi, A.A., Shukor, S.A., Anuar, S.T., & Abdullah, S.A. (2016). Microplastics ingestion by *Scapharca cornea* at Setiu Wetland, Terengganu, Malaysia. *Middle-East Journal of Scientific Research, 24* (6), 2129-2136.

Ibrahim, N.H., & Saili, A.R. (2017). Assessment of Entrepreneurial Inclination among the Seaweed Operator at Semporna, Sabah Using EAO Model. *Journal of International Business, Economics and Entrepreneurship, 2* (1), 2550-1249.

Ibrahim, N.F., Ibrahim, Y.S., & Sato, M. (2019). New record of an estuarine polychaete, *Neanthes glandicincta* (Annelida, Nereididae) on the eastern coast of Peninsular Malaysia. *ZooKeys, 831*, 81.

Ibrahim, Y.S., Hamzah, S.R., Khalik, W.M.A.W.M., Yusof, K.M.K.K., & Anuar, S.T. (2021). Spatiotemporal microplastic occurrence study of Setiu Wetland, South China sea. *Science of The Total Environment, 788*, 147809.

Idris, M.H., Arshad, A., Japar Sidik, B., Ghaffar, M.A. & Daud, S.K. (2008). Biodiversity and distribution of Pen Shells (Bivalvia: Pinnidae) from the seagrass beds of Sungai Pulai, Peninsular Malaysia. *Research Journal of Fisheries and Hydrobiology, 3* (2), 54–62

Idris, M.H., Arshad, A., Japar Sidik,B., Mazlan, A.G., & Siti Khalijah, D. (2009). Morphological characteristics of *Pinna bicolor* Gmelin and *Pinna deltodes* Menke from the seagrass bed of Sg. Pulai, Johor, Peninsular Malaysia. *Sains Malaysiana. 38* (3), 333–339

Idris, M.H., Arshad, A., Amin, S.M.N., Japar, S.B., Daud, S.K., Mazlan, A.G.,Zakaria, M.S. & Yusoff, F.M. (2012). Age, growth and length–weight relationships of *Pinna bicolor* Gmelin (Bivalvia: Pinnidae) in the seagrass beds of Sungai Pulai Estuary, Johor, Peninsular Malaysia. *Journal of Applied Ichthyology. 28* (4), 597-600.

Idris, S.M.M (2016). Proposed development project in Kuala Kedah destroys mangroves. malaysiakini. https://www.malaysiakini.com/letters/360320

Idris, M. H., Musa, N., Piah, R. M., Hussin, W. M. R. W, Mustafa, E. M., & Zein, A. (2021). *Merchang lagoon coastal resources and social economy*. Penerbit UMT

Ismail, N. (1993). Preliminary study of the seagrass flora of Sabah, Malaysia. *Pertanika J. Tropical Agriculture Science. 16* (2), 111-118.

Ismail, M., Phang, S.M., Tong, S.L., & Brown, M.T. (2002). A modified toxicity testing method using tropical marine microalgae. *Environmental monitoring and assessment, 75* (2), 145-154.

Ismail J., & Muhammad Anuar A (2013). Komposisi spesies dan struktur hutan bakau yang telah diteroka. In: *Prosiding Seminar Kebangsaan Pemuliharaan Hutan Persisiran Pantai Negara 2013: Pemeliharaan dan Pemuliharaan Hutan Pesisiran Pantai Untuk Kesejahteraan Masyarakat* (pp. 211-216).

Ismail, M.H., Zaki, P.H., & Hamed, H.A. (2015). Wood density and carbon estimates of mangrove species in Kuala Sepetang, Perak, Malaysia. *Malaysian Forester, 78* (1–2), 115–124.

Ismail, H., Samsudin, M., Tariq Mubarak, H., & Lili, T. (2016). *A Guide to Mangroves of Johor RAMSAR Sites*. Publisher Forest Research Institute Malaysia (FRIM), (pp 1-119).

Ismail, J., Abu Hena, M.K., Idris, M.H., Amin, S.M.N., Hamli, H., Leong, S.S, Al-Asif, A. & Abualreesh, M.H. (2021). Zooplankton species composition and diversity in the seagrass habitat of Lawas, Sarawak, Malaysia. *Biodiversity Data Journal, 9*, e67449.

Japar Sidik, B., Arshad, A., Hishamuddin, O., & Shamsul Bahar. (1995). *Halophila decipiens* Ostenfeld: a new record of seagrass for Malaysia. *Aquatic Botany, 52*, 151-154.

Japar Sidik, B., Muta Hara, Z., Arshad, A., Lam, S.L. & Ogawa, H. (2006). Flowers and sexes in Malaysian seagrasses. *Coastal Marine Science, 30* (1), 184-188.

Japar Sidik, B., Muta Hara, Z. & Arshad, A. (2006). Distribution and significance of seagrass ecosystems in Malaysia. *Aquatic Ecosystem Health & Management, 9* (2), 1-14.

Japar Sidik, B., Lim, L.H., Muta Hara, Z., Arshad, A. & Ogawa, H. (2008). Laboratory culture of the seagrass *Halophila ovalis* (R. Br.) Hooker f. *Journal of Mar. Res. Indonesia, 33* (1): 1-6.

Japar Sidik, B., Muta Harah, Z. & Kawaguchi, S. (2012). Historical review of seaweed research in Malaysia before 2001. *Coastal Marine Science, 35* (1), 169-177.

Japar Sidik, B. & Muta Hara, Z. (2013). Purple Coloration in Leaves of Seagrass, *Halophila* (Hydrocharitaceae). *Journal of Fisheries and Aquatic Science, 8* (2), 388-396.

Japar Sidik, B., Muta Hara, Z. & Short, F.T. (2016). Seagrass in Malaysia: Issues and challenges ahead. In: Finlayson et al (eds.), *The Wetland Book II: Distribution, Description and Conservation*, 1-9. Springer Science+Business Media Dordrecht 2016.

Jaswir, I., Tope, A.H.T., Raus, R.A., Monsur, H.A., & Ramli, N. (2014). Study on anti-bacterial potentials of some Malaysian brown seaweeds. *Food Hydrocolloids. 42*, 275-279.

Jayakumar, S. et al. (2021). Effects of light intensity and nutrients on the lipid content of marine microalga (diatom) *Amphiprora* sp. for promising biodiesel production. *Science of The Total Environment, 768*, 145471. 10.1016/j.scitotenv.2021.145471.

Jin-Eong, O., Khoon, G.W., & Clough, B.F. (1995). Structure and productivity of a 20-year-old stand of *Rhizophora apiculata* Bl. mangrove forest. *Journal of Biogeography*, 417-424.

Johan, I., Abu Hena, M.K., Idris, M.H., Amin, S.M.N., Denil, N.A., Kumar, U., & Karim, N.U. (2020). Species composition and diversity of fishes from the seagrass habitat of Lawas, Sarawak, Malaysia. *Journal of Environmental Biology. 41*, 1382-1389.

John, B.A., & Waznah, A.S. (2011). Accumulation and distribution of lead and copper in *Avicennia marina* and *Rhizophora apiculata* from Balok Mangrove Forest, Pahang, Malaysia. *Sains Malaysiana, 40* (6), 555-560.

Jumaidin, R., Sapuan, S.M., Jawaid, M., Ishak, M.R., & Sahari, J. (2016). Effect of seaweed on physical properties of thermoplastic sugar palm starch/agar composites. *Journal of Mechanical Engineering and Sciences, 10* (3), 2214-2225.

Jumaidin, R., Sapuan, S.M., Jawaid, M., Ishak, M.R., and Sahari, J. (2017). Characteristics of *Eucheuma cottonii* waste from East Malaysia: physical, thermal and chemical composition. *European Journal of Phycology, 52* (2), 200-207.

Jusidin, M.R., Othman, R., Shaleh, S.R.M., Ching, F.F., Senoo, S., & Oslan, S.N.H. (2022). In Vitro Antibacterial Activity of Marine Microalgae Extract against *Vibrio harveyi*. *Applied Sciences, 12* (3), 1148.

Jusoh, M., Kasan, N.A., Hashim, F.S., Haris, N., Zakaria, M.F., Mohamed, N.N., & Takahashi, K. (2020). Isolation of freshwater and marine indigenous microalgae species from Terengganu water bodies for potential uses as live feeds in aquaculture industry. *International Aquatic Research, 12* (1), 74-83.

Kadar, N.A., Shaleh, S.R.M., & Suali, E. (2018). Molecular and phylogenetic identification of marine microalgae inferred by 18S rDNA gene. *Malaysian Applied Biology, 47* (6), 41-45.

Kamaludin, M., Azlina, A. A., Wan Ibrahim, W. N., Mat Alipiah, R., Saputra, J., Abdullah, M. M., Anang, Z., & Omar, C. M. (2022). Effectiveness of a conservation education program among school students on the importance of mangrove ecosystems in Setiu Wetlands, Malaysia. *Applied Environmental Education & Communication, 21* (1), 23-41.

Kambey, C.S.B., Campbell, I., Cottier-Cook, E.J., Nor, A.R.M., Kassim, A., Sade, A., & Lim, P.E. (2021). Evaluating biosecurity policy implementation in the seaweed aquaculture industry of Malaysia, using the quantitative knowledge, attitude, and practices (KAP) survey technique. *Marine Policy,* 134:104800.

Kamil, E.A., Takaijudin, H., & Hashim, A.M. (2020). Distribution of Mangroves in Kedah, Malaysia: A Remote Sensing and Ground-Truth Based Assessment. *IOP Conference Series: Earth and Environmental Science, 549* (1), 012005).

Kanagesan, K., Abdulla, R., Derman, E., Sabullah, M.K., Govindan, N., Gansau, J.A. (2022). A sustainable approach to green algal bioplastics production from brown seaweeds of Sabah, Malaysia. *Journal of King Saud University – Science Open, 34*, Article number 102268.

Kanniah, K.D., Kang, C.S., Sharma, S., & Amir, A.A. (2021). Remote sensing to study mangrove fragmentation and its impacts on Leaf Area Index and gross primary productivity in the South of Peninsular Malaysia. *Remote Sensing, 13* (8), 1427.

Kasawani, I., Kamaruzaman, J., & Nurun-Nadhirah, M.I. (2007). Biological diversity assessment of Tok Bali mangrove forest, Kelantan, Malaysia. *WSEAS Transactions on Environment and Development, 3* (2), 37–44.

Kasawani, I., Mohd-Suffian, I., & Kamaruzaman, J. (2008). Imaging Spectrometry of Mangroves in Tok Bali and Setiu. In: *Prosiding Seminar Pemuliharaan Hutan Persisiran Pantai Negara 2008: Hasil Penyelidikan Dan Aplikasinya Kepada Tanaman Serta Kesedaran Komuniti* (pp. 162-167)

Katayama, T., Nagao, N., Kasan, N. A., Khatoon, H., Rahman, N. A., Takahashi, K., & Jusoh, M. (2020). Bioprospecting of indigenous marine microalgae with ammonium

tolerance from aquaculture ponds for microalgae cultivation with ammonium-rich wastewaters. *Journal of Biotechnology, 323*, 113-120.

Kawaguchi, S. & Hayashizaki, K. (2011). Biodiversity studies on seaweeds and sea grasses in the coastal waters of Southeast Asia (Project-3: Seaweed/ seagrass Group). In : Nishida, S., Fortes, M.D. & Miyazaki, N. (eds.). *Coastal Marine Science in Southeast Asia- Synthesis Report of the Core University Program of the Japan Society for the Promotion of Science : Coastal Marine Science (2001-2010)*, pp: 49-57. TERRAPUB 2011.

Khan, W.R., Rasheed, F., Zulkifli, S.Z., Kasim, M.R.B.M., Zimmer, M., Pazi, A.M., & Nazre, M. (2020). Phytoextraction potential of *Rhizophora apiculata:* A case study in Matang mangrove forest reserve, Malaysia. *Tropical Conservation Science, 13*, 1940082920947344.

Khan, W.R., Zulkifli, S.Z., Kasim, M.M., Zimmer, M., Pazi, A.M., Kamrudin, N.A., & Nazre, M. (2020). Risk assessment of heavy metal concentrations in sediments of Matang mangrove forest reserve. *Trop Conserv Sci. 13* (1).

Khandaker, M.U., Heffny, N.A., Amin, Y.M., & Bradley, D.A. (2019). Elevated concentration of radioactive potassium in edible algae cultivated in Malaysian seas and estimation of ingestion dose to humans. *Algal Research, 38* , 101386

Khaw, Y.S., Khong, N.M.H., Shaharuddin, N.A., & Yusoff, F.M. (2020). A simple 18S rDNA approach for the identification of cultured eukaryotic microalgae with an emphasis on primers. *Journal of microbiological methods, 172*, 105890.

Khaw, Y.S., Tan, H.T., Sopawong, A., Shaharuddin, N.A., Omar, A.R., & Yusoff, F.M. (2021). A Recommendation for a Pre-Standardized Marine Microalgal Dry Weight Determination Protocol for Laboratory Scale Culture Using Ammonium Formate as a Washing Agent. *Biology, 10* (8), 799.

Krishnan, V., Uemura, Y., Thanh, N.T., Khalid, N.A., Osman, N., & Mansor, N. (2015). Three types of marine microalgae and *Nannocholoropsis oculata* cultivation for potential source of biomass production. *Journal of Physics: Conference Series, 622* (1), 012034.

Kok, J.M.L., & Wong, C.L. (2018). Physicochemical properties of edible alginate film from Malaysian *Sargassum polycystum* C. Agardh. *Sustainable Chemistry and Pharmacy, 9*,87–94.

Kunjuraman, V., & Hussin, R. (2017). Sustainable production of seaweed in Malaysia: A review of policies and future prospects. *Current Politics and Economics of South, 26* (2). ISSN: 2157-6270

Kunjuraman, V., Hossin, A., & Hussin, R. (2019). Women in Malaysian Seaweed Industry: Motivations and Impacts. *Kajian Malaysia, 37* (2), 49–74.

Lai, P.J., Chu, W.L., Naidu, R., Khoo, A.S.B., Kok, Y.Y., Shar, M.M., Ling, S.N., Mak, J.W., Lim, P.K.C., Balraj, P. & Phang, S. M. (2008). Antiproliferative activity of microalgal extracts on nasopharyngeal carcinoma (NPC) cells. *Malaysian Journal of Science, 27* (2), 19-31.

Lai, J.I., Yusoff, F.M., & Shariff, M. (2012). Large-scale culture of a tropical marine microalga *Chaetoceros calcitrans* (Paulsen) Takano 1968 at different temperatures using annular photobioreactors. *Pakistan journal of biological sciences: PJBS, 15* (13), 635-640.

Lananan, F., Jusoh, A., Lam, S.S., & Endut, A. (2013). Effect of Conway Medium and f/2 Medium on the growth of six genera of South China Sea marine microalgae. *Bioresource technology, 141*, 75-82.

Lananan, F., Hamid, S.H.A., Din, W.N.S., Khatoon, H., Jusoh, A., & Endut, A. (2014). Symbiotic bioremediation of aquaculture wastewater in reducing ammonia and phosphorus utilizing Effective Microorganism (EM-1) and microalgae (*Chlorella* sp.). *International Biodeterioration & Biodegradation, 95*, 127-134.

Le, D.Q., Tanaka, K., Hii, Y. S., Sano, Y., Nanjo, K. & Shirai, K. (2018). Importance of seagrass-mangrove continuum as feeding grounds for juvenile pink ear emperor *Lethrinus lentjan* in Setiu Lagoon, Malaysia: Stable isotope approach. *Journal of Sea Research, 135*, 1-10.

Lee, A.M.L., Md. Yasir, S., Matanjun, P., & Abu Bakar, M.F., (2013). Antioxidant activity, Total Phenolic and Flavonoid Contents of Selected Commercial Seaweeds of Sabah, Malaysia. *Int. J. Pharm. Phytopharmacol. Res, 3* (3): 234-238

Lee, W.K., Lim, P.E., Phang, S.M., Namasivayam, P., & Ho, C.L. (2016). Agar properties of *Gracilaria* species (Gracilariaceae, Rhodophyta) collected from different natural habitats in Malaysia. *Regional Studies in Marine Science, 7*,123–128.

Lee, W.K., Lim, Y.Y., & Ho., C.L., (2019). pH affects growth, physiology and agar properties of agarophyte *Gracilaria changii* (Rhodophyta) under low light intensity from Morib, Malaysia. *Regional Studies in Marine Science, 30*, 100738.

Lim, H.F. (2002). *Sustainable development of the Matang mangroves and its impacts on local socio-economic livelihood*. Kepong: Forest Research Institute Malaysia (FRIM).

Lim P.E., Kawai H. & Phang S.M. (2008). Some Ralfsiales from Malaysia. In: Phang S.M., Lewmanomont K. & Lim, P.E. (eds.). *Taxonomy of Southeast Asian Seaweeds, Monograph Series 2, Institute of Ocean and Earth Sciences, University of Malaya, Kuala Lumpur.* (pp. 77-81).

Lim P.E. & Phang S.M. (2012). Seaweeds on fish cages at Pulau Ketam. In : Sasekumar A. & Chong, V.C. (eds.). *Mangrove and coastal environment of Selangor, Malaysia. Monograph Series 14, Institute of Ocean and Earth Sciences, University of Malaya, Kuala Lumpur*. (pp. 205-213).

Lim, P.T., Gires, U. & Leaw, C.P. (2012). Harmful algal blooms in Malaysian Waters. *Sains Malaysiana. 41* (12), 1509–1515

Lim, K.C., & Zaleha, K. (2013). Effect of photoperiod on the cellular fatty acid composition of three tropical marine microalgae. *Malaysia Application Biology, 42* (1), 41-49.

Lim, S.J., Wan Mustapha, W.A., Maskat, M.Y., Mamot, S., Ropien, J., & Mohd, D.M. (2014). Isolation and antioxidant capacity of fucoidan from selected Malaysian seaweeds. *Food Hydrocolloids, 42*, 280-288.

Lim, S.J., Wan Mustapha, W.A., Maskat, M.Y., Latip, J., Badri, K.H, Hassan, O., & Yamin, B.M. (2016). Characterisation of fucoidan extracted from Malaysian *Sargassum binderi*. *Food Chemistry, 209*, 267–273.

Lim, S.J., Mustapha, W.A.W., & Maskat, M.Y. (2017). Seaweed Tea: Fucoidan-Rich Functional Food Product Development from Malaysian Brown Seaweed, *Sargassum binderi*. *Sains Malaysiana 46* (9), 1573–1579.

Lim, Y. K., Phang, S. M., Sturges, W. T., Malin, G., & Rahman, N. B. A. (2018). Emission of short-lived halocarbons by three common tropical marine microalgae during batch culture. *Journal of Applied Phycology, 30* (1), 341-353.

Lo, S.L., Yap, T.K., Chen, C.A. & Yoshida, T. (2020). Zooplankton in seagrass and adjacent non-seagrass habitats in Tun Mustapha Park, Sabah, Malaysia. *Borneo Journal of Marine Science and Aquaculture, 4* (1), 6-13.

Lokman, M.H. & Sulong, I. (2001). *Mangroves of Terengganu*, Kolej Universiti Sains and Teknologi Malaysia & Forestry Department Peninsular Malaysia, Terengganu, pp. 135.

Long, S.M., Mohamad, F.A. & Ab Ghani, N.F. (2014). Meiofauna on Seagrass Meadows of Sampadi Island, Lundu, Sarawak. *Monograph Aquatic Science Colloqium 2014, FRST UNIMAS*. (pp 51-60).

Lucas, R., Otero, V., Van De Kerchove, R., Lagomasino, D., Satyanarayana, B., Fatoyinbo, T., & Dahdouh-Guebas, F. (2021). Monitoring Matang's Mangroves in Peninsular Malaysia through Earth observations: A globally relevant approach. *Land Degradation & Development, 32* (1), 354-373.

Mahyiddin, N.H. (2021). Assessment on seaweed composition and water quality analysis at the breakwater Pantai UMT area in Kuala Terengganu, Terengganu. *Bac. of Applied Science (Fisheries) Thesis. University Malaysia Terengganu*

Majid, N., Ibrahim, I.S., Sarbini, N.N., Zakaria, Z.A., & Osman, M.H., (2019). The chemical properties of seaweed for modify concrete. *IOP Conf. Series: Earth and Environmental Science, 220*. Doi:10.1088/1755-1315/220/1/012026

Malusirang, S.R., Bahron, A., Datu Eranza, D.R., & Alin, J.M. (2012). The roles of government agencies in managing the seaweed industry in Sabah, Malaysia. Universiti Malaysia Sabah.

Mansor, M., & Zakaria, M. Y. (2004). Ecological survey on mangrove forests: A case study of Balik Pulau and Pantai Acheh. Universiti Sains Malaysia, Pulau Pinang.

Mansor, R., Ab Rahman, N. S., Mohamad, S. F., Kuppusamy, P., Yusoff, M. M., & Govindan, N. (2013). Isolation and identification of marine algae (*Oscillatoria* sp.) from Kuantan Coastal Region Malaysia and studies on their bioactive and antibacterial properties. *World Applied Sciences Journal, 28* (2), 200-204.

Maria S., Jenarun, J., Rundi, C. & Chua, T.H. (2017). Case Report: Paralytic Shellfish Poisoning in Sabah, Malaysia. *American Journal Tropical Medicine and Hygiene, 97* (6), 1731–1736

Mashitah, S.M., Shazili, N.A.M., & Rashid, M.K.A., (2012). Elemental concentrations in Brown Seaweed, *Padina* sp. along the east coast of Peninsular Malaysia*. Aquatic Ecosystem Health & Management, 15* (3):267–278.

Mashhor, M., Baharuddin, S., Adenan, J., & Asyraf M., (2006) *Mangrove survey in Balik Pulau and Pantai Acheh mangrove forests*, Penerbit Universiti Sains Malaysia Pulau Pinang, 2006, (pp 1-332).

Maslie, S.M. (2010). *Gracilaria* sp. in Asajaya mangrove with special reference to its production. *B. Sc. Thesis. Faculty of Resources Science and Technology, Universiti Malaysia Sarawak.*

Masuda M., Abe, T., Kogame, K., Kawaguchi, S., Phang, S.M., Daitoh, M., Sakai, T., Takahashi Y. & Suzuki, M. (2002). Taxonomic notes on marine algae of Malaysia VIII. Three species of Laurencia (Rhodophyceae). *Botanica Marina. 45* (6), 571-579.

Matanjun, P., Mohamed, S., Mustapha, N.M. & Muhammad K. (2009). Nutrient content of tropical edible seaweeds, *Eucheuma cottonii, Caulerpa lentillifera* and *Sargassum polycystum*. *Journal of Applied Phycology. 21* (1), 75-80.

Matanjun, P., Mohamed, S., Mustapha, N.M., Muhammad K. & Ming, C.H. (2008). Antioxidant activities and phenolics content of eight species of seaweeds from north Borneo. *Journal of Applied Phycology, 20* (4), 367-374.

Matias-Peralta, H.M., & Yusoff, F.M. (2015). Status of planktonic copepod diversity in the Merambong seagrass meadow, Johor, Peninsular Malaysia. *International Journal of Ecosystem, 5* (2), 39-43.

Maya, L.H., Sahadev, S. & Aldrie, A. (2019). The Dynamics Between Intact, Regenerating Mangroves, and Mudflats of Klang, Selangor. In: *Proceeding of The National Seminar on Mangrove and Coastal Forest 2019* (pp. 129-144).

Mazlan, A.G., Chung, Y.S., Zaidi, C.C., Samat, A., Arshad, A., Seah, Y.G., Alam, G.M & Simon, K.D. (2012). Meristic, morphometrics and length-weight relationship of tropical silverside, *Atherinomorus duodecimalis* (Valenciennes in Cuvier and Valenciennes, 1835) in seagrass and mangrove habitats of Tinggi Island, Johor, Malaysia. *Asian Journal of Animal and Veterinary Advances, 7* (10), 921-927.

Mi, Y., Chin, Y.X., Cao, W.X., Chang, Y.G., Lim, P.E., Xue, C.H., & Tang, Q.J. (2020).Native κ-carrageenan induced-colitis is related to host intestinal microecology. *International Journal of Biological Macromolecules, 147*, 284–294.

Misbari, S. & Hashim, M. (2016). Change detection of submerged seagrass biomass in shallow coastal water. *Remote Sensing. 8*, 200.

Mohamed, M.S. et al. (2014). Kinetics and modeling of microalga *Tetraselmis* sp. FTC 209 growth with respect to its adaptation toward different trophic conditions. *Biochemical Engineering Journal, 88*, 30–41.

Muhammad Adlan, A.H., Wan Maznah, W.O. & Yahya, K. (2010). Effect of elevated water temperature on phytoplankton assemblages. *Poster for Conference, Universiti Sains Malaysia*

Mohammad, S.M. (2011). Distribution of element in seaweed along the east coast of peninsular Malaysia. *Thesis Master of Science, Universiti Malaysia Terengganu*.

Muhammad Adlan, A.H., Wan Maznah, W.O, Khairun, Y., Chuah, C.C., Shahril, M.H. & Mohd Noh, A. (2012). Tropical marine phytoplankton assemblages and water quality characteristics associated with thermal discharge from a coastal power station. *Journal of Natural Sciences Research. 2* (10), 88-99.

Mohammad, S.M., Mohd Razali, S.F., Mohamad Rozaiman, N.H.N., Laizani, A.N., & Zawawi, N. (2019). Application of seaweed (*Kappaphycus alvarezii*) in Malaysian food products. *International Food Research Journal 26* (6), 1677-1687.

Mohammad Rozaimi, J. Japar Sidik, B., Misri, K. & Hishamuddin, O. (2006). Photosynthetic light responses of wild and cultured *Halophila ovalis*. Malaysian *Journal of Science, 25* (2): 67-79.

Mohd-Din, M., Hii, K. S., Abdul-Wahab, M. F., Mohamad, S. E., Gu, H., Leaw, C. P., & Lim, P. T. (2022). Spatial-temporal variability of microphytoplankton assemblages including harmful microalgae in a tropical semi-enclosed strait (Johor Strait, Malaysia). *Marine Environmental Research, 175*, 105589.

Mohd Eusop, M. E., Ismail, M. H. & Mohd Kasim, M. R. (2018). Estimating aboveground biomass and carbon stocks of mangrove forests in Kuala Sepetang, Perak. *Malaysian Forester, 81* (2), 145–153.

Mohd Suki, N., Harun, A., Igau, O., & Jainnor, Z., (2013). An exploratory study on product, price, distribution channels, and promotion of seaweeds in Semporna district of Sabah, Malaysia. *Labuan e-Journal of Muamalat and Society, 7*, 28-32.

Mojiol, A. R., & Salleh, N. N. (2017). Mangrove Species Diversity and Structure at Kudat and Banggi Island, Sabah. *Journal of Tropical Resources and Sustainable Science, 5* (1), 27–32.

Mojiol, A. R., Maisyahirah Meor Mohd Najib, W., & Ali Syed Hussein, M. (2019). Tree Species Diversity of Mangrove at Tunku Abdul Rahman Park, Sabah Malaysia. *Acta Scientific Agriculture, 3* (9), 181–187. https://doi.org/10.31080/asag.2019.03.0631

Mok, W.J, Senoo, S., Itoh, T., Tsukamasa, Y., Kawasaki, K. & Ando, M. (2012). Assessment of concentrations of toxic elements in aquaculture food products in Malaysia. *Food Chemistry, 133,* 1326–1332.

Monsur, H.A., Jaswir, I., Simsek, S., Amid, A., Alam, Z., & Tawakalit, A.H. (2014). Cytotoxicity and inhibition of nitric oxide syntheses in LPS induced macrophage by water soluble fractions of brown seaweed. *Food Hydrocolloids, 42*, 269-274.

Monsur, H.A. (2014). Enzyme-aided extraction, purification and characterization of anti-inflammatory compounds from seaweed. *Doctor of Philosophy Thesis, International Islamic University Malaysia* (Abstract)

Motamedi, S., Hashim, R., Zakaria, R., Song, K. I., & Sofawi, B. (2014). Long-term assessment of an innovative mangrove rehabilitation project: Case study on Carey Island, Malaysia. *The Scientific World Journal.*

Muhammad-Nor, S.M., Huxham, M., Salmon, Y., Duddy, S.J., Mazars-Simon, A., Mencuccini, M., Meir, P., & Jackson, G. (2018). Exceptionally high mangrove root production rates in the Kelantan Delta, Malaysia; An experimental and comparative study. *Forest Ecology and Management, 444*, 214–224. https://doi.org/10.1016/j.foreco.2019.04.026.

Muhammad-Nor. S.M., Ariffin. E.H., Nik. S.J. & Wan. S.W.N. (2021) Biomass accumulation and carbon stock of mangrove forest in Delta Tumpat Kelantan and Setiu lagoon Terengganu, 1-24pp.

Muhammad-Nor. S.M., Sahari. M.S. I. & Razali. N.A.M. (2021) Carbon stock assessment along Sungai Kertih mangrove forest, Kemaman Terengganu, 1-63pp.

Mukhtar, A., Zulkifli, S.Z., Mohamat-Yusuff, F., Ismail, A. & Miyazaki, N. (2016). Stable isotope (δ13C and δ15N) analysis as a tool to quantify the food web structure in seagrass area of Pulai River estuary, Johor, Peninsular Malaysia. *Malayan Nature Journal. 68* (1&2), 91-102.

Mukhtar, A., Mohamat-Yusuff, F., Zulkifli, S.Z., Harino, H., Ismail, A. & Inoue, K. (2019). Concentration of organotin and booster biocides in sediments of seagrass area from Sungai Pulai Estuary, South of Johor, Malaysia. *Environments. 6* (26), 1-14.

Mustafa, E.M & Phang, S.M. (2005). Toxicity Assessment in Coastal and Marine Environment. In: *Programme & Abstract, International Conference: Innovations and Technologies in Oceanography for Sustainable Development ITOS 2005, Hotel Istana, Kuala Lumpur, Malaysia, 26-29 September 2005*. (pp 100).

Mustafa E.M., Mohd S.A., Chu W.L & Phang S.M. (2006). Effect of heavy metals, textile dyes and pesticides on growth and biochemical composition in tropical marine chlorophytes. In: *Book of Abstract, The 6th Asia-Pacific Conference on Algal Biotechnology. Dusit Hotel Nikko, Makati City, Philippines, 12-15 October 2006.* (pp 164).

Mustafa E.M. & Phang S.M. (2007). Toxicity and DNA damage detection using RAPD in *Boergesenia forbesii* (chlorophyta) exposed to organophosphate pesticides. In: *Book of Abstract, XIXth International Seaweed Symposium: Seaweed : Science & Technology for Traditional & Modern Utilization, Kobe, Japan, 26-31 March 2007*. (pp 180)

Mustafa, E.M., Azirun, M.S., Chu, W.L. & Phang, S.M. (2008). Algal Bioassay for Organophosphate Pesticides Contamination Using RAPD and Superoxide dismutase (SOD) activity. In: *Book of Programme & Abstract, 11th International Conference on Applied Phycology: Applied Phycology in the 21st Century; novel opportunities in a changing world, National University of Ireland, Galway, Ireland, 21-27 June 2008*. (pp 155).

Mustafa E.M. & Phang S.M. (2009). Effect of Textile Dye Contamination on Growth, Biochemical Composition and Suproxide Dismutase (SOD) Activity in the Marine

Chlorella sp. UMACC 245. In: *Book of Programme & Abstract, International Conference on Marine Ecosystem 2009 (INCOMES 2009): Transboundary Approach in Suitainable and Intergrated Marine Resource Management. 26-28 May 2009, Awana Porto Malai, Pulau Langkawi, Malaysia*. (pp 35).

Mustafa E.M. & Phang S.M. (2009). Bioassay for copper contamination based on DNA damage and superoxide dismutase activity in *Boergesenia forbesii* (Chlorophyta). *Phycologia, 48* (4), 88

Mustafa, E.M & Phang, S.M (2013). Effect of iron enrichment on tropical marine algae, *Tetraselmis tetrahele* and Boergesenia forbesii. *Phycologia, 52* (4), 75

Mustafa, E.M. (2013). Effects of selected chemical contaminants on growth, biochemical composition, DNA damage and Superoxide dismutase activity in four marine algae. In: *Doctor of Philosophy Thesis, Institute of Biological Sciences, Faculty of Science, University of Malaya, Kuala Lumpur*, (pp pages)

Mustafa, E.M. & Phang, S.M. (2014). Assessment of iron enrichment effects on the tropical marine *Chlorella vulgaris* using growth responses, biochemical composition, DNA damage and superoxide dismutase activity. In: *Proceeding The 7th Asian Pacific Phycological Forum (APPF2014), Algae, a world solution, September 20-24 2014, Wuhan China*. (pp.184).

Mustafa, E.M. & Phang, S.M. (2015). Impacts of ocean acidification on marine biodiversity: Gaps and potential research collaboration. In: *WESTPAC Training Workshop on Research and Monitoring of the Ecological Impacts of Ocean Acidification on Coral Reef Ecosystems, 19 – 21 Jan 2015, Phuket Marine Biological Center, Phuket, Thailand*, website (http://iocwestpac.org/calendar/606.html)

Mustafa, E.M, Vello, V., Lim, P.E., Nik Sulaiman, N.M., Majid, Chen, B.J.T, Liew, K.E. & Phang, S.M. (2016). Optimization of Malaysian microalgae for biofuel production.In : *Programme & Abstracts Book The 4th ASIA-OCEANIA Algae Innovation Summit (AOAIS 2016) 18 – 21 Sep 2016, East Lake International Conference Center, Wuhan, China*

Mustafa, E.M. & Phang, S.M. (2016), Effect of elevated temperature and reduction of pH on the biochemical composition of seaweed at Pulau Bidong, Terengganu, Malaysia. In: *WESTPAC Training Workshop on Research and Monitoring of the Ecological Impacts of Ocean Acidification on Coral Reef Ecosystems, 19 – 21 Jan 2015, Phuket Marine Biological Center, Phuket, Thailand,* website (http://iocwestpac.org/calendar/698.html).

Mustafa, E.M, Vello, V., Lim, P.E., Nik Sulaiman, N.M., Majid, N.A., Xavier, D., Schwob, C., Liew, K.E. & Phang, S.M. (2017). Screening of Malaysian microalgae as a potential feedstock for jet-fuel production. In: *Programme & Abstracts Book, The 8th Asian Pacific Phycological Forum (APPF2017), 8 – 13 October 2017, Pullman Hotel Bangsar, Kuala Lumpur, Malaysia*. (pp: 102).

Mustafa, E.M., Phang, S.M., Abdullah, S.A, & Bolong, A.M.A (2018). Use of Superoxide dismutase enzyme and DNA damage in *Boergesenia forbesii* as biomarker for assessing the coral reef benthic organisms response to chemical contamination. In :

Abstracts Book, The 3rd International 'CEDUS-UNHAS' Seaweed Symposium, 20 October 2018, Gammara Hotel, Makassar, Indonesia. (pp: 5).

Mustafa, E.M., Sulaiman, N.S.A., & Halim, N.N.A (2021). Mangroves and phytoplankton species composition along Merchang estuarine area, Marang, Terengganu. In : Idris, M. H., Musa, N., Piah, R. M., Hussin, W. M. R. W, Mustafa, E. M., & Zein, A. (Eds.). *Merchang lagoon coastal resources and social economy*. Penerbit UMT.

Murshidi, A., Yap, T.K., Gallagher, J.B. & Saleh, E. (2018). Seagrass Meadow Impacts on Universiti Malaysia Sabah (UMS) Beach, Kota Kinabalu Sabah (Malaysia). *Journal of Tropical Biology & Conservation (JTBC). 15*, 189-201.

Muta Hara, Z., Japar Sidik, B., & Arshad, A. (2002). Flowering, fruiting and seedling of annual *Halophila beccarii* Aschers in peninsular Malaysia. *Bulletin of marine science. 71* (3), 1199-1205.

Muta Hara, Z., Japar Sidik, B. & Fazrullah, R.A.R (2003). Occurrence and morphological description of seagrasses from Pulau Redang, Terengganu, Malaysia. *Jurnal Teknologi. 38* (C), 29-39.

Muta Harah, Z. & Japar Sidik B. (2013). Occurrence and distribution of seagrasses in waters of Perhentian Island Archipelago, Malaysia. *Journal of Fisheries and Aquatic Science, 8* (3), 441-451

Nabila, G. F., Faridah-Hanum, I., Abd Kudus, K., & Nazre, M. (2011). Assessment of Floristic Composition of Kilim Geoforest Park, Langkawi, Malaysia. *Journal of Agricultural Science, 4* (3). https://doi.org/10.5539/jas.v4n3p23

Nagappan, H., Pee, P.P., Kee, S.H.Y., Ow, J.T., Yan, S.W., Chew, L.Y., & Kong, K.W. (2017). Malaysian brown seaweeds *Sargassum siliquosum* and *Sargassum polycystum*: Low density lipoprotein (LDL) oxidation, angiotensin converting enzyme (ACE), α-amylase, and α glucosidase inhibition activities. *Food Research International, 99*, 950–958.

Najmuddin, M. F., Haris, H., Shahrool-Anuar, R., Norazlimi, N., Md-Zain, B. M., & Abdul-Latiff, M. A. B. (2019). Primatourism: Plant selection by schlegel's banded langur presbytis neglectus in Johor. *IOP Conference Series: Earth and Environmental Science, 269* (1) 12036.

Nakaoka, M., Lee, K.S., Huang, X.P., Almonte, T., Bujang, J.S., Kiswara, W., Rappe, R.A., Yaakub, S.M., Prabhakaran, M.P., Abu Hena, M.K., Hori, M., Zhang P.D., Prathep, A., & Fortes, M.D. (2014). Regional comparison of the ecosystem services from seagrass beds in Asia. In: Nakano, et al., (eds.). *Integrative Observations and Assessments. Ecological Research Monographs.* Springer, Tokyo. (pp. 367-391).

Naqqiuddin, M. A. et al. (2013). The diversity and density of marine dinoflagellates in the middle zone of the Straits of Malacca. *Malayan Nature Journal, 65*, 61-80.

Naqqiuddin, M. A. et al. (2014). Comparison between the diversity and density of marine dinoflagellates in Northern and Southern zone of Malacca straits. *International Journal of Current Microbiology and Applied Sciences, 3,* 723-748.

Natrah, F.M.I., Yusoff, F.M., Shariff, M., Abas, F., & Mariana, N.S. (2007). Screening of Malaysian indigenous microalgae for antioxidant properties and nutritional value. *Journal of Applied Phycology, 19* (6), 711-718.

Natrah, F.M.I., Muta Harah, Z., Japar Sidik, B., Izzatul, N.M.S. & Syahidah, A. (2015). Antibacterial activities of selected seaweed and seagrass from Port Dickson coastal water against different aquaculture pathogens. *Sains Malaysiana. 44* (9), 1269-1273.

Natrah, I., Nagao, N., Katayama, T., Imaizumi, Y., Mamat, N. Z., Yusoff, F. M., & Shariff, M. (2021). High intensity of light: A potential stimulus for maximizing biomass by inducing photosynthetic activity in marine microalga, *Tetraselmis tetrathele*. *Algal Research, 60*, 102523.

Nazarudin, M.F., Yusoff, F., Idrus, E.S., & Aliyu-Paiko, M. (2020). Brown seaweed *Sargassum polycystum* as dietary supplement exhibits prebiotic potentials in Asian sea bass *Lates calcarifer* fingerlings. *Aquaculture Reports, 18*, 100488.

Nazarudin, M.F., Alia, N.H., Balakrishnan, S., Wan Hasnan, W.N.I., Noor Mazli, N.A.I., Ahmad, M.I., Md Yasin,I. S., Isha, A., & Aliyu-Paiko, M., (2021). Chemical, nutrient and physiochemical properties of brown seaweed, *Sargassum polycystum* C.Agardh (Phaeophyceae) collected from Port Dickson, Peninsular Malaysia. *Molecules, 26*, 5216.

Neoh, Y.Y., Matanjun, P., & Lee, J.S. (2016). Comparative study of drying methods on chemical constituents of Malaysian red seaweed. *Drying Technology, 34* (14), 1745-1751.

Ng, F.L., Phang, S.M., Periasamy, V., Yunus, K., & Fisher, A.C. (2014). Evaluation of algal biofilms on indium tin oxide (ITO) for use in biophotovoltaic platforms based on photosynthetic performance. *PLoS One, 9* (5), e97643

Ng, F.L., Phang, S.M., Thong, C.H., Periasamy, V., Pindah, J., Yunus, K., & Fisher, A.C. (2021). Integration of bioelectricity generation from algal biophotovoltaic (BPV) devices with remediation of palm oil mill effluent (POME) as substrate for algal growth. *Environmental Technology & Innovation, 21*, 101280.

Ng, W.L., & Chan, H.T. (2012). Further observations on a natural *Rhizophora* hybrid population in Malaysia. *ISME/GLOMIS Electronic Journal, 10* (1), 1-3.

Nithin, B. R. et al. (2020). Culturing of green photosynthetic microalgae (*Chlorella* sp.) using palm oil mill effluent (POME) for future biodiesel production. *Maejo International Journal of Science and Technology, 2*, 1-8.

Nor, S.M.M., Sahari, M.S.I., Razali, N.A.M., Salam, M.R., Mustaffa, W.F.W., Stephen, E.R. & Mokhetar, N. (2022). Mangrove floristic composition dataset of the Setiu Lagoon, Terengganu Malaysia. *Data in Brief, 42*, 108020.

Norakma, M.N., Zaibunnisa, A.H., & Wan Razarinah, W.A.R. (2021). The changes of phenolics profiles, amino acids and volatile compounds of fermented seaweed extracts obtained through microbial fermentation. *Materials Today: Proceedings*. https://doi.org/10.1016/j. matpr.2021.02.366

Nor Azah, M.A., Saidatul Husni, S., Mailina, J., Noor Rasyila, M.N., Abd Majid, J., Tariq Mubaraq, H., Mohd Shafiq Yuzman, T., Sahrim, L., Shalini, M., Mohammad Faridz, Z.P. & Syahida Emiza, S. (2019). Exploration of Mangrove Plants for Producing Value Added Product. In*: Proceeding of The National Seminar on Mangrove and Coastal Forest 2019* (pp. 95-104).

Nor Hapidah, O. (2007). A Preliminary Study of Mangrove Distribution at Sg. Haji Dorani, Sabak Bernam, Selangor. *Undergraduate thesis, Bachelor of Applied Science in Marine Science, Faculty of Maritime Studies and Marine Science, Universiti Malaysia Terengganu, Terengganu*. (pp 75).

Nor Hasliza, M.Y. (2008). Mangrove community structure and analysis: A case for Tumpat, Kelantan Delta, East Coast of Peninsular Malaysia. *Undergraduate thesis, Bachelor of Science in Marine Science, Faculty of Maritime Studies and Marine Science, Universiti Malaysia Terengganu, Terengganu*. (pp 31).

Norhayati, A., Shukor, M.N., Juliana, S., & Wan Juliana, W.A. (2009). Mangrove flora and fauna of Klang Islands mangrove forest reserves, Selangor, Malaysia. *Malaysian Journal of Science, 28* (3), 275–288. https://doi.org/10.22452/mjs.vol28no3.6

Norilani, W.W., Juliana, W.W., Salam, M.R., & Latiff, A. (2014). Community structure at two compartments of a disturbed mangrove forests at Pulau Langkawi. In: *AIP Conference Proceedings, 1614* (1), 790-794). American Institute of Physics.

Nurol Huda, N. (2008). Penglibatan komuniti dalam projek pemuliharaan hutan persisir pantai di Tanah Bencah Setiu, Terengganu. In: *Prosiding Seminar Pemuliharaan Hutan Persisiran Pantai Negara 2008: Hasil Penyelidikan Dan Aplikasinya Kepada Tanaman Serta Kesedaran Komuniti* (pp. 97-108).

Norra, I., Aminah, A., Suri, R., and Arif Zaidi, J. (2017). Effect of drying temperature on the content of fucoxanthin, phenolic and antioxidant activity of Malaysian brown seaweed, *Sargassum* sp. *J. Trop. Agric. and Fd. Sc., 45* (1), 25 – 36.

Nor Syahirah, Z., Noor, J. N. J., & Syafinie, A. M. (2018). Effect of disturbance on mangrove species diversity in Delta Tumpat, Kelantan, Malaysia. *Tropical Plant Research, 5* (3), 391–395. https://doi.org/10.22271/tpr.2018.v5.i3.048

Norziah, M.H., & Ching, C.Y., (2000). Nutritional composition of edible seaweed *Gracilaria changii. Food Chemistry, 68,* 69-76

Nuhma, M. J., Alias, H., Jazie, A. A., & Tahir, M. (2021). Role of Microalgae as a Source for Biofuel Production in the Future: A Short Review. *Bulletin of Chemical Reaction Engineering & Catalysis, 3*.

Olanrewaju, S.O., Magee, A., Kader, A.S.A., & Tee, K.F., (2017). Simulation of offshore aquaculture system for macro algae (seaweed) oceanic farming. *Ships and Offshore Structures, 12* (4), 553-562

Ong, H.C., Noraini, M. T., & Rozainah, M. Z (2008). Kajian flora dan fauna di hutan terdegradasi di persisiran pantai Sungai Haji Dorani, Selangor. In: *Prosiding Seminar Pemuliharaan Hutan Persisiran Pantai Negara 2008: Hasil Penyelidikan Dan Aplikasinya Kepada Tanaman Serta Kesedaran Komuniti* (pp. 127-130).

Ong, J. E., Ahmad, W. J. W., Yong, J. W. H., Mohamed, M., Wong, Y. Y., & Husin, H. M. N. (2015). The Merbok mangroves: Present status and the way forward. In: *Hutan Paya Laut Merbok, Kedah: Pengurusan hutan, Persekitaran fizikal dan kepelbagaian floraPublisher: Jabatan Perhutanan Semenanjung Malaysia* (pp. 74–84). Jabatan Perhutanan Semenanjung Malaysia.

Ono, J., Yong, J. W., Takayama, K., Saleh, M. N. B., Wee, A. K., Asakawa, T., & Kajita, T. (2016). *Bruguiera hainesii*, a critically endangered mangrove species, is a hybrid between *B. cylindrica* and *B. gymnorhiza* (Rhizophoraceae). *Conservation Genetics, 17* (5), 1137-1144.

Ooi, J.L.S., Kendrick, G.A. & Van Niel, K.P. (2011). Effects of sediment burial on tropical ruderal seagrasses are moderated by clonal integration. *Continental Shelf Research, 31* (19-20), 1945-1954.

Ooi, J.L.S., Van Niel, K.P., Kendrick, G.A. & Holmes, K.W. (2014). Spatial structure of seagrass suggests that size-dependent plant traits have a strong influence on the distribution and maintenance of tropical multispecies meadows. *PloS one. 9* (1), 9(1): e86782. doi:10.1371/journal.pone.0086782

Ooi, J.L.S. & Lim, A.C.O. (2019). Seagrasses and syngnathid fish of Pulau Sibu, Johor. *Malayan Nature Journal, 71* (3), 361-365.

Othman, F. (2010). Mangrove Vegetation Structure and Analysis: A Case for Sungai Chukai, Kemaman, Terengganu, East Coast of Peninsular Malaysia. *Undergraduate thesis, Bachelor of Science in Marine Science, Faculty of Maritime Studies and Marine Science, Universiti Malaysia Terengganu.*

Othman, M.N.A., Hassan, R., Harith, M.N., & Md Sah, A.S.R. (2015). Red Seaweed Gracilaria arcuata in Cage Culture Area of Lawas, Sarawak. *Borneo Journal of Resource Science and Technology, 5* (2), 53-61.

Othman, M.N.A., Hassan, R., Harith, M.N., & Md Sah, A.S.R., (2018). Morphological Characteristics and Habitats of Red Seaweed *Gracilaria* spp. (Gracilariaceae, Rhodophyta) in Santubong and Asajaya, Sarawak, Malaysia. *Tropical Life Sciences Research, 29* (1), 87–101.

Palaniveloo, K., Liaw, Y.Y., Leong, J.Q., Alvin, C., Song, S.L., Thilahgavani, N., Razak, S.A., Kamal, D., Jestin, C., Dinesh, K.C., & Anil, P.K. (2021). Nutritional Profile, Antioxidative and Antihyperglycemic Properties of *Padina tetrastromatica* from Tioman Island, Malaysia. *Foods MDPI, 10*,1932.

Phang S.M. (1984). Seaweed resources of Malaysia. *Wallaceana. 33,* 3-8

Phang, S.M., Shaharuddin,S., Hashim N. & Sasekumar, A. (1996). Studies on *Gracilaria changii* (Gracilariales, Rhodophyta) from Malaysian mangroves*. Hydrobiologia, 327,* 347-352

Phang S.M. (1998). The Seaweed Resources of Malaysia. In: Critchley A & Ohno M. (eds.). *Seaweed Resources of the World.* JICA Publication (pp.79-91)

Phang, S.M., Wong, C.L., Lim, P.E., Yeong, H.Y. & Chan, C.X., (2005). Seaweed diversity of the Langkawi Island with emphasis on the Northeastern Region. *Malaysian Journal of Sciences, 24*, 77-94.

Phang S.M. (2006). Seaweed resources in Malaysia : Current status and future prospects. *Aquatic ecosystem Health & Management. 9* (2), 185-202

Phang S.M., Wong C.L., Lim P.E., Ooi J.L.S., Gan S.Y., Ismail M. & Mustafa E.M. (2007). Chua L.S.L., Kirton L.G. & Saw L.G. (eds.). *Status of Biological Diversity in Malaysia and Threat Assessment of Plant Species in Malaysia.*. Forest Research Institute Malaysia. (pp. 185-210)

Phang S.M., Wong C.L., Yeong H.Y. & Masuda M. (2008). Marine algae of Pulau Tioman, East Coast Peninsular Malaysia. In: .Phang S.M., Amri A.Y., Ooi, L.S.J & Mydin H.A.J. (Eds). *Natural history of the Pulau Tioman group of Islands. Monograph Series 1, Institute of Ocean and Earth Sciences, University of Malaya, Kuala Lumpur*. (pp 19-34).

Phang S.M., Wong C.L., Ng W.S., & Sim M.C. (2008). Checklist of Malaysian *Sargassum* species. In : Phang S.M., Lewmanomont K. & Lim, P.E. (eds.). *Taxonomy of Southeast Asian Seaweeds. Monograph Series 2, Institute of Ocean and Earth Sciences, University of Malaya, Kuala Lumpur.* (pp. 83-103).

Phang S.M., Lim P.E. & Yeong H.Y. (2010). Malaysian seaweed resources in the South China Sea and their potential economic and ecological application. *Journal of Science and Technology in the Tropics, 6* (2), 87-109.

Phang S.M., Lim P.E. & Yeong H.Y. (2010). Malaysian seaweed resources in the South China Sea and their potential economic and ecological application. In: Lim P.E, Hussin H. Idid, M.R. & Mokhtar N.A (Eds). *The South China Sea: Sustaining ocean productivities, maritime communities and climate. Monograph Series 11, Institute of Ocean and Earth Sciences, University of Malaya, Kuala Lumpur.* (pp 185).

Phang S.M., Lim P.E., Yeong H.Y., Ng W.S. & Song S.L., (2010). Marine microalgae collected during the Scientific Expedition to Bachok, Kelantan and the Islands of Terengganu with one new record, Pterocladia for Malaysia. *Malaysian Journal of Science, 29*, 31-46.

Phang, S.M., Yeong, H.Y., Lim, P.E., Md Nor, A.R. & Gan, K.T. (2010). Commercial varieties of *Kappaphycus* and *Eucheuma* in Malaysia. *Malaysian Journal of Sciences, 29* (3), 214-224.

Phang S.M., Sim, M.C., Yow, Y.Y, Yeong, H.Y., & Lim, P.E (2013). *Halimeda* (Bryopsidales, Chlorophyta) from the Sulu-Sulawesi region and Layang-Layang Island of Malaysia. In : Phang S.M., & Lim, P.E. (eds.). *Taxonomy of Southeast Asian Seaweeds II. Pp. 1-38. Monograph Series 15, Institute of Ocean and Earth Sciences, University of Malaya, Kuala Lumpur.*

Phang, S.M. et al., (2015). Checklist of microalgae collected from different habitats in Peninsular Malaysia for selection of algal biofuel feedstocks. *Malaysian Journal of Science, 34* (2), pp.141–167.

Phang, S.M., Yeong, H.Y., Ganzon-Fortes, E.T., Lewmanomont, K., Prathep, A., Hau, L.N., Gerung, G.S & Tan, K.S. (2016). Marine algae of the South China Sea bordered by Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam. *Raffles Bulletin of Zoology, 34*, 13–59.

Phang, S.M., Yeong, H.Y., & Lim, P.E. (2019). The seaweed resources of Malaysia. Botanica Marina, 1-9. https://doi.org/10.1515/bot-2018-0067

Ponnampalam, L.S., Izmal, J.H.F., Kanjana A., Ooi, J.L.S. & Reynolds, J.E. (2014). Aligning conservation and research priorities for proactive species and habitat management: the case of dugongs Dugong dugon in Johor, Malaysia. *Fauna & Flora International, Oryx, 49* (4), 743-749.

Pradisty, N.A., Amir, A.A., & Zimmer, M. (2021). Plant species- and stage-specific differences in microbial decay of mangrove leaf litter: the older the better? *Oecologia, 195*, 843 - 858.

Putz, F.E., & Chan, H.T. (1986). Tree growth, dynamics, and productivity in a mature mangrove forest in Malaysia. *Forest ecology and management, 17* (2-3), 211-230.

Rabbani, G., Yan, B.C., Lee, N.L.Y., Ooi, J.L.S., Lee, J.N., Huang, D. & Wainwright, B. J. (2021). Spatial and Structural Factors Shape Seagrass-Associated Bacterial Communities in Singapore and Peninsular Malaysia. *Frontiers in Marine Science, 8,* 659180

Raheman, N.Y., Nordin, R.M., Abdullah, M., & Hassim, M.F.N. (2020). Association Between Root Complexity of *Rhizophora apiculata* and Sedimentation at Pantai Kelanang, Selangor. *Malaysian Applied Biology, 49* (4), 141-148.

Rahman, M.M., Phang, H.K., Chu, C.M., Kumaresan, S., & Md Yasit, S. (2018). A Cold-inflow Free Solar Chimney Dryer for Seaweed Drying in Sabah, Malaysia. In: *Proceedings of the International Conference on Industrial Engineering and Operations Management Bandung, Indonesia.*

Raman, R., & Mohamad, S.E. (2012). Astaxanthin production by freshwater microalgae *Chlorella sorokiniana* and marine microalgae *Tetraselmis* sp. *Pak J Biol Sci, 15* (24), 1182-1186.

Rasheed, M.Z., Normaniza, O., & Rozainah, M.Z. (2013). Physiological responses of *Avicennia marina var. acutissima* and *Bruguiera parviflora* under simulated rise in sea level. *Sains Malaysiana, 42* (8), 1059-1064.

Raza, M., Zakaria, M. P., & Hashim, N. R. (2011). Spatial and temporal variation of organic carbon in Mangrove sediment of Rembau–Linggi Estuary, Malaysia. *World Appl. Sci. J, 14,* 48-54.

Razali, M. S., Muhammad Khairul, F. Z., Wan Juliana, W. A., Abdullah, D. M., Nasir, M. Z., Mohd Mazlan, N., & Wan Faridah, A. W. K. (2016). Distribution and rarity of mangrove and coastal plants in developing indicators of hotspots in Setiu Wetlands. In: *Prosiding seminar ekspedisi saintifik Tanah Bencah Setiu* (pp. 14-23).

Razali, R. M., Chui, P. L., Hong, C. L., Nyanti, L., Ishak, I., & Po, T. L. (2015). Harmful microalgae assemblage in the aquaculture area of Aman Island, Northern Strait of Malacca. *Malaysian Journal of Science, 34* (1), 20-32.

Razak, N.N. (2016). The performance of dye removal by Malaysia seaweed biomass. *Thesis Bachelor of Engineering (Hons) in Civil Engineering, Faculty of Civil Engineering and Earth Resources, Universiti Malaysia Pahang.*

Renganathan Rajkumar, R. & Takriff, M.S. (2016). Prospects of Algae and their Environmental Applications in Malaysia: A Case Study. *Journal of Bioremediation & Biodegradation.7* (1): 1000321. doi:10.4172/2155-6199.1000321

Rohani, A., Khadri, M. S., & Lee, H. L. (2006). Microalgae associated with *Leptoconops* breeding sites in selected sandy beaches of Malaysia. *Tropical biomedicine, 23* (2), 164-171.

Rosli, N., Hussin, R., & Hossin, A (2014). The react by cultivator toward introduction of new technology in seaweed cultivate system in Semporna, Sabah. In: Ali, I., Lee, H.A., & Raplee, D.R. *1st International Maritime Conference. 21 Oct 2014, Universiti Malaysia Sabah, Labuan International Campus, Sabah.* (pp 86-94). ISBN: 978-967-0521-40-4.

Roushon A., Arshad, A., Amrullah, N., Nurul Amin, S.M., Daud, S.K., Nor Azwady, A.A. & Mazlan, A.G. (2009). Feeding habits and temporal variation of diet composition of fish larvae (Osteichthyes: Sparidae) in the Sungai Pulai seagrass bed, Johore, Peninsular Malaysia. *Journal of biological sciences, 9* (5), 445-451.

Roushon, A., Arshad, A., Nurul Amin, S.M., Siti Khalijah, D., Japar Sidik, B. & Mazlan, A.G. (2010). Feeding habits of larval fishes of the family Gobiidae (Actinopterygii: Perciformes) in seagrass beds of Sungai Pulai estuary, Johor Strait, Malaysia. *Coastal Marine Science, 34* (1):123–128

Roushon, A., Arshad, A., Nurul Amin, S.M., Daud, S.K. & Ghaffar, M.A. (2011). Environment and diversity of ichthyoplankton in the seagrass beds of Sungai Pulai Estuary, Johor, Peninsular Malaysia. *Journal of Food Agriculture & Environment, 9* (3&4), 733-738.

Roushon A., Arshad, A., Nurul Amin, S.M., & Ghafar, M.A. (2014). Fish larval occurrence and distribution in the seagrass-mangrove ecosystems of the Johor Straits. *Malayan Nature Journal, 66* (1 &2), 212-236.

Roushan, A., Arshad, A., Nurul Amin, S.M., Idris, M.H., Ghafar, M.A., & Romano, N. (2016). Influence of habitat structure and environmental variables on larval fish assemblage in the Johor Strait, Malaysia. *Journal of Environmental Biology, 37* (Special issue), 745-754.

Rozaimi, M., Arina, N., Zainee, N.F.A., Raynusha, C. & Hidayah, N. (2020). An uncommon intertidal record of *Halophila decipiens* Ostenfeld in the vicinity of mangroves. *Aquatic Botany, 160,* 103168.

Roy, R.N (1977). Red tide and outbreak of paralytic shellfish poisoning in Sabah. *Med. J. Malaysia, 31* (3), 247-251

Rozainah, M. Z., & Mohamad, M. R. (2006). Mangrove Forest Species Composition and Diversity in Balok River, Pahang, Malaysia. *Ecoprint: An International Journal of Ecology, 13,* 23-28

Rozainah, M. Z., & Nasrin, A. (2010). A demographic study of a mangrove palm, *Nypa fruticans. Scientific Research and Essays, 5* (24), 3896-3902.

Rozainah, M. Z., Nazri, M. N., Sofawi, A. B., Hemati, Z., & Juliana, W. A. (2018). Estimation of carbon pool in soil, above and below ground vegetation at different types of mangrove forests in Peninsular Malaysia. *Marine Pollution Bulletin, 137*, 237–245. https://doi.org/10.1016/j.marpolbul.2018.10.023

Rozainah, M. Z., Sofawi, A. B., Joharee, N. A., & Pauzi, A. Z. (2018). Stand structure and biomass estimation in the Klang Islands Mangrove Forest, Peninsular Malaysia. *Environmental Earth Sciences, 77* (13), 12665. https://doi.org/10.1007/s12665-018-7636-7

Roziawati,M.R. & Faazaz, A.L. (2011). Potentially harmful microalgae from cockle culture area in Sungai Jarum Mas, Perak. *Malaysian Fisheries Journal, 10,* 91-103

Sade, A., Ali, I. & Mohd. Ariff, M.R. (2006) The seaweed industry in Sabah, East Malaysia. *Jati, 11*, 97-107.

Saeed, A.A.H., Harun, N.Y., Sufian, S., Siyal, A.A., Zulfiqar, M., Bilad, M.R., Vagananthan, A., Al-Fakih, A., Ghaleb, A.A.S., and Almahbashi, N., (2020). *Eucheuma cottonii* Seaweed-Based Biochar for Adsorption of Methylene Blue Dye. *Sustainability, 12*,10318.

Safari, S. (2015). Prospects and Policy Review of seaweed as a High-Value Commodity in Malaysia. FFTC Agricultural Policy Platform (FFTC-AP). Http://ap.fftc.agnet.org/index.php

Sahibu, A., Nordahliawate, S., & Abdullah, M. (2020). Presence of Foliar Diseases Caused by Fungi in Mangroves on The East Coast of Peninsular Malaysia. *Malaysian Applied Biology, 49* (4), 181-186.

Saleh, E., Yap, T.K. & Gallagher, J.B. (2020). Seagrass coverage and associated fauna at Gaya Island, Sabah, Malaysia: A pilot seagrass transplantation. *Borneo Journal of Marine Science and Aquaculture., 4* (1), 14-19.

Salim, J. M., Salam, M. R., Pesiu, E., & Shahrudin, R. (2019). Flora checklist and vegetation type of Pulau Sibu, Johor. *Malayan Nature Journal, 71* (3), 311-324.

Salim, J. M., Lee, G. E., Salam, M. R., Shahimi, S., Pesiu, E., Jani, J. M., & Nikong, D. (2020). A checklist of vascular plants and uses of some species for livelihood-making in Setiu Wetlands, Terengganu, Malaysia. *PhytoKeys, 160*, 7.

Saraswathy, R., Rozainah, M. Z., & Redzwan, G. (2009). Diversity and biomass estimation of mangrove trees on Carey Island, Malaysia. *Ecology, Environment and Conservation, 15* (2), 205–211.

Shaari,A.L., Surif, M., Abd. Latiff,F., Wan Omar, WM. & Ahmad, MN. (2011). Monitoring of Water Quality and Microalgae Species Composition of Penaeus monodon Ponds in Pulau Pinang, Malaysia. *Tropical Life Sciences Research, 22* (1), 51–69

Shah, K., Mustafa Kamal, A. H., Rosli, Z., Hakeem, K. R., & Hoque, M. M. (2016). Composition and diversity of plants in Sibuti mangrove forest, Sarawak, Malaysia. *Forest Science and Technology, 12* (2), 70–76. https://doi.org/10.1080/21580103.2015.1057619.

Shah, M.D., Maran, B.A.V., Shaleh, S.R.M., Zuldin, W.H., Gnanaraj, C. & Yong, Y.S. (2022). Therapeutic Potential and Nutraceutical Profiling of North Bornean Seaweeds: A Review. *Marine Drugs, 20* (2), 101.

Shahar, S.S. (2014). Biochemical composition and antioxidant capacity of marine microalgae *Chlorella salina* Butcher and *Isochrysis maritima* Billard and Gayral isolated from Penang Coastal Waters. *Doctoral dissertation, Universiti Sains Malaysia*.

Shahbudin, S., Zuhairi, A., Kamaruzzaman, Y., & Jalal, K. C. A. (2009). Impact of coastal development on mangrove distribution in Kuantan, Pahang. In: *International Workshop on Integrated Coastal Zone Management, 20-22 October 2009, Izmir, Turkey* (pp. 1-11).

Shahrudin, R., Salim, J.M., Pesiu, E., Salam, M.R., Yi, C.J., & Mohd. Hakkim F.H. (2019). The Checklist of Mangrove Plants and Their Distribution on Pulau Sibu, Johor. *Malayan Nature Journal, 71* (3), 333–339.

Sharif, N.A.M., Kahar, N.A.S., Hussein, M.A.S., Ransangan, J., & Yong, A.S.K. (2019). Species diversity and distribution of mud crab in Marudu Bay mangrove forest reserve, Sabah, Malaysia. *Borneo Journal of Marine Science and Aquaculture , 3* (1), 18-24.

Shapawi, R., & Zamry, A.A. (2016). Response of Asian seabass, *Lates calcarifer* juvenile fed with different seaweed-based diets. *Journal of Applied Animal Research, 44* (1), 121-125.

Shuaib, N., Mohammad, M., Matias-Peralta, H. M., Rusiman, M.S. & Sanusi, S.B. (2019). Copepods status in seagrass area of Pulau Tinggi Marine Park, Johor, Malaysia. International Conference on Biodiversity 2018. *IOP Conference Series: Earth and Environmental Science. 269* (1): 012044).

Siah, W.M., Aminah, A. & Ishak, A. (2015). Edible films from seaweed (*Kappaphycus alvarezii*). *International Food Research Journal, 22* (6): 2230-2236.

Sidi, N., Aris, A.Z., Yusuff, F.M., Ley, J.L. & Mokhtar, N.F. (2018). Tape seagrass (*Enhalus acoroides*) as a bioindicator of trace metal contamination in Merambong shoal, Johor Strait, Malaysia. *Marine Pollution Bulletin, 126*, 113-118.

Sit, N.W., Chan, Y.S., Lai, S.C., Lim, L.N., Looi, G.T., Tay, P.I., Tee, Y.t., Woon, Y.Y, Khoo, K.S & Ong, H.C. (2018). In vitro antidermatophytic activity and cytotoxicity of extracts derived from medicinal plants and marine algae. *Journal de Mycologie Me đicale, 28*, 561–567

Sohrabipour, J., Lim, P.E., Maggs, C., Rabiei, R. & Phang, S.M. (2013). The order Gelidiales in Southeast Asia. In: Phang S.M., & Lim, P.E. (eds.). *Taxonomy of Southeast*

Asian Seaweeds II. Monograph Series 15, Institute of Ocean and Earth Sciences, University of Malaya, Kuala Lumpur (pp. 65-82).

Soo, C.L., Chen, C.A., Bojo, O., & Hii, Y.S. (2017). Feasibility of marine microalgae immobilization in alginate bead for marine water treatment: Bead stability, cell growth, and ammonia removal. *International Journal of Polymer Science,* 2017.

Sofawi, B. A., Rozainah, M. Z., Normaniza, O., & Roslan, H. (2017). Mangrove rehabilitation on Carey Island, Malaysia: an evaluation of replanting techniques and sediment properties. *Marine Biology Research, 13* (4), 390-401.

Stankovic, M., Ambo-Rappe, R., Carly, F., Dangan-Galon, F., Fortes, M.D., Hossain, M.S., Kiswara, W., Cao, V.L., Phan, M.T., Mishra, A.K., Noiraksar, T., Nurdin, N., Panyawai, J., Rattanachot, E., Rozaimi, M. Htun, U.S & Prathep, A. Quantification of blue carbon in seagrass ecosystems of Southeast Asia and their potential for climate change mitigation. *Science of the Total Environment.* https://doi.org/10.1016/j.scitotenv.2021.146858

Stanley, O. D., & Lewis III, R. R. (2009). Strategies for mangrove rehabilitation in an eroded coastline of Selangor, Peninsular Malaysia. *Journal of Coastal Development, 12* (3), 142-154.

Suali, E., Sarbatly, R., Anisuzzaman, S. M., Lahin, F. A., Asidin, M. A., & Jusnukin, T. (2017). Effect of membrane on carbonation and carbon dioxide uptake of Chlorella sp. In: *MATEC Web of Conferences, 111, pp 02004.* EDP Sciences.

Subakir, F.N.M., Ishak, N.I., Abu Samah, N., Abdul Aziz, K.A., & Zaharudin, N. (2021). The effects of seaweed-based pellet binders on growth performance, feed efficiency and carcass characteristics in broilers. *Animal Feed Science and Technology, 272*, 114786.

Sudo, K., Quiros, T.E.A., Prathep, A., Luong, C.V., Lin, H.J., Bujang, J.S., Ooi, J.L.S., Fortes, M.D., Zakaria, M.H., Yaakub, S.M., Tan, Y.M., Huang, X. & Nakaoka, M. (2021). Distribution, temporal change and conservation status of tropical seagrass beds in Southeast Asia: 2000-2020. *Frontiers in Marine Science, 8*, 637722.

Suhaili, N. S., Fei, J. L. J., Sha'ari, F. W., Idris, M. I., Hatta, S. M., Kodoh, J., & Besar, N. A. (2020). Carbon stock estimation of mangrove forest in Sulaman lake forest reserve, Sabah, Malaysia. *Biodiversitas, 21* (12), 5657–5664. https://doi.org/10.13057/biodiv/d211223

Syed, N.N.F., Zakaria, M. H. & Bujang, J. S. (2016). Fiber characteristics and papermaking of seagrass using hand-beaten and blended pulp. *BioResources, 11* (2), 5358-5380.

Tachihana, S., Nagao, N., Katayama, T., Hirahara, M., Yusoff, F. M., Banerjee, S., & Furuya, K. (2020). High productivity of eicosapentaenoic acid and fucoxanthin by a marine diatom Chaetoceros gracilis in a semi continuous culture. *Frontiers in Bioengineering and Biotechnology, 8.*

Tamin, N. M., Zakaria, R., Hashim, R., & Yin, Y. (2011). Establishment of Avicennia marina mangroves on accreting coastline at Sungai Haji Dorani, Selangor, Malaysia. Estuarine, *Coastal and Shelf Science, 94* (4), 334-342.

Tan, D. D., Wan Juliana, W.A., & Maimon, A. (2012). Community structure and productivity of mangrove forests in two national parks of West Malaysia. *Malaysian Forester, 75* (2), 165–176.

Tan, H.S., Rahim, A. A. & Ross, O.H. (2015). Preliminary study of mysid community on seagrass bed of Pulau Tinggi, Johor. The 2015 UKM FST Postgraduate Colloquium. *AIP Conference Proceedings.* 1678: 020035. AIP Publishing LLC.

Tan, K.S. & Ransangan, J. (2016) Effects of Environmental Conditions and Nutrients on the Occurrence and Distribution of Potentially Harmful Phytoplankton in Mesotrophic Water. *Sains Malaysiana 45* (6), 865–877

Tan, Ji; Tan, P.L., Poong, S.W.; Brakel, J., Gachon, C,,Brodie, J., Sade, Ahemad; Kassim, Azhar; Lim, Phaik-Eem (2022). Genetic differentiation in wild *Kappaphycus* Doty and *Eucheuma* J. Agardh (Solieriaceae, Rhodophyta) from East Malaysia reveals high inter- and intraspecific diversity with strong biogeographic signal. *Journal of Applied Phycology, 34* (5), 2719 – 2733.

Tangah, J., Chung, A.Y.C., Baba, S., Chan, H.T. & Kezuka, M., 2020. Rehabilitation of Mangroves in Sabah: The SFD-ISME Collaboration (2014−2019). *Sabah Forestry Department, International Society for Mangrove Ecosystems, and Tokio Marine & Nichido Fire Insurance Co., Ltd.*

Tao, D.G., Salihon, J., & Meng, L. (2009). Modelling of microalgae growth and oil production by using sewage and carbon dioxide for biodiesel. In: Noor, M.M, Rahman, M.M. & Kadirgama, K. (eds). *The Proceedings of National Conference on Postgraduate Research, Universiti Malaysia Pahang, Malaysia*. Paper (No. 011, pp. 59-66).

Tariq Mubarak H., Noraishah S., Mohd, Rizuwan M., & Azharizan M. N (2013). Penilaian stok karbon di hutan paya laut di Pulau Kukup. In: *Prosiding Seminar Kebangsaan Pemuliharaan Hutan Persisiran Pantai Negara 2013: Pemeliharaan dan Pemuliharaan Hutan Pesisiran Pantai Untuk Kesejahteraan Masyarakat* (pp. 292-295)

Tee, M.Z., Yong, Y.S., Rodrigues, K.F. & Yong, W.T.L. (2015). Growth rate analysis and protein identification of *Kappaphycus alvarezii* (Rhodophyta, Gigartinales) under pH induced stress culture. *Aquaculture Reports, 2,* 112–116.

Tengku Zarawie, T. H., Suratman, M. N., Jaafar, J., Mohd Hasmadi, I., & Abu, F. (2015). Field assessment of above ground biomass (agb) of mangrove stand in Merbok, Malaysia. *Malaysian Applied Biology, 44* (3), 81–86.

Teo, C.L., Atta, M., Bukhari, A., Taisir, M., Yusuf, A.M., & Idris, A. (2014). Enhancing growth and lipid production of marine microalgae for biodiesel production via the use of different LED wavelengths. *Bioresource technology, 162*, 38-44.

Teo, C. L., & Idris, A. (2014). Enhancing the various solvent extraction method via microwave irradiation for extraction of lipids from marine microalgae in biodiesel production. *Bioresource Technology, 171*, 477-481.

Teo, C.L., Idris, A., Wahidin, S., & Lai, L.W. (2014). Effect of different light wavelength on the growth of marine microalgae. *Jurnal Teknologi, 67* (3).

Teo, B.S.X., Gan, R.Y., Abdul Aziz, S., Sirirak, T., Mohd Asmani, M.F. & Yusuf, E. (2021). In vitro evaluation of antioxidant and antibacterial activities of *Eucheuma cottonii* extract and its in vivo evaluation of the wound-healing activity in mice. *Journal of Cosmetic Dermatology, 20* (3), 993 – 1001.

Teoh, V.Y.J. & Woo, S.P. (2021). The diversity of echinoderms in the seagrass meadows of Penang Island, Malaysia. *IOP Conference Series: Earth and Environmental Science. 711*, 012012.

Tevan, R. et al. (2017). Biosynthesis of silver nanoparticles using marine microalgae *Isochrysis* sp.. *Journal of Chemical Engineering and Industrial Biotechnology, 2* (1), 1–12.

Tevan, R. et al. (2018). Ayurvedic mediated green synthesis of gold and silver nanoparticles from marine microalgae, *Isochrysis* sp.. *International Journal of Engineering & Technology Sciences, 7*, 422-425. 10.14419/ijet.v7i3.7.18895.

Tharek, A., Jamaluddin, H., Salleh, M.M., Yahya, N. A., Kaha, M., Hara, H. & Mohamad, S. E. (2020). Astaxanthin production by tropical microalgae strains isolated from environment in Malaysia. *Asian J. Microbiol. Biotechnol. Env. Sci, 22*, 168-173.

Then, A.Y.H., Adame, M.F., Fry, B., Chong, V.C., Riekenberg, P.M., Mohammad Zakaria, R., & Lee, S.Y. (2021). Stable isotopes clearly track mangrove inputs and food web changes along a reforestation gradient. *Ecosystems, 24* (4), 939-954.

Thien, V.Y., Yong, W.T.L., Anton, A. & Chin, G.J.W.L. (2020). A multiplex PCR method for rapid identification of commercially important seaweeds *Kappaphycus alvarezii, Kappaphycus striatus* and *Eucheuma denticulatum* (Rhodophyta, Solieriaceae). *Regional Studies in Marine Science, 40*,101499

Tiong, A.C.Y., Tan, I.S., Foo, H.C.Y., Lam, M.K., Mahmud, H.B., and Lee, K.T. (2020). Macroalgae-derived regenerated cellulose in the stabilization of oil-in-water Pickering emulsions. *Carbohydrate Polymers, 249*,116875.

Tope, A.H.T, Jaswir, I., Raus, R.A., & Ademola, H. M. (2012). Solvent extraction of anti-microbial bioactive compounds from seaweed of Malaysia origin: screening and optimization. *Abstract Conference Proceedings, 2nd Asia Pacific Pharmacy Education (PharmED) Workshop, 3* (1), 54. ISSN: 2045-080X.

Tope, A.H.T (2012). Extraction and fractionation of Malaysian seaweed possessing anti-bacteria activity. *Thesis Master of Science Biotechnology Engineering. Kulliyah of Engineering, International Islamic University Malaysia.*

Usup, G., Ahmad, A., Matsuoka, K., Lim, P. T., & Leaw, C. P. (2012). Biology, ecology and bloom dynamics of the toxic marine dinoflagellate *Pyrodinium bahamense*. *Harmful Algae. 14* , 301-312.

Varaippan, C.S. (2003). Potent antibacterial activity of halogenated metabolites from Malaysian red algae, *Laurencia majusculea* (Rhodomelaceae, Ceramiales). *Biomolecular Engineering, 20*, 255-259.

Varaippan, C.S., Ang, M.Y., Ong, C.Y., and Phang, S.M. (2004). Biologically active polybrominated indoles in the red algae, *Laurencia similis* from the coastal waters of Sabah (Rhodomelaceae, Ceramiales). *Malaysian Journal of Science, 23* (2), 119-126.

Varaippan, C.S & Phang, S.M. (2005). Morphology and Halochamegrene Metabolite Content of *Laurencia majuscule* (Rhodomelaceae, Ceramiales). from the Spratly Islands. *Malaysian Journal of Science, 24* (2), 29-36.

Varaipan, C.S., Suzuki, M., Ishii, T., Okino, T., Abe, T. & Masuda, M. (2008). Antibacterial activity of halogenated sesquiterpenes from Malaysian *Laurencia* spp. *Phytochemistry, 69,* 2490-2494.

Vairappan, C.S., & Yen, A.M. (2008). Palm oil mill effluent (POME) cultured marine microalgae as supplementary diet for rotifer culture. *Journal of applied phycology, 20* (5), 603-608.

Vairappan, C.S., Anangdan, S.P., Tan, K.L., & Matsunaga, S. (2010). Role of secondary metabolites as defense chemicals against ice-ice disease bacteria in biofouler at carrageenophyte farms. *Journal of Applied Phycology, 22*, 305–311.

Vairappan, C.S. & Kamada, T. (2019). Seaweed Diversity and Chemical Composition of Red Algae Genus *Laurencia* in Mantanani Island. In: Abdullah, M.H., Ali, I., Isnain, Z., & Joseph, C.G. (eds.). *Mantanai Island.* (pp 123-140). ISBN 978-967-2166-42-9.

Wah, L. M., Mojiol, A. R., & Saleh, E. (2011). Diversity of Mangroves Ecosystem in Semporna Mangrove Forest. *Borneo Science, March,* 57–65.

Wainwright, B. J., Zahn, G.L., Zushi, J., Lee, N.L.Y., Ooi, J.L.S., Lee, J.N. & Huang, D.W. (2019). Seagrass-associated fungal communities show distance decay of similarity that has implications for seagrass management and restoration. *Ecology and evolution*, 1-10.

Wan Hazma, W.N., Muta Harah, Z., Japar Sidik, B. & Natrah, F.M.I. (2015). Macro and micro nutrients of tropical seagrasses, *Halophila ovalis, H. spinulosa* and *Halodule uninervis* in Johore, Malaysia. *Iranian Journal of Fisheries Sciences, 14* (1), 246-261.

Wan Maznah, W.O., Syarifah Rahmah, Lim, C.C., Lee, W.P., Kaniz, F. & Mat Isa, M. (2016). Effects of tidal events on the composition and distribution of phytoplankton in Merbok river estuary Kedah, Malaysia. *Tropical Ecology, 57* (2), 213-229.

Wong, S.C (2013). Seaweed communities of inter-tidal rocky shores around Bintulu, Malaysia. *Thesis Master of Science, Universiti Putra Malaysia.*

Wong, C. J., James, D., Besar, N. A., Kamlun, K. U., Tangah, J., Tsuyuki, S., & Phua, M. H. (2020). Estimating Mangrove above-ground biomass loss due to deforestation in Malaysian Northern Borneo between 2000 and 2015 using SRTM and landsat images. *Forests, 11* (9), 1018.

Woo, S.P., Ng, P.F.A., Razalli, N.M., Nilamani, N., The, C.P., Yasin, Z., Tan, S.W. & Toshihiko, F. (2014). New records of sea stars (*Echinodermata asteroidea*) from Malaysia with notes on their association with seagrass beds. *Biodiversity Journal, 5* (4), 453-458.

Yahya, N., Idris, I., Rosli, N. S., & Bachok, Z. (2018). Population dynamics of mangrove clam, *Geloina expansa* (Mousson, 1849)(Mollusca, Bivalvia) in a Malaysian mangrove system of South China Sea. *Journal of Sustainability Science and Management, 13* (5), 203-216.

Yahya, L., Harun, R. & Abdullah, L.C. (2020). Screening of native microalgae species for carbon fixation at the vicinity of Malaysian coal-fired Power Plant. *Scientific Reports, 10* (1).

Yap, T.K., Saleh, E. & Gallagher, J.B. (2020). Impacts of associated fauna on seagrass during the conditioning period in husbandry tanks: Gaya Island, Sabah, Malaysia case study. *Transactions on Science and Technology, 7* (2), 50-57.

Yee, C. S., Okomoda, V. T., Hashim, F., Waiho, K., Abdullah, S. R. S., Alamanjo, C., ... & Kasan, N. A. (2021). Marine microalgae co-cultured with floc-forming bacterium: Insight into growth and lipid productivity. PeerJ, 9, e11217.

Yen, A. M. (2008). Use of marine microalgae in bioremediation of palm oil mill effluent.Thesis in Master of Science, Borneo Marine Research Institute, University Malaysia Sabah.

Yong, W.T.L., Chin, J.Y.Y., Thien, V.Y. & Yasir, S. (2017). Heavy metal accumulation in field cultured and tissue cultured *Kappaphycus alvarezii* and *Gracilaria changii*. *International Food Research Journal, 24* (3), 970-975.

Young, D. (2006). TACARA natural carrageenan production. In: Phang, S.M., Critchley A.T. and Ang P.O. Jr (eds.). *Advances in Seaweed Cultivation and Utilization in Asia*. University of Malaya Maritime Research Centre Publication, Malaysia. (pp 153-160).

Yow, Y.Y, Lim, P.E. & Phang, S.M. (2012). Assessing the use of mitochondrial cox1 gene and cox2-3 spacer for genetic diversity study of Malaysian *Gracilaria changii* (Gracilariaceae, Rhodophyta) from Peninsular Malaysia. *J Appl Phycol.* DOI 10.1007/s10811-012-9942-x.

Yushada, A., Nurjannah, S., Rasidi, R., Siti, N., & Ishak, W.M.F, (2018). Mechanical Properties of Particleboard from Seaweed (*Kappaphycus alvarezii*). *AIP Conference Proceedings. 2030,* 020215 (2018). DOI: 10.1063/1.5066856.

Zainal, A., Yahya, L., Chik, M. N., Hussien, N. K., & Boosroh, M. H. (2017). Effect of zeolite 4a to marine microalgae culture. *Chemical Engineering Transactions, 56,* 487-492.

Zainal Abidin, A. A., Suntarajh, M., & Balia Yusof, Z. N. (2020). Transformation of a Malaysian species of Nannochloropsis: gateway to construction of transgenic microalgae as vaccine delivery system to aquatic organisms. *Bioengineered, 11* (1), 1071-1079.

CHAPTER 6

LAWS AND POLICIES

Wan Izatul Asma Wan Talaat
Izarenah Md. Repin
Nurashikin Salihudin
Hemalatha Raja Sekaran
Mohd Safuan Che Din
Mohamad Sabri Ahmad
Mohd Sukuran Taib

1.0 INTRODUCTION

Marine biodiversity comprises of enormous interlinked marine ecosystems, which establish an interconnecting web of marine living resources and their habitats. Marine and coastal areas assist in sustaining a wide variety of flora and fauna. Human has been benefiting from these resources for years. However, marine and coastal ecosystems are sensitive to human activities, and conservation of marine and coastal biodiversity requires the protection of a wide range of environmental components. It has been widely recognized that links between science and coastal management could be strengthened by improving the capacity for decision-making by considering scientific data (Bultitude et al., 2012).

An important component of improving the use of science, especially in marine biodiversity conservation is the role of laws and policies, which incorporates the application of science. The policies and laws can set out a range of coastal planning and marine spatial zones management, which are generally implemented by the local, state or federal governments. Thus, policies and laws undoubtedly play a key role in determining the scientific basis for the management of marine biodiversity. Nevertheless, another challenge exists in effective engagement across stakeholder groups to integrate the diverse knowledge types from these groups into decision-making (Coffey & O'Toole, 2012).

Conservation of marine resources and ecosystems in line with sustainable development is currently facing tension from the development in vulnerable coastal areas and multiple-use conflicts in maritime space. Scientific data as well as policies and laws provide valuable contributions to addressing how development is approved on the coast. At the government level, the policymakers recognize the critical role of science in management, providing information about habitats, and ecosystem functions as well as anticipated responses to any change. Nevertheless, there are many challenges associated with applying science to management

A growing body of scientific research investigates the barriers occurring within environmental governance networks to identify ways to improve the application of science. Effective communication is necessary to overcome current and forthcoming challenges, particularly between scientists, policymakers, and the local communities. Among the aspect of scientific research has received relatively little attention in the literature is the law and policy as well as their roles to address existing gaps.

Malaysia has to date passed several laws and policies that directly and indirectly relate to marine biodiversity management and conservation. It should be noted that laws and policies which cover inland, riverine and coastal areas are pretty much connected to marine biodiversity. At the same time, Malaysia is very committed to achieving Sustainable Development Goals (SDGs). Among the 17 goals, SDG 14 on Life under Water is the most relevant in conserving and sustainably using the oceans and their resources. This target includes preventing and reducing all types of marine pollution and also set goals to achieve in the fishery sector, for instance by combating IUU (illegal, unreported and unregulated) fishing and eliminating destructive fishing practices. SDG

14 acknowledges the significance of scientific knowledge and technology transfer to improve ocean health and enhance marine biodiversity.

1.1 PROBLEM STATEMENT

There have been several issues raised in past studies on marine biodiversity, resources and health in Malaysian waters. Islam et al. (2017) indicated that the coral reef and fisheries habitat has been under stress in Pulau Perhentian due to excessive human pressure through tourism activities despite strict enforcement of fishing rules in the marine protected area (MPA) by the then Marine Park Department and other enforcement agencies. Miller et al. (2015), in their studies in Sabah, indicated the frequency of coral bleaching and pigmentation as well as coral disease prevalence has been reported within three National Parks in Sabah, with reef sites near coastal development and tourism having the highest prevalence.

A report by Reef Check Malaysia (2018) has also revealed that the tourist influx has negative impacts on corals, which include physical damage by divers, snorkelers and boats and pollution from sewage. Fish bombing by locals also contributed to the reduction in living corals. Moreover, the study shows that most indicator species of both fish and invertebrates are present in low numbers or completely absent from multiple surveys.

It should be noted that coral reefs are valuable economic and biological resources in Malaysia, unlimited to tourism per se but also serves as a key natural habitat to many marine species. Both findings in Miller et al. (2015) and Islam et al. (2017) above are supported by Safuan et al. (2021), whereby human activities have severely affected corals. It was identified that the farthest area from the mainland (Pulau Tioman; 38.5 km) has comparatively more coral composition than the ones closer, except for Pulau Bidong (12.5 km). However, the fact that Pulau Bidong as a heritage island is not a major tourist destination may correlate to less stress placed on its coral communities. Pulau Perhentian (16 km) on the other hand has significantly less coral composition and more algae composition. This may be attributed to intensive tourism development. Pulau Kapas and the islands of Labuan have more dead corals since they are closest to the mainland indicating that anthropogenic activities do affect the coral cover (Safuan et al., 2021).

A study by Akmal and Shahbudin (2020) discovered that the severity of coral diseases and signs of compromised health is greater across the west coast and offshore areas than in the east coast area, which could have been influenced by coastal development and tourism activities.

Meanwhile, Mohammed et al., 2015 investigated the spatial water quality patterns of Johor islands and identified pollution sources in the waters of Johor Marine Park. They found that lack of integrated sewage and waste management, wood preservatives used for boats and structures on the island, boating activities, and thermal pollution from

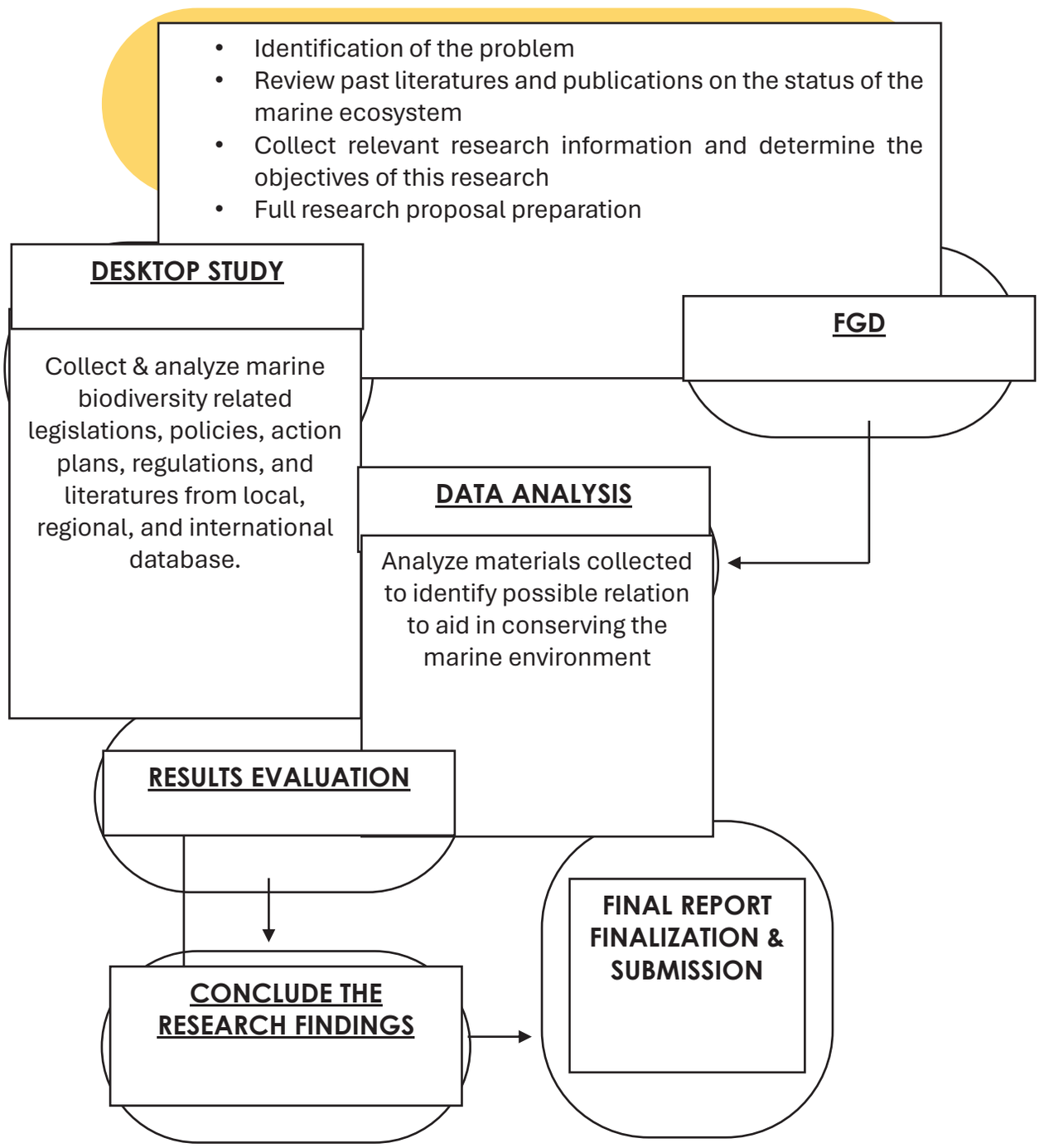
global climate change have adversely affected the water quality (Mohammed et al., 2015), and therefore will likely harm marine biodiversity in the area. Ng et al. (2017) posited that tourism activities were perceived to pose negative environmental impacts on the island and are likely to threaten the conservation of the island's natural resources. Apart from that, Saadon et al. (2020) indicated that IUU fishing activities have negative impacts on the sustainability of marine resources and caused fish stocks to decline. With very limited regional enforcement bodies and the absence of a regional multilateral agreement, IUU fishing is difficult to overcome and eventually will affect the global fish stocks and national economy. Although the existing framework is considered comprehensive, it warrants for stringent law enforcement to combat IUU fishing in Malaysian waters (Ghazali et al., 2019).

2.0 OBJECTIVES

I. To record, document, and analyze data on the policies and legislation related to marine biodiversity and other related data from previous studies in Malaysian waters, which are to be translated into a comprehensive inventory report.
II. To analyze the information gap and further research requirements to obtain additional information to ensure it represents the area of interest to be protected more thoroughly.

3.0 MATERIALS AND METHODS

This study is a desktop study, as shown from the flowchart below, and involves the collection and analysis of data, both primary and secondary, which include marine biodiversity-related legislations, policies, action plans, regulations, and literature from local, regional, and international databases. All the sources are available in the google drive shared. The method employed is qualitative by way of content analysis of the data gathered. This study is also complemented with inputs from Focus Group Discussions conducted with stakeholders.



4.0 RESULTS

The sea, both its space and resources, are pertinent for nation growth where numerous economic activities including fisheries, shipping, eco-tourism as well as oil and gas exploration and mining depend on. Marine biodiversity loss can be caused by many factors including unscrupulous exploitation, polluted environment, massive tourism, illegal and unlawful activities and even climate change.

As a maritime nation, Malaysia is blessed with approximately **4,675 km coastline and 515,000 km2 of marine space**. As a federated nation, Malaysia comprises of 13 states and three federal territories. 11 states are located on the Asian mainland (called as the West or Peninsular Malaysia) and another two states of Sabah and Sarawak are located on the Borneo Island (called as the East Malaysia). These two main territories are separated by the large marine ecosystem of South China Sea. As a maritime nation, Malaysia is surrounded by four main seas: Andaman Sea on the north-west, Strait of Malacca on the West of Peninsular Malaysia, South China Sea on the east of Peninsular and the west of Sabah and Sarawak, and the Sulu-Sulawesi Sea on the north and east sides of Sabah.

For the purpose of clearer understanding, the results are deliberated through TWO main themes namely:

1. Protection of the Marine Environment and Biodiversity
2. Addressing IUU Fishing

These two main themes are both crucial in promoting food security through marine biodiversity conservation, pollution control and practicing sustainable fisheries, among others. As noted by Jefferson et. al. (2021), despite the oceans' abundance of marine biodiversity, there are declining due to many stressors. Marine protected area (MPA) mechanism has been used to protect biodiversity, conserve threatened species as well as rebuild exploited species but most often than not, MPAS are often perceived as restrictive to fishing. This has inevitably slowed the progress towards targets set for ocean protection because there will always resistance whenever a new marine area is to be designated as an MPA.

Fishing, or exploitation of marine living resources, has always been taken to contradict biodiversity conservation. Since the tussle between exploitation and conservation will always remain, taking a middle ground would serve best because as supported by the findings by Jefferson et. al. (2021), increased marine protection would best protect both food security as well as conserve biodiversity and threatened species. Their models using a global approach suggested that protecting 30% of the ocean will not lead to food insecurity, as the majority of catch can be maintained alongside marine conservation.

4.1. Protection of the Marine Environment and Biodiversity

To protect marine diversity, its surrounding environment must also be protected. This is because biodiversity loss can be caused by many factors including unscrupulous exploitation and pollution to the marine environment, be it land-based or sea-based like vessel-sourced pollution, etc. Thus, to protect the marine environment and biodiversity, it is important to look into the main international laws on marine environmental protection, and the corresponding national policies as well as the domestic laws.

4.1.1 The International Laws on Marine Environmental Protection

Since the environment, especially the marine environment, does not know any legal Since the environment, especially the marine environment, does not know any legal boundaries, Malaysia requires international cooperation in managing the environment. Apart from the pacta sunt servanda obligation under the Vienna convention requiring nations to adhere to the international laws they have acceded to and ratified, there is a more critical reason for Malaysia to domesticate the applicable international laws in conserving the marine environment. The international conventions, better known as multilateral environmental agreements (MEAs) endorse and publish specific guidelines and recommendations in many subject matters related to marine conservation and protection. These guidelines and recommendations were promulgated based on decades of scientific studies by scientists across the globe and form a part of the technical assistance that Malaysia would require to build effective MPAs.

By joining the conventions, Malaysia obtains access to a large scale of technical assistance and knowledge. It is therefore most understood that Malaysia should make use of this scientific knowledge and technical assistance by adopting them in the domestic marine governance framework. The most relevant MEAs, which were entered into under regional and international organizations are discussed follows.

01

United Nations Convention on the Laws of the Sea 1982 (UNCLOS 1982)

02

Convention on Biological Diversity 1992 (CBD)

03

Convention on International Trade in Endangered Species on Wild Fauna and Flora 1973 (CITES)

04

Convention on the Protection of World Cultural and Natural Heritage, 1972 (WHC)

05

Convention on the Conservation of Migratory Species of Wild Animals 1979 (CMS)

06

The International Maritime Organisation (IMO) Conventions

01. United Nations Convention on the Laws of the Sea 1982 (UNCLOS 1982)

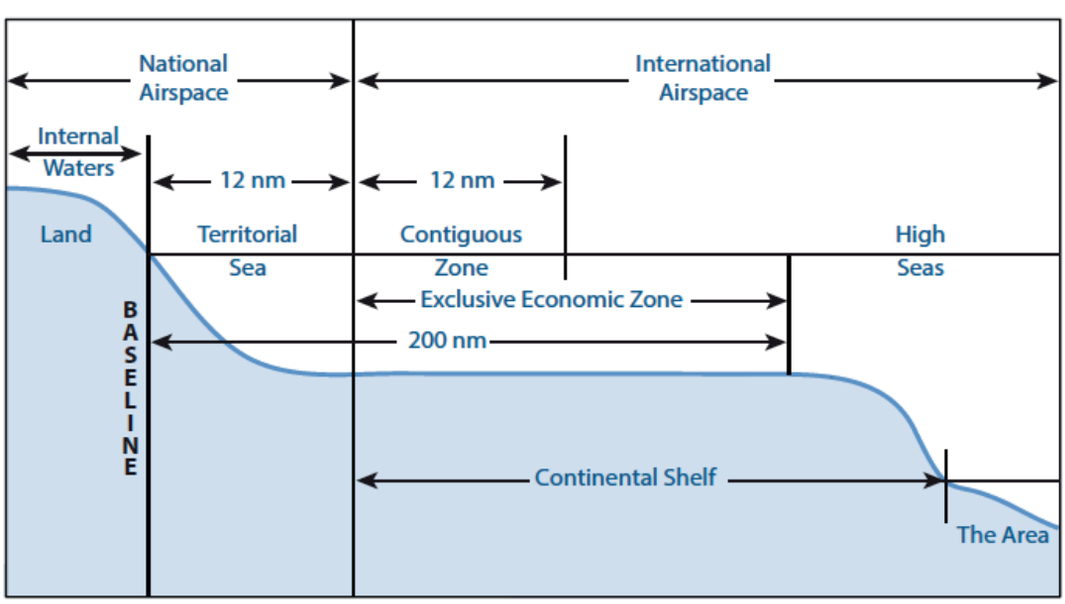
The Preamble to UNCLOS states that *"The problems of ocean space are closely interrelated and need to be considered as a whole"*. UNCLOS defines the rights and responsibilities of nations in their use of the world's oceans, establishing guidelines for businesses, the environment, and the management of marine natural resources. Coming into force in 1994, amongst the most significant issues covered by UNCLOS is the protection of the marine environment.

UNCLOS has three general norms namely:

I. Regulates the use of the marine environment and its resources by the norms defining the legal status of different marine spaces.
II. Oversees the fulfillment of the rights and obligations of states in marine areas.
III. Provides the basis for creating an ocean governance framework.

UNCLOS contains legal norms aimed at the effective protection of the marine environment including the obligation of States to prevent transboundary pollution, the introduction of the environmental impact assessment (EIA), the concept of the protection of marine biodiversity, and the designation of MPAs.

UNCLOS set the limit of various maritime zones (Figure 1), measured from a carefully defined baseline (normally the low water mark or "territorial waters", which is commonly defined as a belt of coastal waters extending 12 nautical miles (at most) from the baseline of a coastal state. For territorial waters, including internal waters that cover all water and waterways on the landward side of the baseline, the rights to set laws, and regulate the use and use of any resources are exclusively vested with the coastal state.



The coastal state has absolute sovereignty over its territorial sea area which consists of both the seabed and the marine waters within that specified zone. Beyond this 12-nautical miles limit, a coastal state could no longer exert sovereignty but it could, however, exercise sovereign rights up to 200 nautical miles (approximately 370 kilometers) of the exclusive economic zone (EEZ), otherwise known as the fishing zone.

Malaysia ratified this convention in 1996. It provides for maritime zones with certain jurisdictions such as the internal waters, territorial sea, contiguous zone, EEZs, continental shelves, and the high seas. Malaysia has claimed her internal waters, territorial sea, contiguous zone, and the EEZ, which was enabled by, inter alia, the Continental Shelf Act 1996, Petroleum Mining Act 1966, Territorial Sea Act 2012, and the Exclusive Economic Zone Act 1984 (EEZ 1984).

Along with the conferred rights to claim the maritime space, UNCLOS requires states to observe their obligations to protect the marine environment from vessel pollution (Article 17) and any other measures to preserve and protect the marine environment (Articles 192 and 193). Considered the Constitution of the sea, UNCLOS strongly calls for States to dutifully observe the stipulations contained therein.

Article 56(1)(b)(iii) of UNCLOS provides for the Coastal States including Malaysia to have jurisdiction over the protection and preservation of the marine environment in their EEZs. In exercising this jurisdiction, a coastal State is empowered to enact laws and regulations for the prevention, reduction, and control of vessel-sourced pollution in the EEZ. Other pertinent provisions are Articles 207–208 which to prevent, reduce and control pollution, UNCLOS obliges its States to create legal rules, standards, and recommendations at the international and regional levels.

UNCLOS also provides that a coastal state has sovereign rights in her EEZ/Continental Shelf to explore and exploit natural resources. The coastal state shall have exclusive rights to exploit or conserve any resources, living and non-living, be it within the water column, on the sea floor, or under the sea floor's subsoil. However, these rights should also be interpreted in conjunction with the responsibilities for the protection and rational management of these resources. In other words, the coastal state must act as the "resource manager" in its EEZ.

02 Convention on Biological Diversity 1992 (CBD)

Signed and ratified in 1992 and 1994 respectively, CBD provides for a broader scope of biodiversity protection in Malaysia. Known informally as the Biodiversity Convention, CBD is a multilateral treaty with THREE main objectives namely:

I. Conservation of biological diversity.
II. Sustainable use of its components.
III. Fair and equitable sharing of benefits arising from genetic or biological resources.

CBD has two supplementary agreements, the first one is on biosafety and the second one is on access and benefit sharing. The Cartagena Protocol on Biosafety is an international treaty governing the movements of living modified organisms (LMOs) resulting from modern biotechnology from one country to another. It was adopted on 29 January 2000 as a supplementary agreement to the CBD and entered into force on 11 September 2003.

The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (ABS) provides a transparent legal framework for the effective implementation of one of the three objectives of the CBD: the fair and equitable sharing of benefits arising out of the utilization of genetic resources. The Nagoya Protocol was adopted on 29 October 2010 in Nagoya, Japan, and entered into force on 12 October 2014.

CBD created momentum for the creation of the 1998 National Policy on Biodiversity. Apart from the enactment of the Biosafety Act 2007 and the Access to Biological Resources and Benefit Sharing 2017, it has also resulted in the amendment and enactment of various existing and new federal laws such as the Wild Life Conservation Act (2010), Environmental Quality Act (1974), Fisheries Act 1985, Continental Shelf Act 1966, etc. The CBD has also catalyzed the increased numbers of MPAs in Malaysia.

03 Convention on International Trade in Endangered Species on Wild Fauna and Flora 1973 (CITES)

CITES is a multilateral treaty to protect endangered plants and animals from the threats of international trade. It was drafted as a result of a resolution adopted in 1963 at a meeting of members of the International Union for Conservation of Nature (IUCN). To accord direct protection to the wildlife trade, Malaysia acceded to the convention in 1977.

Malaysia subsequently amended the Protection of Wildlife Act 1972 into the Wildlife Conservation Act, 2010, and enacted the International Trade in Endangered Species Act (INTESA), 2008. Consequently, Malaysian wildlife is categorized into Appendices I, II, and III following their population status.

In view that there is special allowance under the Federal Constitution for Sabah and Sarawak in certain areas including wildlife protection, Sarawak has enacted the Natural Resources Ordinance, 1954 and Wildlife Protection Ordinance, 1990 and Sabah enacted the Fauna Conservation Ordinance (1963). However, given that CITES was ratified much later than both the Sabah and Sarawak legislations, the uniformity between the Federal and state laws is subject to examination.

04 Convention on the Protection of World Cultural and Natural Heritage, 1972 (WHC)

As the global interest on protected areas increases over the years, Malaysia sAs the global interest in protected areas increases over the years, Malaysia signed the convention, which it ratified in 1988. It has enabled the domestication of more legal documents and tools to designate protected areas as heritage areas. The most significant feature of this Convention is that it links together the concepts of nature conservation and the preservation of cultural properties in a single document. The Convention recognizes how people interact with nature, and the fundamental need to preserve the balance between the two. The Convention sets out the duties of States Parties in identifying potential sites and their role in protecting and preserving them. By signing the Convention, each country pledges to conserve not only the World Heritage sites situated on its territory, but also to protect its national heritage.

05 Convention on the Conservation of Migratory Species of Wild Animals 1979 (CMS)

Also known as the Bonn Convention, it is another vital convention that can provide for the holistic protection of marine species. The primary aim of CMS Agreements is to maintain a viable population of each species, especially the threatened species, to ensure a sustainable population for continuous survival (Caddell, 2005). CMS publishes a regularly-reviewed list of Appendices on terrestrial and marine organisms according to scientific data on their threat status.

State Parties are obliged to domestically restrict takings of species in Appendix I (endangered species) and take further actions to conserve and take measures to reduce threats to the species (Article 3, CMS 1979).

Malaysia has yet to become a signatory to this convention. However, in 2011, Malaysia became the 33rd country to conclude the Memorandum of Understanding (MOU) on the Conservation and Management of Marine Turtles and their Habitats within the Indian Ocean and South-East Asia region (IOSEA) under the auspice of this convention, despite not being a Member State.

06 The International Maritime Organisation (IMO) Conventions

Adopted on 2 November 1973 at IMO, and then modifies in 1978, MARPOL 73/78 is the main international convention (plus regulations) covering the prevention of pollution of the marine environment by ships from operational or accidental causes.

I. International Convention on Civil Liability for Oil Pollution Damage 1969 (CLC 69)
II. International Convention for the Prevention of Pollution from Ships, 1973
III. Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships (generally referred to as MARPOL 73/78), which contains six annexes covering pollution from ships in almost all methods and form, whether direct or indirect, and liquid or gaseous as can be seen from Figure 1 below. Malaysia only adopts Annexes I, II, and V.

Adopted on 2 November 1973 at IMO, and then modifies in 1978, MARPOL 73/78 is the main international convention (plus regulations) covering prevention of pollution of the marine environment by ships from operational or accidental causes.

Other IMO Conventions ratified and adopted by Malaysia:

- International Convention for the Safety of Life at Sea (SOLAS) 1974 or as amended
- International Convention on Tonnage Measurement of Ships, 1969
- International Regulations for Preventing Collision at Sea (COLREGS), 1972
- International Convention on Load Lines, 1966 or as amended
- International Convention on Civil Liability for Oil Pollution Damage (CLC) 1969, Protocol of 1992

There are other conventions under IMO relating to marine environmental protection, which are still being considered for ratification by Malaysia (Siti, 2006) as follows:

I. Convention of the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (London Dumping Convention)
II. International Convention on the Control of Harmful Anti-Fouling Systems on Ships 2001 (AFS)
III. International Convention for the Control & Management of Ships' Ballast Water and Sediments 2004

4.1.2 Malaysian Policies and Laws Relating to Protection of the Marine Environment and Biodiversity

The National Policies

01 National Biodiversity Policy 1998

The Malaysian National Policy on Biological Diversity was officially declared on April 16 1998 and its declared vision is to transform Malaysia into a world center of excellence in conservation, research, and utilization of tropical biological diversity by the year 2020 in its Policy Statement, it is stated that this National Policy is aimed to generally conserve Malaysia's biological diversity and to ensure that its components are utilized sustainably for the continued progress and socio-economic development of the nation. Both the vision statement and the Policy statement undeniably emphasize Malaysia's commitment to the conservation and sustainable use of her biological diversity heritage for the sustainable progress of the nation. However, the direction of legislative, administrative, and other measures are effectuating both the vision and policy statements of principles and six heads of objectives.

Four of the 11 statements of principles warrant mention here, namely:

I. Principle (VI): It is the duty of the Government to formulate and implement the policy framework for sustainable management and utilization of biological diversity in close cooperation with scientists, the business community, and the public.
II. Principle (VII): The role of local communities in the conservation, management, and utilization of biological diversity must be recognized and their rightful share of benefits should be ensured.
III. Principle (IX): The interdependence of nations on biological diversity and in the utilization of its components for the well-being of mankind is recognized. International cooperation and collaboration are vital for fair and equitable sharing of biological resources, as well as access to and transfer of relevant technology
IV. Principle (XI): In the utilization of biological diversity, including the development of biotechnology, the principles and practice of biosafety should be adhered to

Among the six heads of objectives, three heads merit further deliberation. These are:

I. Objective I: “To optimize economic benefits from sustainable utilization of the components of biological diversity".
II. Objective IV: "To ensure the preservation of the unique biological heritage of the nation for the benefit of present and future generations"
III. Objective VI: "To emphasize biosafety considerations in the development and application of biotechnology"

The government's duty towards sustainable management and utilization of biological diversity is outlined by two basic rules under the CBD i.e.:

Public Trust Doctrine

Principle (VI) categorically declares the duty of the government in a manner that can achieve sustainable development of biological diversity in Malaysia. In this regard, the government is mandated to work in close cooperation with scientists, the business community, and the public. This duty if read together with Objective (iv), that is, preserving the unique biological diversity for the benefit of present and future generations must necessarily imply the existence of a broader duty like public trust. This public trust doctrine, though never expressly stated in any of the many natural resource legislations, can and should be judicially recognized as an implied duty imposed on the government under the combined operations of Principle (VI) and Objectives (iv) of the National Biodiversity.

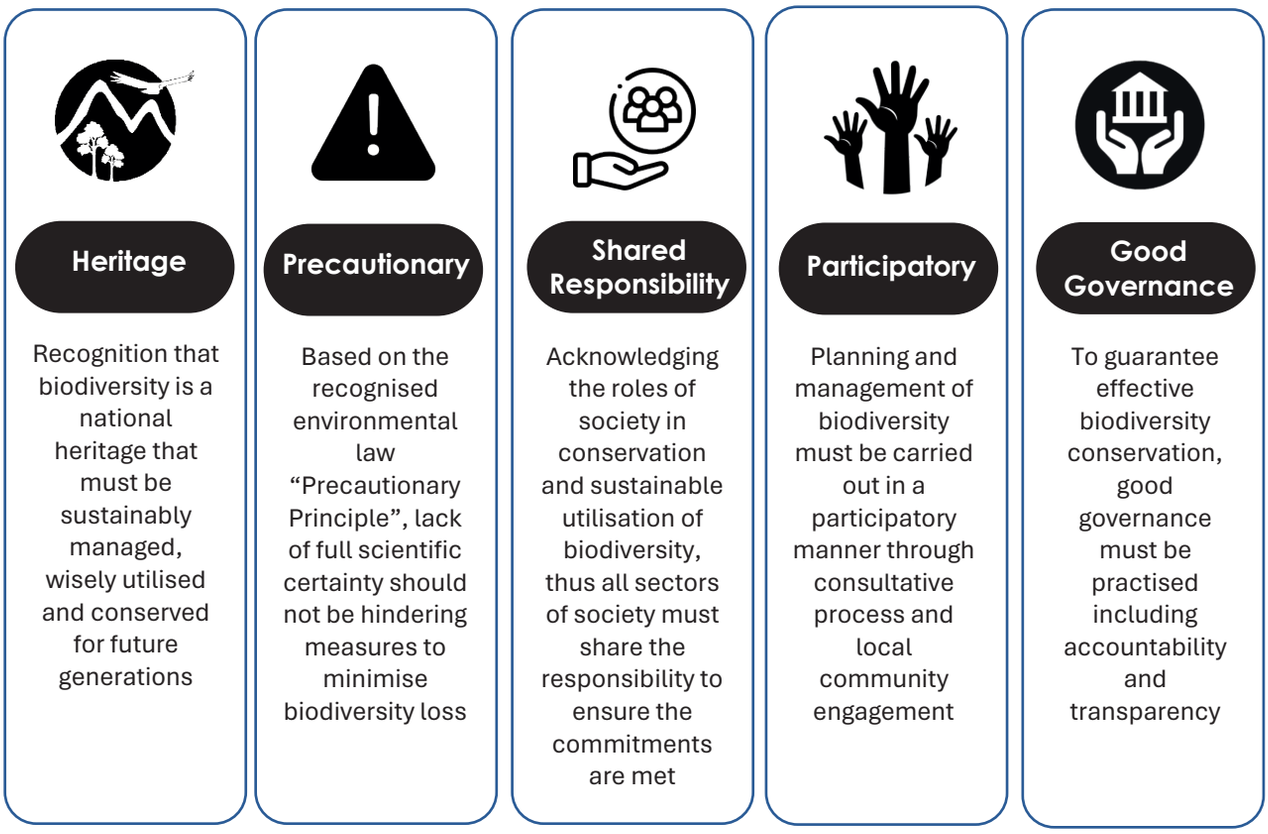
Traditional Knowledge and Rights of Indigenous Communities

Quite related to the principle of sustainable management and use of biological diversity is the need to recognize, protect and enforce the rights of indigenous communities to have continued access to biological resources not only for the continued sustenance of their culture but also to protect their knowledge, acquired over thousands of years of experimentation and experience, about the uses biological resources can be put to, particularly in medicinal and pharmaceutical preparations. This knowledge, popularly termed as “traditional knowledge” is required by the CBD to be duly protected. Principle (VII) takes cognizance of this but in a rather oblique way. There is no specific mention of ‘traditional knowledge’ among the 15 strategies for effective management of biological diversity outlined in the Policy, none either directly or indirectly refers to traditional knowledge.

02 National Biodiversity Policy 2016-2025

Attempting to meet Aichi Biodiversity Target 17, which states that a policy instrument shall have been developed and adopted by each State Party by 2015, the Government has stepped up the efforts to protect and conserve our biodiversity through the launching of the Second National Policy on Biodiversity 2016-2025 (Second NPBD) through numerous stakeholders’ consultations and inputs.

Reiterating Malaysia’s commitment to continuously conserve her biodiversity, promote its sustainable use and ensure fair and equitable sharing of the benefits arising out of the utilisation of biological resources in its Policy Statement, the Second NPBD emphasises on five salient Principles as follows:



These five Principles are to guide the goals, targets and actions set under the Second NPBD support the national vision for sustainable development. The seventeen targets set under the Policy corresponds with all the Aichi Targets. Principle 4 strategically puts a stress on participation from local actors as emphasised by the Aichi Targets. Correspondingly, to achieve sustainable use and conservation of biodiversity, this strategic plan of the CBD requires States to:

(i) raise awareness for biodiversity (Aichi Target 1);

(ii) integrate biodiversity values into national and local development strategies (Aichi Target 2); and

(iii) involve different stakeholder groups in developing approaches to sustainable production (Aichi Target 3).

As noted by Zinngrebe (2016), reaching these Aichi targets will require understanding local actor groups and their value systems, as well as allowing for local approaches to sustainable development (for instance, traditional ecological knowledge) to be incorporated into biodiversity governance. Lying in the same vein, recognition of community-based management approach in biodiversity conservation, such as the Tagal practice in Sabah cited under Target 2 of Goal 1, is a notable move because biodiversity conservation requires cooperation from all sectors, most particularly the direct beneficiaries of the resources.

Guided by the five salient principles, the Second NPBD set five national goals to achieve, which can be basically narrated as follows:

I. **Increased commitment** of all stakeholders in biodiversity conservation
II. **Reduced** direct or indirect pressures on biodiversity
III. **Protected key ecosystems**, species and genetic diversity
IV. **Accrued equitable benefits** from utilization of biodiversity to all
V. **Improved knowledge**, skill and capacity to conserve biodiversity

The Policy dedicates a specific section on implementation by stressing on shared responsibility to conserve biodiversity. Section 3 on Implementation Framework spells out the roles and responsibilities of all the seven segments of society; federal government, state governments, civil society, indigenous and local communities (ILCs), private sectors, research and education communities, and last but not the very least, the general public. Realising the importance of community participation and local actors, the Malaysians are urged to play their parts in biodiversity conservation.

With five national goals, 17 targets and 57 actions to achieve by 2025, it is quite a daunting task for Malaysia. However, the time-bound and quantifiable targets, which correspond to the Aichi Targets, may assist the Second NPBD to fare better than its predecessor. With clearer targets, actions and timelines for implementation, as well as calls for active participation by all stakeholders through its five salient Principles, this Policy may be able to help Malaysia fulfil her obligations under the CBD and meet the Aichi Targets, as well as the Sustainable Development Goals set under the 2030 Agenda for Sustainable Development.

03 National Environmental Policy 2002

The NEP 2002 was established for continued economic, social, and cultural progress of Malaysia and enhancement of the quality of life of its people, through environment well being and sustainable development. Its objectives are:

I. A clean, safe, healthy and productive environment for present and future generations
II. Conservation of the country's unique and diverse cultural and natural heritage with effective participation by all sectors of society
III. Sustainable lifestyles and patterns of consumption and production

04 National Agro-Food Policy 2.0 (2021-2020)

The overriding objective of the NAP 2.0 is the maximization of income through the optimal utilization of resources in the sector. This includes maximizing agriculture's contribution to national Gross Domestic Product (GDP), export earnings as well as maximizing income of farmers, breeders and fishermen. The objectives of NAP 3 are as follows:

- To enhance Food Security
- To increase Productivity and competitiveness of the sector
- To deepen linkages with other sectors
- To create new sources of growth for the sector
- To conserve and utilize natural resources on a sustainable basis

NAP 2.0 has been formulated with the vision of developing a sustainable, resilient, and technology-based agro-food sector in driving economic growth, improving people's well-being as well as prioritizing food security and nutrition. Since fisheries is under the Ministry of Agriculture and Food Industry, the NAP 3 (as well as the other preceding two policies) provides the direction of fisheries in Malaysia, as part of food sources.

The are four subsectors under NAP 2.0 namely paddy and rice, fruits and vegetables, livestock, and fisheries and aquaculture. The implementation shall be guided by 18 strategies and 58 action plans. The strategies focus on high-value activities along the food value chain that could generate higher income for the target groups and improve the socioeconomic status of farmers, breeders, fishermen and agropreneurs.

05 National Forestry Policy 2021

This Policy cover key areas including sustainable forest management, biodiversity protection and conservation, climate change mitigation and adaptation, latest technology application, strengthening research and development as well as enhancing knowledge sharing. A provided under the Federal Malaysian Constitution, forestry falls under the jurisdiction of the respective State Governments. As such, each State is empowered to enact laws on forestry and to formulate forestry policy independently. The Federal Government may only provide advice and technical assistance to the States, training, research, and in the maintenance of experimental and demonstration stations. NFP 2021 was formulated by encompassing the key aspects of the forest policies of the Peninsular Malaysia, Sabah and Sarawak.

The National Land Council (NLC) was established to facilitate the adoption of a coordinated and common approach to forestry, as well as reconcile cross-sectoral policies that interface with the forestry sector. The NLC enables the Federal and the State Governments to discuss and resolve common problems and issues relating to forestry policy, administration and management, as well as to enhance cooperation between the Federal and State Governments, in order to ensure a coordinated approach in forestry management.

Mangrove forests are part of the marine ecosystems and hosts to many coastal and marine lives, hence explains while NFP 2021 also warrants mention here as part of national policy framework studied. Systematic management of mangrove forests started as early as 1904, with the adoption of the first working plan for Mangrove Forests in Matang, which has been identified as the best described mangrove forests in the world, and serves as sustainably managed mangrove forests model.

06 National Ecotourism Plan 1996

The NEP 1996 is the first comprehensive plan for the country formally adopted by the Government of Malaysia to assist them at Federal and State levels for the development of Malaysia's ecotourism potential. This Plan is part of, and to support, the National Tourism Policy 1992. NEP consists of 25 easy-to-use guidelines for the management and promotion of ecotourism in the country, which are divided into four categories:

Category 01 — Guidelines for Categorizing Sites and Activities (Guideline 1)

Category 02 — Carrying Capacity and Limits of Acceptable Change (Guideline 2)

Category 03 — Guidelines according to Ecosystems (Guideline 3: marine park and islands)

Category 04 — Guidelines according to Practices (Guidelines 11 – 25 covering issues such as zoning, local community participation, marketing and promotion, visitor roles and responsibilities, health and safety, monitoring, conservation programmes and others)

The Plan provides specifically for guidelines to be adopted and implemented on marine park islands, which can basically be divided into TWO main parts, namely in the operation of facilities in marine parks and in the operation of recreational activities in marine parks.

07 National Forestry Policy 2021

The NEP 2016-2025 aims to increase potential existing eco-tourism destinations in the country towards sustainable tourism direction. This Plan revises and enhances the findings of recent studies on developing potential ecotourism destinations. It serves as an instrument within the overall sustainable development of Malaysia and the economy and as a tool for the conservation of ecotourism sites in the country. The objectives of the NEP 2016-2025 are basically to consolidate recent reviews and studies of the NEP 1996, to review the success and shortcomings in the implementation of the NEP 1996, and most substantially to recommend policies, strategies, and action plans to improve the planning, sustainable management, conservation, financing, promotion and operation of ecotourism sites.

A new definition of ecotourism was introduced through the revised NEP, as clearly illustrated in Figure 3 below.

Figure 3: The newly-founded definition of "ecotourism" by the NEP 2016-2025

The NEP 2016-2025, which could well be referred to as at the 2nd NEP, has TW0 focus areas namely Strategy and Policy Direction, and Tourism Clusters as can be seen in Figure 4 below.

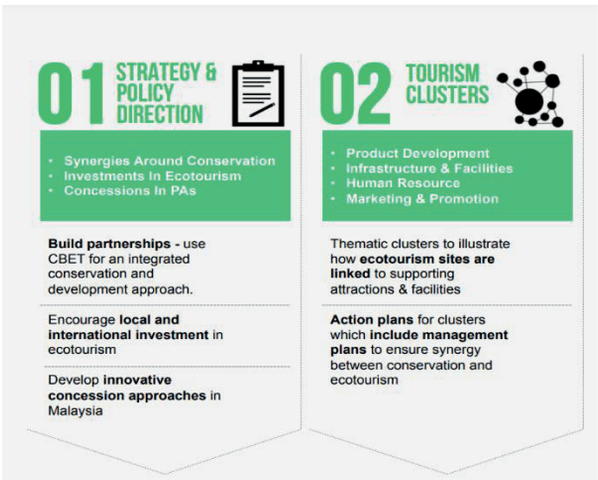


Figure 4: The Focus Areas of the NEP NEP 2016-2025

Under the first focus area i.e., Strategy and Policy Direction, five main findings were gathered namely:

Another major finding is on the Ecotourism Spectrum, where three Ecotourism Spectrum was found namely Soft Ecotourism, Adventure Ecotourism and Hard Ecotourism. The characteristics of the different spectrums are as illustrated in Figure 5 below.

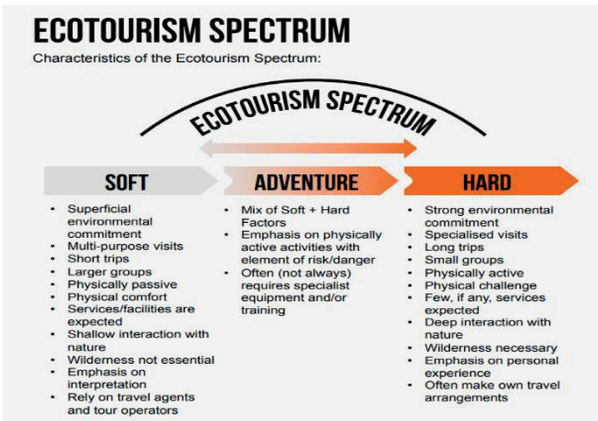


Figure 5: The Ecotourism Spectrum and Characteristics under the NEP 2016-2025

08 National Policy on Climate Change 2009

The NPCC promotes the implementation of both adaptation and mitigation in an integrated and balanced manner. This Policy serves as the framework to mobilize and guide government agencies, industry, community as well as other stakeholders and major groups in addressing the challenges of climate change in a concerted and holistic manner. Emphasis is on strengthening the capacity of the nation to reduce its vulnerability to climate change whilst promoting mitigation responses that also enhance sustainable development.

09 National Marine Litter Policy and Action Plan 2021-2030

The NMLPAP 2021-2030 was launched to guide national actions on addressing marine litter according to the following objectives:

I. To address marine litter pollution through robust policy development.
II. To document concrete steps ahead on tackling marine litter pollution based on scientific evidence and lessons learned from international, regional and local efforts
III. To coordinate efforts at every level of the Federal Government, State Government, local government, as well as public, private and social sectors
IV. To foster further research and innovation to prevent, monitor and tackle marine litter pollution
V. To deploy and implement cutting-edge technologies and innovation backed with strong national standards and guidelines, as well as strengthened institutional and legal framework to ensure Malaysia is at the forefront of global efforts in tackling marine plastic pollution
VI. To promote the sharing of best practices and lessons learned, while enhancing regional and international cooperation, and creating awareness and instigating behavioural change
VII. To increase access to finance and facilitating private sector engagement to promote investment, trade and market creation, and market-based incentives in industries and activities that enable marine litter management and prevention

10 National Physical Plan-4

In formulating the physical planning direction of the country, the NPPs translate and coordinate other economic, social and sectoral development policies into physical and spatial dimensions under the auspice of the Town and Country Planning Act 1976. The policies, strategies and actions contained in the NPPs are to be translated at the regional or state planning level through state structure plans and economic corridor development plans, and at the local planning level through local plans and special area plans. The NPP-4 set the direction for physical development, including the economy, environment and social (aspects) for the entire planning area in the Peninsular and the Federal Territory of Labuan.

The NPP-4 has outlined three development thrusts, 11 strategic directions, 39 strategies:

Four key strategic initiatives have been outlined by NPP-4:

I. Protection of natural resources areas and national food security
II. Provision of fiscal incentives for the Conservation of Natural Resources and the Protection of National Food Security
III. Establishment of a New Regional Planning Committee for Inter-State Land Use Coordination
IV. Inclusion of State Waters as a Local Planning Authority (LPA) Area

11 National Coastal Zone Physical Plan-2

The newly-launched NCZPP-2 is a strategic plan on land, as well as territorial waters, use that outlines the direction of utilisation, conservation and management of coastal and marine resources in the Peninsular Malaysia and Labuan. The NCFZPP-2 incorporates strategic directions and implementation plans to build coastal areas (physical) and local communities (social) resilience, developed based on contextual measures and indicators of the Coastal Vulnerability Index (CVI).

I. Development Resilient to Coastal Geohazards
II. Ecological Asset and Sustainable Ecosystem Services
III. Strong and Effective Governance
IV. Alert and Capable Community

The most important thrust is Thrust 2 where conservation and preservation of marine ecological assets important in ensuring the well-being of the people, especially in terms of ensuring the supply of seafood and source of income. Healthy and quality marine ecosystems must be preserved and restored to ensure that this marine ecosystem can continue to supply resources and services such as fisheries, tourism and recreational opportunities, as well protection from disasters such as erosion, floods and tsunami to local residents.

In general, Thrust 2 was designed with the purpose to empower coastal and ecological assets through protection, conservation and sustainable use of resources. Strategy and action plans drafted was carried out with comprehensive land use planning through the implementation of the Environmentally Sensitive Coastal Areas framework. Figure 6 below describes Thrust 2, which are focusing on Ecological Asset and Sustainable Ecosystem Services in the coastal areas of Peninsular Malaysia and Labuan.

Figure 6: The Second Core Thrust of NCZPP-2

Thrust 02 underlying purpose:

I. To protect the marine ecosystem heritage through Marine Spatial Planning and designation of seascapes
II. To ensure implementation of the Environmentally Sensitive Coastal Areas framework in land use planning to ensure sustainable development
III. To contribute to sufficient fishery resources through fisheries management plans implementation, strict enforcement, and ecosystem-based fisheries management
IV. To intensify pollution control management by ensuring compliance to permissible discharge limit from anthropogenic activities such as industrial affluent, sewage, domestic sullage, agricultural run off, as well as water discharge from livestock and aquaculture farming

Environmentally Sensitive Coastal Areas framework was developed by factoring in the following nine identified biodiversity clusters (Figure 7) below:

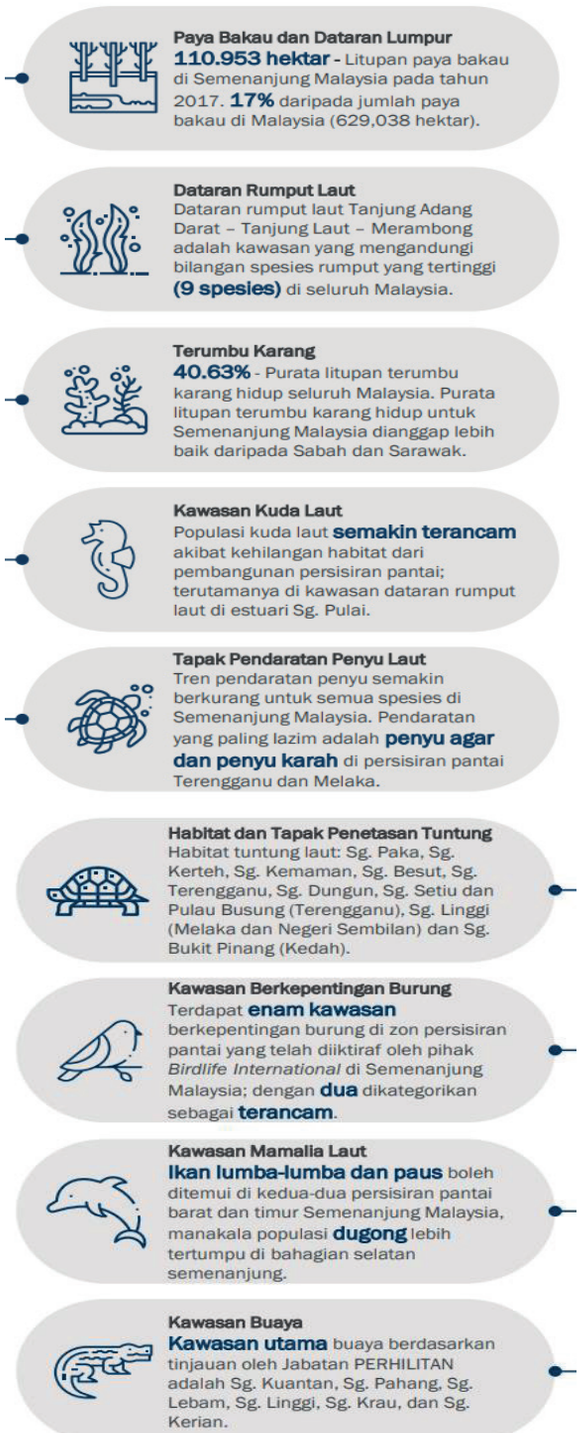


Figure 7: The identified sensitive coastal and marine biodiversity clusters under the NCZPP-2

Figure 8 below are the 4 Strategies and 11 Actions to be taken under Thrust 2, One of the most important actions to be taken is to and implement Marine Spatial Planning (Action AE 1.3), which is a necessary action towards ecosystem-based management

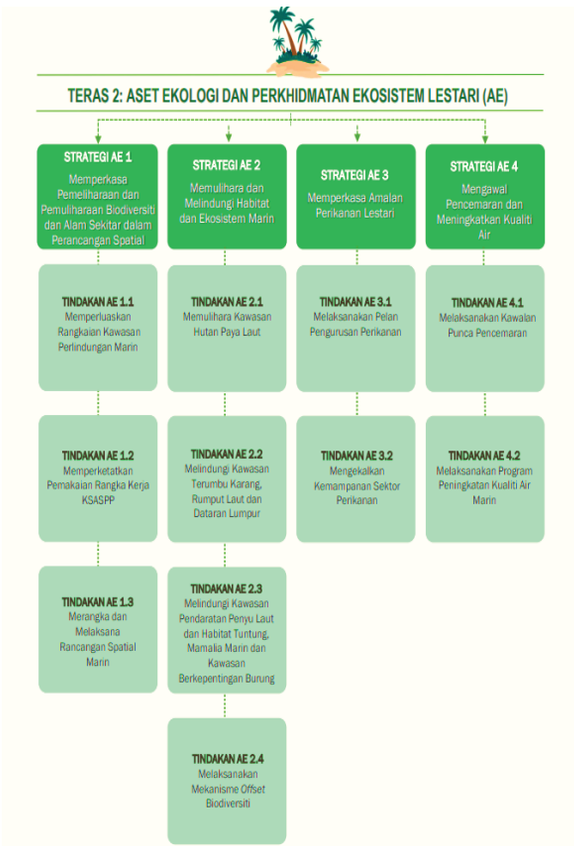


Figure 8: The strategies to protect marine environment and biodiversity under the NCZPP-2

Strong and Effective Governance is essential to ensure assets, biodiversity and coastal vulnerability are managed and planned well. Thus, Thrust 3 puts high importance on 3 targets namely:

I. Coordination and Cross-agencies Cooperation
II. Coordinated Jurisdictions
III. Clear Interpretation and Application of Procedures

Figure 9:
Thrust 3 of NCZPP-2, which is to encourage strong and effective governance

In order to achieve Target 3 of Thrust 3, one of the strategies is to engage local communities in coastal zone management. To do that, the NCZPP-2 lists down two actions to be taken namely by:

I. Supporting governance and monitoring process, management and decision making at local level via inter-community platform
II. Encouraging community engagement in conservation work and environmental conservation and empowering Community Conserved Areas (CCA)

Figure 10: Thrust 4 of NCZPP-2, which is to create alert and capable community

The Laws

The Federal Constitution of Malaysia has divided the jurisdictions between the federal and state governments, as listed under the Ninth Schedule. Table 1 below describes the distribution of powers between federal and states, as provided under the Federal Constitution. This distribution of powers is only applicable to the Peninsular Malaysia, which gained her independence from the British as Malaya in 1957.

Federal List	State List	Concurrent List
Mineral resources	Land	Wildlife
Marine and estuarine fisheries	Agriculture	Town and country planning
Pest control	Forestry	National parks
Shipping and navigation	Infrastructure activities for state works	Rehabilitation
Water supplies	Water	Eroded and mined land
Tourism	Riverine fisheries	Drainage
Infrastructure activities for federal works		Irrigation
		Housing

Table 11. Distribution of Powers in the Federal Constitution (Adopted from the Ninth Schedule of the Federal Constitution

The federal government is empowered to regulate all matters relating to marine and estuarine fisheries whereas the state governments' jurisdictions are over all land matters including the foreshore and riverine fisheries. Due to the depleting marine fisheries resources and degradation of coral reefs, which were induced by an endless list of issues such as overfishing, prohibited fishing methods, pollutions and sedimentation, the Fisheries (Prohibited Area) Regulations was enacted under the then Fisheries Act 1963, which was a federal law. Pulau Redang in Terengganu became the first fisheries protected area (FPA) (Talaat et. al., 2013), which was subsequently converted into a marine park island when the Fisheries Act was amended in 1985.

At present, Malaysia has a plethora of maritime and marine-related laws that provide on control of oil pollution, protection of the marine environment, management of fishing activities, protection of marine mammals, transboundary movement of GMO/ hazardous materials and other marine related issues. These piecemeal federal legislations are primarily segmented as well as sector-based.

For instance, the Fisheries Act 1985, which covers matters relating to fisheries activities such as vessel licensing and fishing tools in the Malaysian waters caters only on fishing vessels while the Merchant Shipping Ordinance 1952 (MSO 1952) regulates on other types of vessels plying the water, such as oil tanker and cargo vessels. This segmentation is also acknowledged by Hamid (2007), who opines that both the Environmental Quality Act 1974 (EQA 1974) and the MSO 1952 are not yet harmonious to effectively prevent marine pollution. This loophole is reflected as the EQA 1984 and the MSO 1952 have contrarily defined oil discharge occurring in the territorial sea. Table 2 below lists down the main federal legislations realating to the protection of marine environment and biodiversity.

Government Level	Legislations
	• Territorial Sea Act 2012 • Fisheries Act 1985 • Exclusive Economic Zone 1984 • Continental Shelf Act 1966 • Baselines of Maritime Zones Act 2006 • Wildlife Conservation Act 2010 • International Trade in Endangered Species Act 2008 • Environmental Quality Act 1974 • Merchant Shipping (Oil Pollution) Act 1994 • Malaysian Maritime Enforcement Agency Act 2004 • Wildlife Conservation Act 2010 • Merchant Shipping Ordinance 1952 • National Parks Act 1980 • Penal Code Act 547 • Customs (Prohibition of Exports Amendment No.4) Order 1993 • Land Conservation Act 1956 (revised 1991) • National Land Code 1965

Table 12: Federal laws relating to marine environmental protection

Since Sabah and Sarawak are given special allocation under Article 74 of the Federal Constitution, the state laws of these two states appear to be more recent and updated, and in line with the relevant MEAs. The relevant state laws relating to marine environmental protection are illustrated in Table 13 below.

Government Level	Legislations
SABAH	• Fisheries Regulations 1964 • Sabah Biodiversity Enactment 2000 • Environmental Protection Enactment (2002, amended in 2004) • Forest Enactment 1968 • Town and Country Planning Ordinance 1950 • Water Resources Enactment • Fauna Conservations (Turtle Farms Regulations 1964 • Fauna Conservations Ordinance 1963 9Act. No. 11 • Parks Enactment 1984 • Customs (Prohibition of Imports) And Prohibition of Exports (Amendment) Order 1971 • Wildlife Conservations Enactment 1997 • Conservation of Environment Enactment, 1996
SARAWAK	• Fisheries (Maritime) Regulations 1976 • Natural Resources and Environment Ordinance 1993 (amended the Natural Resources Ordinance 1949) • Turtle Trust Ordinance 1957 • Fisheries Ordinance 2003 • Turtle (Prevention of Disturbance) Rules 1962 • Wildlife Protection Ordinance 1998 (Amended 1995) • Sarawak Biodiversity Centre (Amendment) Ordinance 2003 • National Parks and Nature Reserves Ordinance 1998 • Sarawak Forestry Corporation Ordinance 1995

Table 13: Sabah and Sarawak laws relating to marine environmental protection

NATIONAL PLAN OF ACTIONS

National Plan of Actions (NPOA) are basically strategic plans designed by governments to guide action, and often the allocation of resources, over a specified period of time and towards the fulfilment of a policy objective. Apart from the laws and policies providing for marine environmental and biodiversity protection, there have been several NPOAs introduced by the government, mainly the Department of Fisheries that are aimed to guide the management of certain subject matter or objectives. These NPOAs which are more specific, and mostly are for target species, are as follows:

I. NPOA for Conservation and Management of Sea Turtles 2008
II. NPOA for Conservation and Management of Shark
III. NPOA on Aquatic Invasive Alien Species 2021-2025
IV. NPOA on IUU Fishing
V. NPOA on Sea Cucumber
VI. NPOA on Dugong
VII. NPOA for The Management of Fishing Capacity in Malaysia (NPOA-Capacity)
VIII. Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (NPOA-CTI-CFF)

4.1.3 Marine Protected Areas in Malaysia

The precious coral reefs are important for many different reasons including breeding habitats of various commercially valued species of marine resources and should be protected. Organizations under the United Nations such as the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) and the international NGOs like the International Union for Conservation (IUCN), through its World Commission on Protected Areas, have repeatedly called for the increase the coverage of protected areas globally (UNEP-WCMC, 2016).

The political process of MPAs designation is significant to meet various biodiversity conservation efforts, fisheries management, and social welfare (Christie & White, 2006), as well as the global goal of food security of Sustainable Development Goals (SDG) (Tsurita et. al., 2018). MPAs are also an effective medium to sustain the quality of marine biodiversity as well as in maintaining ecosystem services and functions. The local communities and the marine ecosystems could benefit from the protected areas, and the resources therein, due to the flow of ecosystem services (Tonin, 2018). MPAs may also benefit in terms of providing resistance to the unpredictable impacts of climate change (Sala & Giakoumi, 2018).

MPAs with legal structure have existed since 1970, while MPAs before that year was voluntarily established without any legal structure. MPA governance can be either top-down (centralized) or bottom-up (decentralized). Top-down or centralized MPA is the formal and common method of MPA designation. In Peninsular Malaysia, MPAs are governed by the Division of Marine Park (formerly Department of Marine Park) of the Fisheries Department Malaysia, which was established to manage the existing 42 marine parks gazetted under Part IX of the Fisheries Act 1985.

One type of MPAs is the no-take zone, also known as a no-take marine reserve, which offers a greater amount of protection to the ecosystems and marine life especially corals (Abesamis et al., 2017). No take zone has been regarded as the most effective type of MPAs since it restores fish assemblages and ecosystems (Sala & Giakoumi, 2018). Nevertheless, it must also be borne in mind that the successful implementation of MPAs depends greatly on the support of all stakeholders and the acceptance of the local communities (Tonin, 2018). Therefore, designating MPAs without considering the local needs and knowledge may not succeed because the cooperation of the local communities, is crucial to guarantee the success of the MPAs.

There are many definitions of protected areas but the widely used definitions are from the Convention on Biological Diversity (CBD) 1992 and the International Union for Conservation of Nature (IUCN). Since the IUCN works have been well recognized and applied in many conventions, it is pertinent to discuss protected areas under the organization. All the six categories of protected areas designed by IUCN carry certain specifications from "totally protected" to "multiple use zones". The revised definition of protected areas under IUCN is:

A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values

The CBD, on the other hand, defines protected areas in Article 2 as "*a geographically defined area which is designated or regulated and managed to achieve specific conservation objectives*". However, as noted by both Dudley (2008) and Woodley et al (2011), it was agreed by the CBD Secretariat that their protected area definition brings the same meaning to the newly found definitions by the IUCN. What remains is the true intent of 'protected areas' that CBD carries. The Aichi Biodiversity Target, which was agreed upon by the State Parties during the 10th Conference of Parties (COP-10) in Nagoya, was set to further clarify marine protection. To strengthen the MPA framework, Target 11 of Aichi Targets provides a more detailed measurement and time frame:

By 2020, at least 17 percent of terrestrial and inland water, and 10 percent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed ecologically representative and well-connected systems

This Target 11 was renewed during COP-15 of CBD held in 2021 or better known as the Kunming-Montreal Biodiversity Target.

Benefits of MPA

Here are arrays of benefits of MPAs, mainly; fishery activities, recreation, watershed protection, ecological processes, education and research, cultural values, income source, and biodiversity. Some scholars classified the benefits of MPAs into different categories; "for humans" and "for nature" (Angulo-Valdés, & Hatcher, 2010; Vu, 2013), while others put it into "fisheries management" and "biodiversity conservation" categories (Chaboud, 2011). The classification can further be divided as follows:

Benefits for human

Can be divided into two categories; "directly" and "indirectly". Direct benefits would mean the benefits are more felt by on-site users in terms of fisheries benefits such as larger fish biomass and abundance (Halpern, 2003). Indirect benefits, it is those accrued by individuals living outside of the protected area, for example, tourism opportunity, employment opportunity, shore protection, ecosystem recovery, maintaining global climate change, and political conflict resolution (Badalamenti et al, 2000). Most direct benefits for humans are often associated with extractive uses of natural resources, which is in the range of "fisheries management" as mentioned above, while indirect benefits sustain the fisheries ecosystem for a longer natural resource extraction period (Rodwell & Roberts, 2000; Potts, 2014).

Benefits for nature

Similar to biodiversity conservation in which it affects ecological processes such as nutrient cycling, climate stability, critical habitat, biological diversity, food web, and ecosystem resilience, among others (Board, 2001; Angulo-Valdés & Hatcher, 2010). Aside from providing provisions to on-site communities, protected areas can deliver ecosystem services at a global scale, provided the spatial magnitude is large (Halpern, 2003). At the local scale, on-site communities can benefit mainly from fisheries, such as wider larvae dispersal, overflowing, abundance, size, and diversity of catch as observed by both Guidetti et al (2014) and Harrison et al (2012). Costello (2014) is of the view that if a large enough protected area is designated worldwide, more substantial ecosystem services and benefits can be delivered, such as carbon sequestration, complete protection of migratory animals, sea defense, coastal erosion, and climate control. This view is supported by Potts et al (2014) who opine that this can be achieved through the protection of critical marine components and processes such as substratum, coral reefs, seagrass beds, and hydrological, geological, and evolutionary processes.

These categorizations of benefits are mutually supportive and interdependent. As suggested by Potts (2014), the fishery benefits for human use could not be sustained without the stability of marine components (e.g. habitat, sea space) and the processes (e.g. food web dynamics, ecological interactions). Ideally, MPAs are generally aimed at achieving any of the two main objectives but a well-designed and executed MPA can balance both fisheries management objectives and biodiversity conservation (Halpern, 2003; Rice et al, 2012).

There are several international conventions and treaties recognizing the necessity to focus on marine biodiversity conservation. Firstly, the Convention on Biological Diversity. (CBD) is the first global agreement specifically intended to provide for the conservation and sustainable use of biodiversity. The introduction of this Convention reflects the global response to the threat of worldwide biodiversity loss and it had been entered into force on 29 December 1993. The Convention encompasses all living organisms and their ecosystems and establishes principles and procedures for the management and conservation of biological diversity. Next is the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention), which is an intergovernmental treaty providing the framework for national action and international cooperation to conserve and wisely use wetlands and their resources.

Other than that, the 1995 Fish Stocks Agreement, which is concerned with the management of straddling stocks and highly migratory species, also highlights that the conservation of marine and coastal biodiversity must be balanced with the sustainable use of marine living resources to ensure the marine ecosystem remains healthy.
In addition, marine environmental law principles also navigate the conservation of marine biodiversity, including customary international law, international law (i.e, the 1973 Convention on International Trade in Endangered Species in Wild Fauna and Flora, the 1982 Law of the Sea, decisions of the International Court of Justice (ICJ), International Tribunal of Law of the Sea (ITLOS) and the World Trade Organization (WTO) Panel (George, 2008).

Apart from the above-mentioned conventions, marine pollutions conventions are significantly linked to the conservation of marine biodiversity, such as OILPOL 1954, Intervention Convention 1969, London Convention 1972 and its protocol, MARPOL 73/78, OPRC 1990, Bunker Oil Convention 2001, AFS Convention 2001, Ballast Water Convention 2004 and Nairobi Convention 2007.

At the national level, Malaysia has taken initiative to introduce several policies on the management of marine biodiversity in the country, mainly the National Policy on the Environment 2002, Third National Agriculture Policy (DPN 3), National Policy on Biodiversity Policy 1998, National Policy on Biological Diversity 2016 – 2025, and National Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (NPOA - IUU). There are also around 45 legislations that directly and indirectly regulate marine biodiversity in Malaysia, including Part IX of the Fisheries Act 1985, Access to Biological Resources and Benefit Sharing Act 2017, Biosafety Act 2007, National Forestry Act 1982, and National Parks Act 1980.

Nevertheless, Talaat et al., (2013) have urged to revisit the policy and legislative aspects of safe and sustainable use of resources as there is no single unified and comprehensive federal legislation to deal with the management, of safe and sustainable use of biological resources. Basiron and Kaur (n.d) have proposed the government formulate a specific national policy for managing the oceans.

Such policy is required in balancing the need to continue and perpetuate the provision of goods and services from the sea and for development and economic activities. This policy is seen as key to resolving conflicts between different uses and users of the sea, alleviating pressure on the marine environment and resources, and taking cognizance of the need for integrated planning and management of Malaysia's waters.

Management of MPA in Malaysia

The jurisdiction over MPAs in Malaysia is divided along the lines of List I, II, and III of the Schedule IX of the Federal Constitution. The Schedule demarcates the power division of two authorities, namely the Federal and State governments, each exercising a certain degree of authority over MPAs in their respective jurisdictions.

Designation of marine parks through the political process in Malaysia serves to protect, conserve and manage the biological diversity of marine areas inclusive of endangered and threatened species as well as their natural habitats.

As a result, the MPAs in Malaysia are uniquely governed by distinct authorities. A possible challenge for holistic MPA management would be the state-sanctioned marine parks, which derived their power from States' enactments. For the time being, as provided by the Federal Constitution, only Sabah and Sarawak on Borneo Island have been conferred with bigger jurisdictions on environmental matters. The distinct jurisdiction in managing the MPAs in Malaysia is divided into three as illustrated below.

Federal MPAs

MPAs in Peninsular Malaysia are run by the Federal agency i.e., the Division of Marine Park and Resources Management Marine Parks and Resources Management Division, formerly known as the Department of Marine Park. Currently parked under the Fisheries Department Malaysia, it currently oversees 42 marine parks in Peninsular Malaysia listed under the auspice of Part IX of the Fisheries Act 1985. In 1994, Section 41(1) of the Establishment of Marine Parks Malaysia Order 1994 provided a 2nm buffer zone encircling the marine park islands.

The section contained specific words on advising against exploitative activities jeopardizing the marine environment with the exception of Kapas Island, which is only up to 1 nautical mile from the island's baseline. Concurrently, it created a safe zone for critical habitats for certain species, mainly marine endangered species. Among the restrictions are mollusk and corals collecting, which can be penalized. The prohibitions against such activities are enforced within a 2nm buffer zone radius encircling the marine park islands.

SABAH MPAs

Sabah MPAs were created under the auspice of the Parks Enactment 1984 (repealing the National Parks Enactment 1977), which came with the clear prohibition of tree cutting, coral removal, and pollution activities (Section 48, Part VIII, Parks Enactment 1984). Violations within the Sabah Marine Parks can be penalized up to RM750,000.00 of fine, and/or one to seven years imprisonment, which is a pricey deterrence for illegal coral trade.

Aside from the 1984 Parks Enactment, the Wildlife Conservation Enactment 1997 allows the creation of three other types of MPAs, namely Conservation Areas, Wildlife Sanctuaries, and Wildlife Hunting Areas. Reiterating the SDG's goals of sustainable development, both enactments complement one another by way of providing critical habitats to endangered species while preserving the rights of the indigenous communities for food hunting within the sanctuaries.

SARAWAK MPAs

The Turtles Board as the custodian agency for the Talang Talang Besar Island, Talang Talang Kechil Island, and Satang Besar Island derives its powers from the Sarawak Turtle Trust Ordinance 1957. The Sarawak 2003 State Fisheries Ordinance Marine, enforced by the Marine Fisheries Department, regulates fishing activities within its territorial waters. The Wild Life Rangers of the Sarawak Forestry Corporation (SFC) guard the Sanctuaries, where many threatened species reside, as empowered by the Wildlife Protection Ordinance 1998 (Amended 1995). The waters around three islands off Sarawak, namely Pulau Talang-Talang Besar, Pulau Talang-Talang Kecil, and Pulau Satang, have also been gazetted as fisheries protected areas, whereby collection of marine fauna and flora is prohibited.

Fishing in fisheries-protected areas is also prohibited unless specifically licensed to do so. Talang-Satang National Park, Miri-Sibuti, and Sarawak's Turtle Islands are among the MPAs of Sarawak that is also patrolled by the Wild Life Rangers. Alas, as suggested by Tisen (2009), this has yet to fulfill the 10% quota of land designated as protected areas (as targeted under Aichi Target 11) despite Sarawak adopting the IUCN's suggestion of including ecological, biological, topographical, and social factors into MPAs designation. It would be the responsibility of the Protected Areas and Biodiversity Conservation (PABC) Unit under the SFC, specifically the Planning Department to try and find measures to set Sarawak MPAs to achieve the 10% target.

4.2 Addressing IUU Fishing

Illegal, unreported and unregulated ("IUU") fishing is a global issue faced by many coastal countries, thus warranting a separate section. It represents a major threat to the long-term sustainability of the world's oceans. IUU fishing undermines national and regional efforts to manage fisheries sustainably and to conserve marine biodiversity. Such fishing is neither a new phenomenon in capture fisheries nor confined to the high seas. It also occurs in the EEZs, which accommodate diverse habitats (Riskas et. al., 2018) and connects both national and foreign vessels to territorial waters.

By circumventing regulation by authorities, IUU fishing causes billions of dollars of revenue loss annually to the legitimate fishing industry. As territorial waters are vast and require multiple governing bodies to ensure regulations, owners of IUU fishing vessels are difficult to trace (Azmath and Grewal, 2017). With the growing demand for marine resources and the limited marine resources, particularly to support food supply, IUU fishing has become a great threat to fishing countries.

The international fishing communities have been working closely with one another to overcome this issue. However, some countries have limited funding to manage and control fishing activities within their territorial waters (Petrosian et. al., 2015). These activities can be resilient to international regulatory measures, hiding behind the inability or unwillingness of states to enforce fisheries regulations (Miller et. al., 2014).

4.2.1 Main Factors Contributing to IUU Fishing

IUU fishing may result from the fact that many countries have yet to adopt adequate frameworks for fishing management at the national level. Given that IUU fishing refers to a broad spectrum of fishing activities classified as 'illegal', 'unreported', and 'unregulated', it may occur on the high seas or within national jurisdictions. There are several factors contributing to the occurrence of such fishing activities, one of which is poor governance, referring specifically to the limited and overlapping enforcement by relevant authorities (Dirhamsyah, 2012. Absent regional enforcement bodies or multilateral agreements, IUU fishing is difficult to overcome, and issues relating to overfishing and other fishing problems will continue (Zhang, 2018).

IUU fishing is also triggered by the high and growing demand for seafood, particularly in Southeast Asia, where the populations profoundly depend on marine resources for food and income (Johns, 2013). IUU fishing is highly profitable simply because it is more 'expensive' to be a responsible fisher in the market. Given that such fishing is unreported and unregulated, it provides lucrative revenue with no imposed tax. IUU fishing also occurs on such a large scale because it can often be practiced with impunity. This is mainly the case in the territorial waters or EEZs of countries that cannot afford to implement costly and complex fisheries control measures. The complexity of the fishing industry, and the many levels of organization involved in this industry leave it vulnerable to the influence of organized transnational crime and corruption.

The ocean plays a very important role in the development of marine-related economic activities, including oil and gas exploration, sea transport services, and fisheries. Although Malaysia has yet to ratify all international conventions relating to fisheries and marine activities, the country has to a certain extent adopted comprehensive monitoring, control, and surveillance ("MCS") system for its EEZ, which was founded based on the United Nations Convention on the Law of the Sea 1982 ("UNCLOS"). Malaysia has also adopted various pre-emptive mechanisms to prevent the exploitation of marine resources, which focus on the west coast of the Malaysian Peninsular (Saharuddin, 2001).

Being a fisheries nation, Malaysia is facing serious and worsening problems in fisheries management. Its problems with IUU fishing are generally associated with encroaching fishers from neighboring countries such as Vietnam, Thailand, and Indonesia.

Approximately 980,000 metric tonnes of fish (worth RM6 billion) are said to be stolen in Malaysian waters (mainly East Coast) annually by illegal foreign vessels usually from Thailand, Vietnam, and Indonesia (Majid, 2017). It has been roughly estimated that only 50 percent of the fish caught in Malaysian waters are landed; the rest are 'unreported' mainly because of territorial sea encroachment by foreign fishing vessels (David, 2017). On the East Coast of the Malaysian Peninsular, encroachment of foreign fishers not only affects the livelihood of the local fishers but also destroys marine biodiversity, as well as being entangled with drugs and firearms trafficking.

4.2.2 Major Impacts of IUU Fishing

There are several major impacts of IUU fishing as follows:

Overfishing

According to the UN Food and Agricultural Organization ("FAO"), up to thirty percent of global catches may be caught illegally or remain unreported (NIC, undated). Unreported catches make sustainable fisheries unworkable and threaten all conservation measures. IUU fishing targets already depleting stock and juveniles or occurs in areas that are closed to fishing (Agnew et. al., 2009). Overfishing is greatly enabled by the existence of foreign vessels equipped with sophisticated technologies. Malaysia and Indonesia have been severely affected economically by overfishing by such technologies (Pedrason et. al., 2016). Therefore, such activities can also be considered an economic crime (Nova, 2016).

Bycatch

Also associated with the presence of large vessels equipped with sophisticated technologies. By-catch is not limited to commonly fished species or fish of unfavorable sizes, but may also include whales, dolphins, seabirds, turtles, sharks, rays, and other forms of marine wildlife (Hall et. Al., 2017). The use of banned and destructive fishing gear such as trawls, bombs, and cyanide damage the sea floors, and reefs leading to even greater amounts of by-catch, as well as interrupting marine biodiversity (Nova, 2016). Thus, investing in programs to tackle IUU fishing can help to resolve issues such as turtle extinction and other consequences of by-catch (Riskas, 2018).

Severe economic loss

Most likely to be inflicted on coastal communities and small-scale fisheries, apart from the national economy. This economic loss is a result of overfishing leading to depleting fish stocks and marine biodiversity, as well as creating significant collateral damage to marine ecosystems (Pedrason et. al., 2016; Petrosian et. al., 2015; Agnew et. al., 2009).

Social damage

IUU fishing constitutes more than a crime against fish because the documented crimes other than fisheries crimes associated with IUU fishing (e.g., document forgery, human trafficking for labor, smuggling, money laundering, and drugs trafficking) fall within the definition of transnational criminal activities according to this classification system. It has demonstrated that one crime is vital for the other to flourish (Noonan and William, 2016).

Maritime security breaches

The complexity of the maritime-security breaches does not allow for each illegal activity to be understood, addressed, and suppressed individually. In addition, IUU fishing not only causes fisheries disputes and maritime incidents involving fishers but also poses serious threats to maritime security and stability. Thus, a comprehensive and inclusive approach is needed to explore, understand and disrupt the linking and overlapping of various maritime-security breaches (Chapsos and Hamilton, 2018).

4.2.3 Combatting IUU Fishing: International and Regional Framework

As international awareness is increasing, the global community is trying to address the underlying weaknesses of the regulatory regime, threats to marine biodiversity, and the revenue losses of fisheries nations, which leads to the re-examination of the international regulatory framework for fisheries in many countries. Pomeroy et al. have proposed several strategies to improve the sustainability of fishery resources, including strengthening transboundary or regional fisheries management, engaging the private fisheries sector, implementing an ecosystem-based approach to fisheries management ("EAFM"), and enforcing a market-based approach (Pomeroy et. al., 2016). Some countries, including Australia and Malaysia, have advanced efforts at the national level by reinforcing their domestic legal frameworks, while the European Union has proposed stricter measures to limit trade in IUU fish (Pedrason et. al., 2016).

The importance of monitoring and regulatory enforcement for both fishing activities and trade must never be ignored when combatting IUU fishing (miller et. al., 2014). Effective coordination between government agencies, data and research management, and participation and commitment by all stakeholders are also pertinent in combating IUU fishing (Zhang, 2018). Such cooperation requires an effective governance framework that includes regulation, enforcement, coordination, and participation that involves multiple stakeholders.

Among the earliest multilateral action taken by the international community to alleviate problems relating to ocean governance were the United Nations Convention on the Law of the Sea I (1958) and II (1960). Given that these two conventions failed to address issues about territorial limits and fisheries rights, the UNCLOS was further negotiated and signed in 1982 to define the rights and responsibilities of nations concerning their use of the world's oceans and to establish guidelines for businesses, environment, and management of marine natural resources. Following the measures stipulated in the UNCLOS, several legal instruments have been created (Table 14).

UN	FAO
FEDERAL	FAO Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, 1993
United Nations Fish Stocks Agreement, 1995	FAO Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, 1993
	FAO Agreement on Port State Measures to Prevent, Deter and Eliminate IUU Fishing, 2009

Table 14:
International Instruments to Combat IUU Fishing

The FAO Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, 1993 prevents the 're-flagging' of vessels fishing on the high seas under flags of states that are unable or unwilling to enforce international fisheries conservation and management measures (FAO, 1995). The maintenance of records of fishing vessels is covered extensively by the provisions of this agreement. The United Nations Fish Stocks Agreement 1995 ensures the long-term conservation and sustainable use of straddling and highly migratory fish stocks within the framework of the UNCLOS (Tahindro, 2017). This Agreement spells out the duties of flag states, including those related to registration and records of vessels, authorizations, MCS, as well as compliance and enforcement. Cooperation in international, regional, and sub-regional enforcement is also addressed in the agreement, along with boarding and inspection procedures and port state measures.

Several international plans of action ("IPOA") have been introduced to address specific issues in fisheries governance, including the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing 2001 ("IPOA-IUU"). This IPOA serves as an international tool to combat IUU fishing, used by all states in general, flag states, coastal states, market states, port states, and regional fisheries management organizations ("RFMOs"). The IPOA-IUU calls on all countries to develop and implement a consistent NPOA, and to review it periodically. The core elements of the IPOA-IUU are the implementation of the responsibilities relating to fisheries of flag states, coastal states, and port states, as well as the introduction of market-based measures (FAO, 2001).

The FAO Agreement on Port State Measures to Prevent, Deter and Eliminate IUU Fishing 2009 was signed to prevent vessels engaged in IUU fishing from using ports and landing their catches. The execution of this agreement aims to reduce the incentive of such vessels to continue operating and to block fishery products of IUU fishing from reaching national and international markets. This international agreement also covers the role of flag states and RFMOs in the implementation of port state measures.

Although many international instruments have underlined the principles of responsible fisheries for coastal states to regulate matters concerning sustainable marine-resources management, it is also important to ensure that comprehensive regional fisheries management considers measures to protect marine ecosystems at the regional level. Through regional efforts, several measures can be adopted such as preventive actions against the adverse effects of IUU fishing on marine ecosystems and the sustainability of fishing industries (Table 15).

SEAFDEC	ASEAN	CTI-CFF
SEAFDEC Regional Fishing Vessels Record (RFVR)	ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain	CTI-CFF Regional Plan of Action (RPOA)
	ASEAN Catch Documentation Scheme (ACDS)	

Table 15: Regional Instruments to Combat IUU Fishing

One significant measure taken by the Association of Southeast Asian Nations (ASEAN) members through the Southeast Asian Fisheries Development Centre (SEAFDEC) is the Regional Fishing Vessels Record ("RFVR"). This measure aims to develop a regional record of fishing vessels, beginning with vessels measuring 24 meters in length (which could be expanded later with the recording of vessels measuring fewer than 24 meters) and applicable to countries in the region that are attempting to improve their fishing licensing systems which conform to regional and international requirements. The refined fishing licensing systems and the RFVR could be used effectively as a fisheries management tool for combatting IUU fishing in Southeast Asia.

Another substantive regional effort was to create the ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain. It was introduced to provide tools for the ASEAN Member States ("AMS") to ensure that fish and fisheries products from the region entering the global supply chain do not come from IUU fishing activities. The objectives of the guidelines are as follows:

I. To introduce strategies and recommend appropriate measures for the AMS to prevent the entry of IUU and fisheries products into the supply chain
II. To guide for the AMS to develop, strengthen and implement effective fisheries management for responsible and sustainable fisheries
III. To promote regional collaboration among the AMS to strengthen MCS systems of fish and fisheries products entering the supply chain

The ASEAN Catch Documentation Scheme ("ACDS") was also introduced under the requirement of SEAFDEC Member Countries to comply with the requirements of the EC Regulation 1005/2008. The objectives of the scheme are as follows:

I. To provide a unified framework that will enhance the traceability of fish and fisheries products for effective marine fisheries management in AMS
II. To enhance the credibility of fish and fisheries products for intraregional and international trade
III. To prevent the entry of fish and fisheries products attained from IUU fishing activities into the supply chain of AMS

In addition, through a multilateral partnership, the Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security ("CTI-CFF") has successfully implemented its Regional Plan of Action ("RPOA") aiming to sustain marine and coastal resources. The RPOA is guided by nine principles designed to promote responsible fishing practices, including combatting IUU fishing, in the region. This plan of action was agreed to by the fisheries ministers of six countries in May 2007. Among the goals and targets relating to combatting IUU fishing are Goal 2 through EAFM and Goal 5 through Threatened Species Status Improving ("TSSI"). Three targets are stipulated under Goal 2 namely:

I. Criminalization and enforcement to combat IUU fishing as "transnational organized crime"
II. Improved enforcement of IUU fishing through greater collaboration

III. New surveillance, enforcement, and judicial cooperation measures to address IUU fishing

The targets enumerated under Goal 5 are two-pronged:

I. Enforcement of legislation and action on shark fishing, including reducing the incidence of IUU catch
II. Recognition and enforcement of laws and regulations to combat IUU fishing and trafficking of threatened marine species as transnational organized crime

RPOA has faced many challenges, which demonstrates the need for ongoing commitment by participating states. RPOA measures may be able to stop the increase of IUU fishing, particularly in Southeast Asia. Thus, the development of a system to detect IUU vessels, as well as regional cooperation and collaboration are essential to combat the growing IUU fishing in national waters. Looking at the regional cooperation between Thailand and Malaysia, it is suggested by Agnew et. al. (2009) that the importance of regional cooperation can be further extended through an information-sharing system to accomplish a mutual maritime-security objective. Regional cooperation in the fisheries sector will ultimately assist to meet the needs to provide food security and economic development, create a sustainable fisheries sector, and prevent maritime conflict (Bellmann et. al., 2016).

4.2.3 Combatting IUU Fishing: The Domestic Legal Framework

The Fisheries Act 1985 had undergone several amendments till 2012, to strengthen governance in Malaysian waters. This legislation provides regulatory and enforcement measures to combat unauthorized marine-related activities, particularly illegal maritime encroachment by foreign fishing vessels in Malaysia's territorial waters. Section 6 of the Act empowers the Director General of Fisheries to make plans to regulate matters of IUU fishing in Malaysia under the NPOA-IUU. Given that IUU may also involve local fishers or vessels, Section 8 stipulates that any fishing activity in Malaysia's fisheries waters requires a valid license issued and that the vessel shall not contravene any condition in the license issued. Concerning foreign fishing vessels, Part V of the Act spells out their rights and duties, including that to access fisheries resources in Malaysian fisheries waters (Section 15 to Section 24).

Section 15 prohibits any fisheries activity by foreign fishing vessels unless authorized under an international fisheries agreement between Malaysia and other states or international organizations under which the vessel is flagged. However, the operation of such vessel shall require a permit under Section 19 and to comply with fishing regulations as embedded in Section 17. Yuliantiningsih et. al. (2018) noted that the Indonesian Government has campaigned for illegal fishing to be recognized as a transnational organized crime to promote for more effective regional control mechanism on IUU Fishing.

The Fisheries Act 1985 provides details on the prohibited fishing methods under Section 26, including the use of explosives, poisons or pollutants, electrical equipment, or any prohibited gear. Further, no person is allowed to fish, disturb, harass, catch or take any aquatic mammal or turtle beyond the national jurisdiction; any aquatic mammal or turtle caught should be released instantly (Section 27). To ensure compliance with the rules and regulations, Section 46 prescribes measures to be taken where any authorized officer may act without a warrant if they believe there is a violation.

This provision allows an authorized officer to halt and search any vessel or vehicle transporting fish, and further inspect all the documents and anything else on board, including the crew, equipment, and the catch. Section 47 of the Fisheries Act 1985 allows authorized officer to enter, seize and arrest without a warrant when he has reason to believe that an offense has been committed under the Fisheries Act 1985. Section 47A, Section 47B, and Section 47C authorize any fisheries officer to investigate, require the attendance of witnesses, and examine witnesses.

The enactment, amendment, and enforcement of the Fisheries Act 1985 reflect Malaysia's commitment to enhancing its local fisheries sector, as well as to ensuring its compatibility with international legal requirements and management practices. This Act has well translated the state's obligations as enumerated under the UNCLOS. Malaysia also has several other pieces of federal legislation that help to strengthen and complement the implementation of the Fisheries Act 1985, particularly those related to fisheries management and enforcement in the EEZ.

These laws are specified in the Exclusive Economic Zone Act 1984, the Continental Shelf Act 1966, the Territorial Sea Act 2012, and the Maritime Enforcement Agency Act 2004, which are also essential in governing maritime-related activities and resources in Malaysia's EEZ. The first three Acts were enacted to define national jurisdiction and sovereign rights in the maritime space, while the fourth Act was adopted to establish the Malaysian Maritime Enforcement Agency, which is the national coast guard.

4.3 Ecosystem-based Management Approach to Protect Our Marine Biodiversity

With anthropogenic pressures generally increasing, managing each of these activities in silo is therefore insufficient to conserve marine ecosystems as a whole (Talaat and Kaur, 2019). The main reason for the continuous deterioration of the marine ecosystems and environment is the current piecemeal governance strategy, as management has largely been carried out sectorally (Halpern et al., 2008), and the potential cumulative impacts are often not dealt with comprehensively.

The interlinkage between ocean governance and Marine Spatial Planning (MSP) was first raised by Underdal (1980) and was further supported by Hu (2012), who proposed that the solution to the crisis that has been echoed for the last three decades is based on integrated and ecosystem-based approaches to ocean governance. This brings MSP into attention, as potentially the best solution to sustainably manage a marine and coastal space, where allocation of human activities in specific marine areas can be made according to objectives (e.g. either for the development or preservation of an area) or specific uses. An all-encompassing planning and management framework is imperative to ensure that impacts from coastal and marine activities would accrue socio-economic and environmental benefits, without which these activities can adversely cause undesirable environmental and social impacts.

As noted earlier by Ehler & Douvere (2009), we can only plan and manage human activities in coastal and marine areas, but not the marine ecosystems or components of the ecosystems. The complication in governing her waters (Figure 11) is magnified for Malaysia as a federation, particularly when it comes to regulating anthropogenic activities and multiple uses in marine and coastal space (Talaat and Kaur, 2019). As an ecosystem-based approach to sustainable development, MSP can be invoked to better manage her marine and coastal areas and their environment.

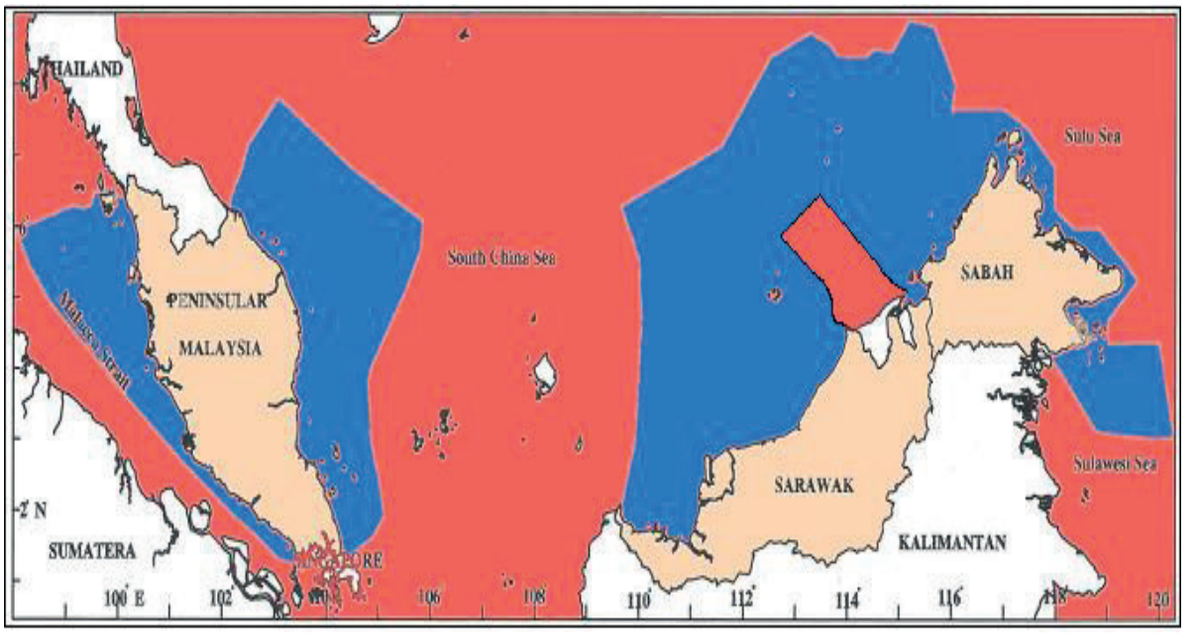


Figure 11: Malaysian fisheries waters or EEZ (Source: Department of Fisheries Malaysia, 2016)

In implementing MSP, stakeholders at all levels must be engaged from the beginning. The local communities' traditional knowledge and practices should never be sidelined in the decision-making process. Their years of living in and off the marine and coastal environment should be factored in and inform the policies and decisions made.

MSP is one of the Key Ocean Management Domains of the UN Decade of Ocean Science 2021-2030, and MSP is crucial in order to achieve sustainable ocean as well as sustainable ocean economy (another term for Blue Economy) as can be seen from Figure 12 below.

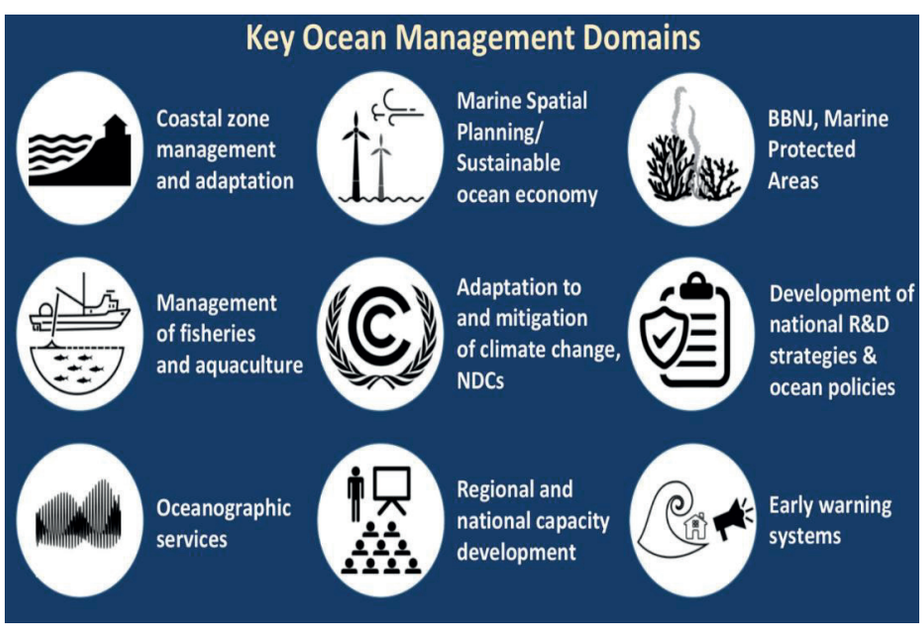


Figure 12:
Key Ocean Management Domains of the UN Decade of Ocean Science 2021-2030
(Source: UN Ocean Decade Implementation Plan, 2021)

5.0 GAPS IN THE MALAYSIAN MARINE ENVIRONMENTAL GOVERNANCE FRAMEWORK

5.1 The Division of Power in Marine Environmental Protection

The jurisdiction of the State and Federal governments is separated as provided by the Federal Constitution. States are given rights over estuarine fishing and turtle conservation (Item 12, List II of the Federal Constitution). As mangrove is considered vegetation on land, it automatically falls under the State jurisdiction (List II of the Federal Constitution). The marine fish stocks, which are under the jurisdiction of the Federal government (List I of the Federal Constitution) are highly dependent on the mangroves, which are under the state's jurisdiction, as critical nursery and spawning areas. This sectoral power division creates obstacles to an integrated approach toward sustainable marine environment management. Another form of power division is provided by the Territorial Sea Act 2012, which sets the boundaries for the management of marine water. States are empowered to regulate fisheries matters starting from the low water mark up to 3 nm as provided under Section 3(3).

Federal jurisdiction on the territorial waters is limited up to 12nm from the low water mark seaward. As each State has independent control over their respective marine areas, it resulted in an imbalance in marine protection, such as a different level of protection for turtles. As accorded by UNCLOS 1982, the Exclusive Economic Zone Act 1984 (EEZ 1984) has provided for the establishment of the EEZ. This Act allows Malaysian fishing vessels to harvest marine resources in the EEZ and the Malaysian government to implement marine pollution regulations on the vessels (Part IV of the EEZ Act 1984).

Apart from List II of the Federal Constitution, the Borneo states of Sabah and Sarawak have been conferred additional powers as codified in the Supplemental List IIA and IIIA of the Federal Constitution. These provisions have added another layer of complexity to the Malaysian marine governance framework. Supplemental List IIIA of the Federal Constitution provides for both Sabah and Sarawak to establish authorities such as the Sabah Biodiversity Centre and Sarawak Forestry Corporation. The outcome of this power division is that the federal laws emulated by the Federal government can only be implemented in Sabah and Sarawak through adoption and consent.

This fragmented approach to pollution management, according to Mustafa & Mokhtar (2012), contributes to hampered effective marine protection. Similarly, enforcement of sea and maritime affairs are under the jurisdictions of different departments. The Marine Department, the Maritime Enforcement Agency, Marine Police, Marine Parks Department, Royal Malaysian Navy, and Fisheries Department are all involved in enforcing these laws in the Malaysian waters where their jurisdictions are often overlapping leading to inefficient operation and enforcement.

As suggested earlier by Saharuddin (2001), the presence of too many government agencies and interested private sectors in Malaysia can create overlaps in function and jurisdictions. For example, the Department of Fisheries includes the marine turtles under its Annex of protected species (under the Fisheries Act 1985), but the Department of Wildlife, empowered by the Wildlife Act Conservation2010, has no jurisdiction over the matter.

Currently, the enforcement of these legislations is under the purview of 11 immediate departments, which would have inevitably prevented the successful implementation of conservation legal tools in many ways. The aims and missions of most of these departments do not prioritize on conservation and management of marine wildlife. Although the departments displayed their visions and missions for the responsible harvest of natural resources, the exploitative activities are more apparent while disciplined and responsible use is pushed to the back. This, unfortunately, does not reflect the subsidiary and participatory element of sustainable governance (Boesch, 1999).

The complication of overlapping jurisdiction can be seen in the case of sea turtles. The primary fishery law, the Fisheries Act 1985, could not uniformly protect the sea turtles throughout the whole country as it is ultra vires of the Federal Constitution as endangered species fall under State jurisdiction according to Clause 3, Article 76 of the Federal Constitution. This resulted in limited protection by state borders. For instance, the jurisdiction in Brunei Bay within the Malaysian border alone falls under the purview of three distinct legislations (and enforcement agencies) i.e. the Sabah Environmental Protection Enactment (2002), the Sarawak Wild Life Protection Ordinance (1998), and the federal Wildlife Conservation Act, 2010. When it comes to turtles, the federal Fisheries Act, 1985 is also involved.

As suggested by Brown (2005), without harmonization across departments and legislation, issues are not only challenging to address but are possible to recur and thus, leading to more confusion. There is thus a need to create a fundamental framework of cooperation across all levels as put forth by Omar et al. (2017). The success achieved by South Korea was then quoted by Cho, (2006) who then illustrated that the country had improved tremendously in policy implementation after a moderate overhaul of sectoral approaches by institutions and policies towards centralized management in 1996.

5.2 Sectorial and Outdated Domestic Legal Framework on Marine Environmental Protection

Ensuing from the above problem due to the divisions of power, it has also been found that most of the existing domestic legal frameworks are dated and unaligned with some of the obligations imposed on Malaysia as a State Party to the MEAs signed and ratified. For instance, the CBD, CITES, and UNCLOS that Malaysia has accessed and ratified to has yet to be fully incorporated into its legal framework. Most of the existing laws were enacted before these MEAs were signed and there are generally piecemeal and sectorial legislations. Table 1.1 below lists the main federal legislations relating to marine environmental protection.

The environmental laws, which are mostly outdated, especially relating to marine environmental management, must therefore be revised to comply and work well with CBD, CITES, UNCLOS, and other UN treaties. Major reviews must be performed on our outdated ecosystem management governance framework (which includes the legislative, policy, and administrative measures) to harmonize with the international treaties, before irreversible damages, such as high-valued marine species mass extinction and massive coral de-population take place in the Malaysian waters.

5.3 Lack of Spatial Management Consideration in Marine Protection Efforts

The loss of critical habitat in a marine space is crucial to the survival of both the marine environment as well as the human population that depend on their livelihood in such marine space. As noted by Williams (2008), the current sphere of protection often leaves out the critical habitat characteristics such as feeding area, mating area, spawning, protection, and straddling route. This could undermine or threaten the endangered marine organisms inhabiting Brunei Bay. In protecting habitats, which are ecologically sensitive areas, enforcement agencies must be clear in their areas of jurisdiction. An integrated governance framework is therefore urgently needed in Malaysia for this matter. This was to be addressed as per the suggestion put forth by Mokhtar and Aziz (2003) that Malaysia can achieve this coordinated enforcement by firstly devising an Integrated Coastal Zone Management Policy, which can overcome jurisdictional and authoritative boundaries.

As noted by Jaaman (2010), although Brunei Bay is inhabited by seven species of marine mammals and three species of turtles, to date, there is no proposed framework of a protected area as yet at this semi-enclosed bay. Similarly, the status of these marine endangered species (MES) especially the Dugongs and turtles in Malaysia are still in endangered and critically endangered status (IUCN Red List, 2017).

Since MES are the biological indicators of the state of our oceanic health, it is thus relative to the habitat loss that contributes to the degenerative population of the MES in the Malaysian waters which are recording a decline in coverage since 1980 (FAO, 2007).

As noted by Waycott et al (2009), a similar loss has also been recorded among the global seagrass population. Ideal marine environmental management planning and framework are supposed to involve all the stakeholders as they reside and interact within the areas. As stated by Ruiz-Frau et al., (2011), for MPAs to be sustainable and successful, relevant stakeholders must be involved at the early stage of policy decision-making.

5.4 Lack of Local Participation in MPAs Management

While the marine parks areas are being managed by a federal agency while the management of the terrestrial parts of these islands falls under the local governments. Sadly, there is an absence of any formal involvement of the local communities in the management of these marine parks, indicating the lack of local community engagement in marine conservation efforts.

Furthermore, despite one of the objectives behind the designation of MPAs is to increase the local community's economy by conserving the fish biological cycle, some local fishermen are still struggling. Islam et al. (2017) reveal that the no-take area has caused hardship to the local communities' livelihoods as they heavily depend on fishing activities. The detrimental impacts on the livelihood of these fishermen, which were not taken into consideration by the policymakers, have inexorably encumbered the enforcement of MPAs regulations. This would exacerbate since the local and indigenous communities were seldom consulted before the management decision-making on the establishment of such zoning (Stacey et al., 2017).

Pursuant to that, effective enforcement of MPAs regulations by the then Marine Park Department and related agencies could have been undermined through overselling of tourism activities or mass tourism, which has inadvertently caused adverse impacts on the coral reef and other marine life (Islam et al., 2017), thus affecting the livelihood of the local population. A stark opposite can be seen in the Wet Tropics of Queensland, Australia where successful cooperation between the authorities and the local community was manifested when the locals were enabled to use knowledge to resolve species management issues (Hill, Baird, & Buchanan, 1999).

In many countries, co-management has long been recognized as a medium to describe joint management arrangements between the government and the local community. Although local fishermen have limited scientific knowledge and traditional ecological knowledge (TEK) is attained informally through long experiences, it has already been recognized that this knowledge facilitates scientific research by providing baseline information. Since TEK has now been proven globally as promoting the sustainable use of the marine environment and resources, acknowledging the TEK along with the local communities' interests will assist in achieving effective management of the fishery or marine resources.

Community participation within a system of co-management requires that they take on the responsibility along with the government to create a civil society. Coined upon the notion of community–based management under Principle 22 of the Rio Declaration on Environment and Development in 1992, the principle of co-management maintains that the roles and participation of local communities and other stakeholders should be encouraged to achieve sustainable development.

5.5 Failure to Adopt and Comply Ecotourism Guidelines

Although the main aims of designating MPAs under the Fisheries act 1985 are to preserve a specific habitat and to ensure the marine ecosystem is sustained, the Act 1985 allows these MPAs for recreational, as well as for research and educational use. Thus, although in the MPAs, preservation of the health of the marine ecosystem is given the utmost priority, it is irrefutable that the eco-tourism activities allowed within or near the protected areas have been causing serious environmental degradations to the MPAs in Peninsular Malaysia. Coral bleaching and broken corals due to trampling are typical occurrences in these marine park islands.

Kaur (2006), who conducted a study on the assessment of ecotourism impacts on marine park islands in Malaysia and predicted the trend of increasing visitor numbers to marine parks in Malaysia to continue, noted that ecotourism in Malaysia is just as damaging as mass tourism. She observed the following negative effects of ecotourism in the Malaysian marine parks as follows:

I. Main activities in marine park islands such as snorkeling and diving by irresponsible tourists are damaging the corals
II. Demand for accommodation has resulted in a concentration of chalets/resorts in unsuitable areas and unnecessary facilities development (the airport and marina in Pulau Tioman, and the chalet complex in Pulau Payar, for example).
III. The presence of tourist facilities places a high demand on limited water resources and is in direct conflict with ecotourism
IV. Most marine park islands still lack proper sewage and solid waste disposal systems causing pollution and leakage into the marine environment

There is an obvious reason why it is so difficult to manage MPAs according to the Guidelines provided by the National Ecotourism Policy 1997, which goes back to the overlapping jurisdictions in managing marine park islands (refer to the first gap). The marine park areas are being managed by the Fisheries Department, which is a federal agency, while the management of the terrestrial parts of these islands falls under the respective local authorities, which receive a budget from their respective state governments.

5.6 Gaps in Marine Conservation in Unprotected Areas

Most past and current discussions are on protection in MPAs. While MPAs are accorded with distinct degrees of protection, it goes without saying that formal recognition and efforts are being paid in attempting marine conservation therein. For other areas, one question arises – "Whether there are marine conservation measures in areas that are not protected, or in non-MPAs?" This question leads to other questions – "If the area is not designated as an MPA, what are measures to be taken to preserve the ecosystem and its services?", "Who should be responsible to care for these unprotected areas?", "How to guide the protective measures in these unprotected areas?".

Although it may be difficult to address these questions simultaneously, there may still be a silver lining in every cloud. The existing policies, laws, and plans may still be of use provided these areas are identified as critical habitat or environmentally sensitive areas, whether via the NCZPP-2 or through scientific studies. However, protecting unprotected areas always remains a daunting task. Implementation of laws, regulations, and guidelines would more difficult than in MPAs, particularly when there are pending issues like overlapping jurisdictions, low capacity in budget and manpower, and low level of awareness.

RECOMMENDATIONS

A. Shifting to Co-Management in MPA Designation and Management

Co-management or collaborative management by engaging the local communities, or Co-management or collaborative management by engaging the local communities, or community-based management, is the concept that could be able to remedy ineffective MPAs management in Peninsular Malaysia. As mentioned above, the establishment of no-take zones would limit access to marine resources and would likely force the local fishermen to commit illegal fishing within and beyond the water boundary. This would exacerbate since the local and indigenous communities were seldom consulted before the management decision-making on the establishment of such zoning (Stacey et al., 2017). A previous study in the Wet Tropics of Queensland, Australia has shown successful cooperation between the authorities and the local community whereby the locals were allowed to use knowledge to resolve species management issues (Hill, Baird, & Buchanan, 1999).

There have also been inclining numbers of governing frameworks to promote the rights of the local communities, including the indigenous, to access the natural resources, and to engage them in the management of conservation areas as well as to compensate for their loss due to imposing restrictions, such as no-take area (Stacey et al., 2017). This shows the importance of local community engagement in the management and decision-making process and the role of good governance to assist the management of MPAs (Pomeroy, Lani, John, & Gonzalo, 2005).

The basis of community-based MPAs is to converge the craftsmanship of fisheries management and biodiversity conservation (Christie & White, 2006). Bottom-up or community-based approaches are prevalent in some jurisdictions whereby the institutional frameworks are irresolutely resulting from colonialism or ineffective government, or simply because of financial and technical resources constraints.

Even so, some factors may contribute to effective community-based management of MPAs on account of the active participation of resource users and because of this, a sense of ownership, trust, and collaboration may build up (Pollnac & Pomeroy, 2005; Christie & White, 1997).

As noted above, it has also been already proven that the formal marine conservation efforts via MPAs designation have led to adverse impacts on the indigenous semi-migratory and nomadic peoples since such reserves impose restrictions on to access marine resources. Nevertheless, their participation and engagement in the conservation programs would assist these communities in designing programs to safeguard the sustainable use of marine resources (Stacey, Acciaioli, Clifton, & Steenbergen, 2017).

Following the above discussion, since these MPAs are also designated as tourist destination islands, it may not be wrong to infer that this top-down decision was made without consideration of the resource users' (in this case the local fishermen's) knowledge, perception, and understanding of their surrounding marine environment. The local communities may have not been consulted from the beginning during the MPA designation process. Being a country that has been considered to have good governance and is financially stable, community-based MPAs are almost absent in this country, as opposed to neighboring Thailand, the Philippines, and Indonesia, where the local communities play integral and essential roles in managing their marine environment.

The effectiveness of an MPA management is judged based on several indicators such as levels of local participation or engagement in the decision-making process and the assessment of the impacts on local community livelihoods (McClanahan, Marnane, Cinner, & Kiene, 2006).

It is also crucial to know whether the local community has the motivation to participate in resource management (Jones, Qiu, & Santo, 2013) because this will lead the direction in policy and decision-making. As noted by Cinner (2005), several studies have already emphasized the importance of local engagement to navigate the successful implementation of MPAs management.

There are several social challenges to be encountered to include the local community in MPA management, such as bureaucracy that includes top management authority to make the final decisions (Stephenson, Berkes, Turner, & Dick, 2014). Nonetheless, it is also irrefutable that engaging the local and indigenous community in the decision-making process of an MPA governance and management is crucial to protect and conserve marine biodiversity and resources. One good example of the role of community in the collaborative governance for the establishment of MPAs and resource management is well reflected in the case of the Haida Nation where it was incorporated for the purpose of marine conservation and sustainable use of marine resources (Gaymer et al., 2014). However, a study by Chaigneua and Daw (2015) showed that most community support for MPAs was assessed at the village or community level rather than individually. They suggested that individual differences should be considered as a criterion in developing a community-based conservation program to attract more public participation.

Several large-scale MPAs in the Pacific like the Phoenix Islands Protected Area, the Pacific Remote Islands Marine National Monument, the Motu Motiru Hiva Marine Park, and the Natural Park of the Coral Sea (in Australia), have established successful collaborations whereby their cooperation inclusive of bilateral agreements, research, monitoring, and enforcement to manage maritime jurisdictional territories and their resources (Friedlander et al., 2016). Through a collaborative process, which involved resources and information sharing, and knowledge exchange, the sustainability of

marine resources could be achieved. Gaymer et al. (2014) in their study have highlighted the challenges to reach the balance between top-down and bottom-up processes, which is better known as the community-based approach. This has indicated that despite the many studies suggesting the importance to engage the local communities, political will is still necessary to engage these communities.

Traditional Ecological Knowledge (TEK) of the local communities is used to sustain the community and its culture, and to maintain the biological resources necessary for the continued survival of the community (Hansen, 2002). Leopold, Herrenschmidtb, & Thamanc (2008) define marine TEK as part of the larger body of indigenous knowledge including a complex knowledge of the sea (i.e. reefs, lagoons, and target species), the livelihood activities (fishing techniques and practices, management rules), and the related beliefs and legends of social and cultural values. Therefore, the information and knowledge of the local fishermen as direct users has been helping many conservation efforts with their knowledge of the presence, abundance, and threats of marine lives, which have become the starting points for most scientific research to understand more and tackle the problems efficiently (Rajamani, Rodriquez-Vaga, & Oii, 2014).

Martin et al. (2007) believed that an ecosystem and community-based approach will assist local communities to conserve the marine environment and resources. Thus, it is crucial to engage the local fishermen and communities in protecting the marine environment, starting from when the MPA designation process commences to the joint management of the MPA. This stand is supported by Setiati, Peniati, & Partaya (2018) because the local communities are the ones being directly impacted by the volatility of supply in the fishery and other marine resources. Taking into consideration of their livelihood dependency on the marine environment and resources as direct users has been helping many conservation efforts. Their knowledge of the presence, abundance, and threats of marine life has become the baseline information for most scientific research to overcome threats to the marine environment.

Collaborative management with the community's participation or community-based management would eventually help develop interests and commitment to work together with the relevant government agencies to manage as well as conserve the marine environment and resources sustainably. This approach may be able to help safeguard the effectiveness of the MPAs as well as other marine coastal areas that are not afforded similar protection. Engaging the local communities as direct users of the marine resources could create a sense of belonging and responsibilities, which would assist not only in the effective management of the MPAs but from the early stage of designating such MPAs as well.

Engaging the local communities as direct users of the marine resources could create a sense of belonging and responsibilities, which would assist not only in the effective management of the MPAs but from the early stage of designating such MPAs as well.

B. Adoption and Implementation of Marine Spatial Planning (MSP)

MSP is specifically spelled out by the National Coastal Zone Physical Plan-2 as one of the Actions to be taken under Thrusts 2 to protect the ecological assets and ecosystem services played by coastal and marine biodiversity. According to Ehler & Douvere (2009), MSP is a practical management tool to establish a rational organization of marine space uses, and create a balance between the demand for development with the need to protect the marine ecosystem. MSP is said to have originated in 1972, during the establishment of the Great Barrier Reef Marine Park in Australia (Ogden, 2010). It has further been adopted in many countries, such as Germany, Belgium, Canada, and China. In Europe, the Maritime Spatial Planning Directive compels Member States to formalize their marine spatial plans by 2021 and reinforce the integrated and cross-sectoral aspect of MSP (Pınarbaşı et al., 2017).

Agenda 21 of the United Nations Conference on the Environment and Development (UNCED) in 1992 and Article 192 of the UNCLOS (Chapter 17) encourage the coastal state to practice sustainable management to preserve the marine ecosystem. While the CBD also states the need for engagement from different stakeholders to achieve sustainable development for the conservation of the environment. Numerous anthropogenic activities have compromised the marine environment and its natural ecosystems. Therefore, it is crucial to protect the ecosystem to continue to be well-functioning. According to Aziz et al. (2019), the vital part of MSP is to create protection for the long-term sustainability of marine resource utilization by using an ecosystem-based approach to manage selected coastal and ocean areas.

As an ecosystem-based management tool, the application of MSP has been said as important to promote sustainable planning (Bartel and Janssen, 2016), accomplishing sustainable management of marine resources (Domínguez-tejo et al., 2016) as well as supporting the development of offshore renewable energy, especially in Europe (Qiu & Jones, 2013; Christie et al., 2014; Kyriazi et al., 2016). The importance of adoption of MSP has been iterated through the United Nations Decade of Ocean Science 2021-2020 where MSP is set as one of the Key Ocean Management Domains and Figure 13 below illustrates the IOC-UNESCO's 10-Step Approach for MSP.

MSP is a practical way to manage marine space and human activities, including fisheries, shipping, tourism, and marine mining (Santos et al., 2019; Aziz et al., 2020). On the other end, according to Ehler & Douvere (2009), MSP is also practical to establish a rational organization for uses of marine space and balance the demand for development to protect the marine ecosystem. It is a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that are usually achieved through a political process.

MSP is adopted by identifying specific management measures for areas based on the location MSP is adopted by identifying specific management measures for areas based on the location and prioritized activities in the ocean space. A set of regulations and zoning plan is then developed to regulate the area within the boundaries appointed. Zoning does not necessarily apply to the whole planning area. A specific zone can be identified within the areas, for example, an ecological zone to conserve nursery and feeding ground, cultural zones to protect archaeological and historic spots, and economic zones where exploration activities and fishing are allowed (Ehler & Douvere, 2009). When adopted effectively, MSP can benefit economically, ecologically, and socially without suppressing development activities, as indicated by IOC-UNESCO, including promotion of sustainable use of resources and space, balancing between social development and nature conservation, reduction of anthropogenic impacts on marine ecosystems, identification of impacts caused by decision in the allocation of ocean space use and preservation of cultural heritage.

Figure 13: IOC-UNESCO's 10-Step Approach for MSP
(Sourced from http://msp.ioc-unesco.org/)

MSP is a public policy process for a society to better determine how the ocean and the coasts are sustainably used and protected, for now, and for future generations. MSP employs a practical way to create a more rational use of marine space and the interactions among its uses by balancing the demands for development with the need to protect the environment as well as to deliver social and economic outcomes in an open and planned way. Area-based and participatory management approach of MSP would allow strong engagement and commitment (most particularly from the local authority and the local communities) in addressing pollution and other stressors in a specific area.

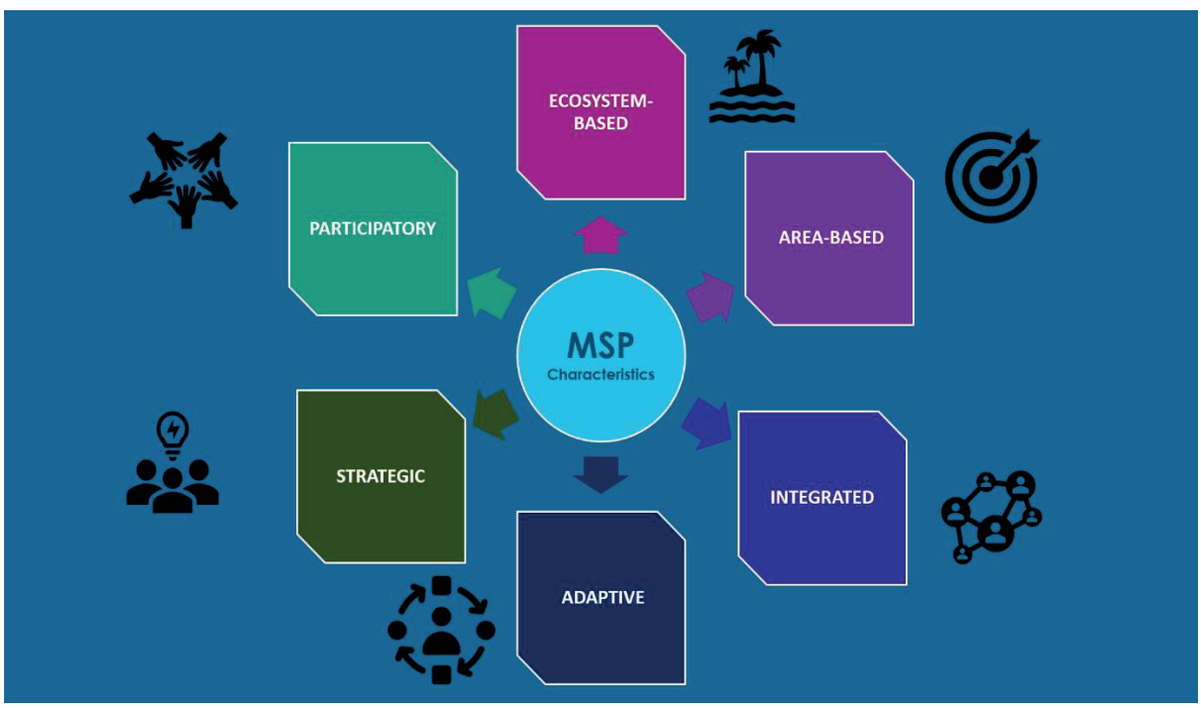


Figure 14: The Characteristics of MSP

As an ecosystem-based management tool (the characteristics of MSP are as shown in Figure 14 above), MSP is potentially the best solution to sustainably manage a marine and coastal space, where allocation of human activities in specific marine areas can be made according to objectives (e.g., either for the development or preservation of an area) or specific uses. An all-encompassing planning and management framework is imperative to ensure that impacts from coastal and marine activities would accrue socio-economic and environmental benefits, without which these activities can adversely cause undesirable environmental and social impacts.

C. Strengthening MPAs and Other Islands Management in line with Ecotourism Guidelines

Since most of our marine parks attracts tourists due to its natural surroundings, it is important Since most of our marine parks attract tourists due to their natural surroundings, it is important to strengthen the management of these MPAs by abiding by the laws, regulations, and guidelines available. As noted by Kaur (2006), successful ecotourism practices should entail the maximization of the environmental and economic benefits, while minimizing any ecological damage to the surrounding. Ecotourism is defined by the National Ecotourism Plan 1996 (NEP) as

> ***Travel and visitation that is environmentally responsible to relatively undisturbed natural areas to enjoy and appreciate nature (including any accompanying cultural features; both past and present), promotes conservation, has low visitor impact and provides for beneficially active socio-economic involvement of local populations***

The NEP 1996 was introduced to promote ecotourism and also serves as the implementation part of the National Tourism Policy 1992. The National Ecotourism Plan 2015-2025, which is a revised NEP that is more strategic, cluster-focused, and time-bound, proposed a new definition of ecotourism, which reads as:

> ***Tourism experiences evolved through collaboration between Government, the private sector and local communities***

Consequentially, given the recent developments including the UN Global Agenda on Sustainable Development 2030, which sets the Sustainable Development Goals, ecotourism under the NEP 2016-2025 must include the following elements:

Taking that into consideration, the following Guidelines that were first introduced by the NEP 1996 on the management of marine parks and islands in Malaysia, which generally fall into the TWO main aspects as discussed below, should be adopted to strengthen MPA management, while at the same time taking into consideration of the recent developments.

01 Operation of Facilities in Marine Parks

Despite the influx of tourists to marine parks, Kaur (2006) did not recommend further tourism development and other related activities in some of the major marine park islands. Table 6 below describes examples of guidelines for the operation of facilities in marine parks, as provided in the NEP Guidelines.

Facilities	Guidelines
Facilities Development	• Proper placement of facilities to avoid loading the marine environment with high levels of silt during the construction phase. • Facilities must be limited to lowland areas, on very small islands and at water catchment areas. • Buffer zones, where building construction should not be allowed in this area, or to be established at beach areas, with an ideal minimum setback of 100 meers from the high-water mark. • Vegetation at the beach strand should be maintained and replanted to prevent erosion. • Only low-density and low-rise tourist accommodation (such as single storey chalets and frame huts) should be developed, whilst providing adequate services and amenities for tourists.

Facilities	Guidelines
Facilities Management	• Sustainable and environmental-friendly use of resources must be conducted. For instance, indigenous species of plants should be used for landscaping. • Locally-available materials, recycled and non-toxic substances should be used as building materials to minimize impact on the environment. • Energy saving devices and energy efficient equipment ought to be used on the islands. • The use of any kind of herbicides, pesticides and fertilizers should be avoided. • Phosphate-free, non-chlorine bleaches and biodegradable detergents are suggested to be used as cleaning products to avoid eutrophication (the biological response to the excess input of nutrients into a water body) of the island water column
Freshwater Management	• Freshwater should be used sustainably to prevent the need for costly importing of freshwater from the mainland. • Extraction of groundwater through tube wells should be monitored. • Low-flow toilets or other water-saving technologies are suggested. • Direct discharge of freshwater into the reef areas should not be allowed to prevent any changes in salinity, which could affect the corals adversely

Facilities	Guidelines
Sewage Treatment and Disposal	• A central sewerage system must be used and no direct discharge of sewage into the sea should be allowed. • Septic tanks should be placed at proper distances from water sources, monitored for efficiency and the sludge pumped out at intervals to avoid contamination of the water column. A • Grey water (effluent from washing) and black water (effluent from toilets) must be streamed separately. It should be recycled after filtered and disinfected for non-consumptive purposes (through flush toilets and urinals). • Oils and fats from crockery must also be removed with absorbent towels prior to washing.
Freshwater Management	• Waste should be minimized at the source through reducing, reusing, recycling, and repairing whenever possible. • Litter around islands should be collected on a regular basis. • Efficient numbers of litter bins should be provided. Staff should patrol the beaches, especially during peak times.

Table 6:
NEP Guidelines on the operation of facilities in marine parks
(Adopted from Kaur, 2006 and National Ecoutourism Plan 1996)

02 Operation of Recreational Activities in Marine Parks

Tourist influx in marine parks irrefutably affects the surrounding marine environment, most particularly by irresponsible tourists. Table 8 below describes examples of guidelines for the operation of recreational activities in marine parks, as provided in the NEP Guidelines.

FACILITIES	GUIDELINES
SCUBA diving & snorkelling	• Size of divers or snorkelers' groups should be limited to avoid over-using a specific site. • All personnel must be qualified. • Proficiency of new divers should be verified before allowing them to dive at fragile or difficult dive.
BOATING	• Boats should be navigated properly to avoid contact with corals, especially during low tide. • Boat engines must also be maintained and inspected regularly to avoid oil leaks and spills. • Boat hulls must be kept clean to minimize drag
ANCHORING	• Mooring buoys should be used where available and anchors must not be dropped onto the coral reef areas since anchors and chains from boats can destroy fragile coral environments
FISH (AND TURTLE) FEEDING	• Fish (and turtle) feeding may disturb normal feeding patterns and cause stress as the food introduced may not be part of the normal diet, which may alter fish and turtle behaviour and have an impact on the ecological balance of species on the reef. • Fish (and turtle) feeding should be well supervised and conducted by the staff. • Fish (and turtle) should not be fed directly by hand, instead it should be broadcasted into the water. • People should not be in the water when feeding fish
TURTLE WATCHING	• Since all the four species in Malaysia are threatened with extinction, visitors are not allowed to disturb turtles nesting and should be aware about all the restrictions on access to turtle nesting

D. Mainstreaming Food Security in Marine Biodiversity Conservation

Seafood security is vital not only for the market but those in the fishing industry. Taking into consideration that fishing is a major source of income for coastal and island communities, the conservation of marine natural resources is crucial to safeguard its sustainable supply. Intensive measures should be taken by all the stakeholders – from the authorities to the local fishermen. International cooperation is crucial to resolve IUU fishing effectively. Through regional fisheries management and cooperation, IUU fishing and its related problems can be addressed. Such cooperation would also assist in the implementation of existing initiatives to promote the well-being of ecosystems, sustainable tourism, marine-resources conservation, and food security (Riskas et. al., 2018).

It has also been suggested by Tran Yen Hoang (2017) that the determination of the areas of cooperation should follow the biological features as well as the straddling patterns of the fish stocks. While sustainable fishing methods and practices must be promoted, consideration should also be paid to the Strategies, Actions, and Targets of the Second National Coastal Zone Physical Plan-2 (NCZPP-2) to preserve the Malaysian coastal and marine ecological assets and biodiversity. Figure 15 below shows how the Targets under Thrust 2 – Ecological Assets and Ecosystem Services may collectively promote food security through marine biodiversity protection and conservation. This must also be read together with the Environmentally Sensitive Coastal Areas Framework under the NCZPP-2.

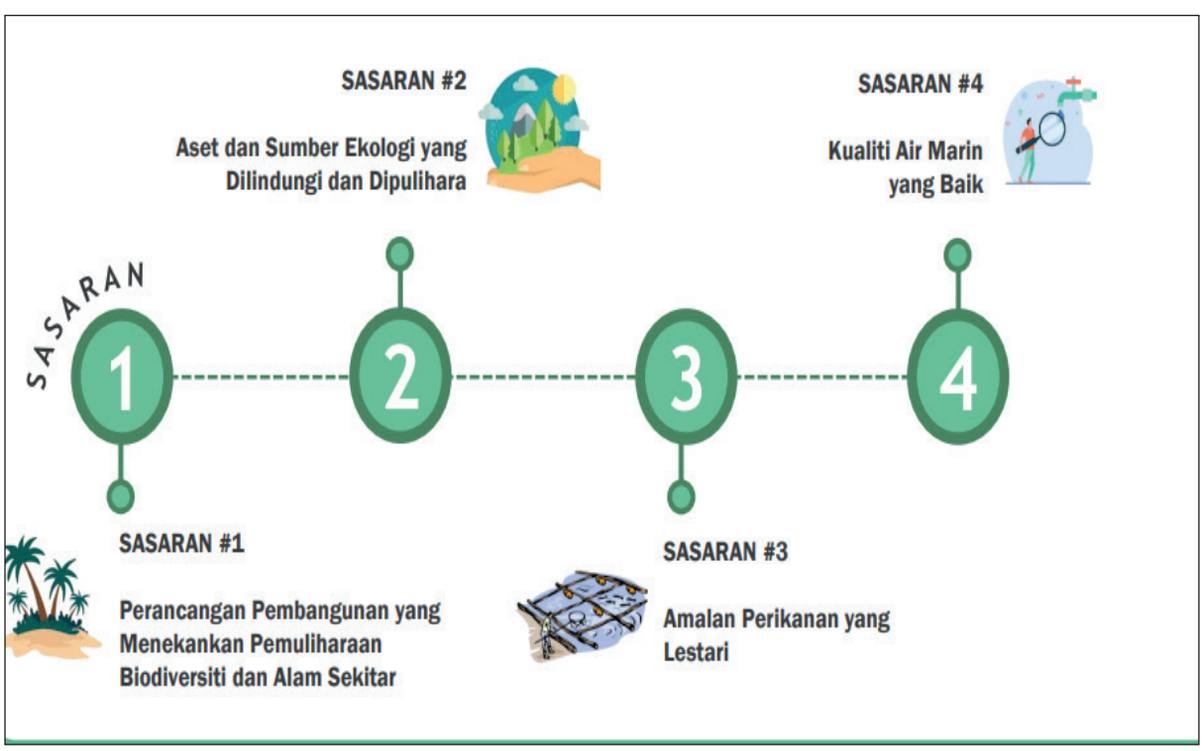


Figure 15: The targets under Thrust 2 of the NCZPP-2 to protect sustainable ecological assets and ecosystem services

The collective efforts set through the Strategies, Actions, and Targets under the Plan may be able to address the challenges to sustainable fisheries as shown in Figure 16. Whenever there is a face-off between ecotourism promotion and seafood security, coastal and marine areas that are deemed to be sensitive such as critical habitats must be preserved including adhering to Ecotourism Guidelines. Biodiversity conservation should be not focused only to safeguard the aesthetic value of the marine ecosystem but also on its ability to provide a safety net in food production.

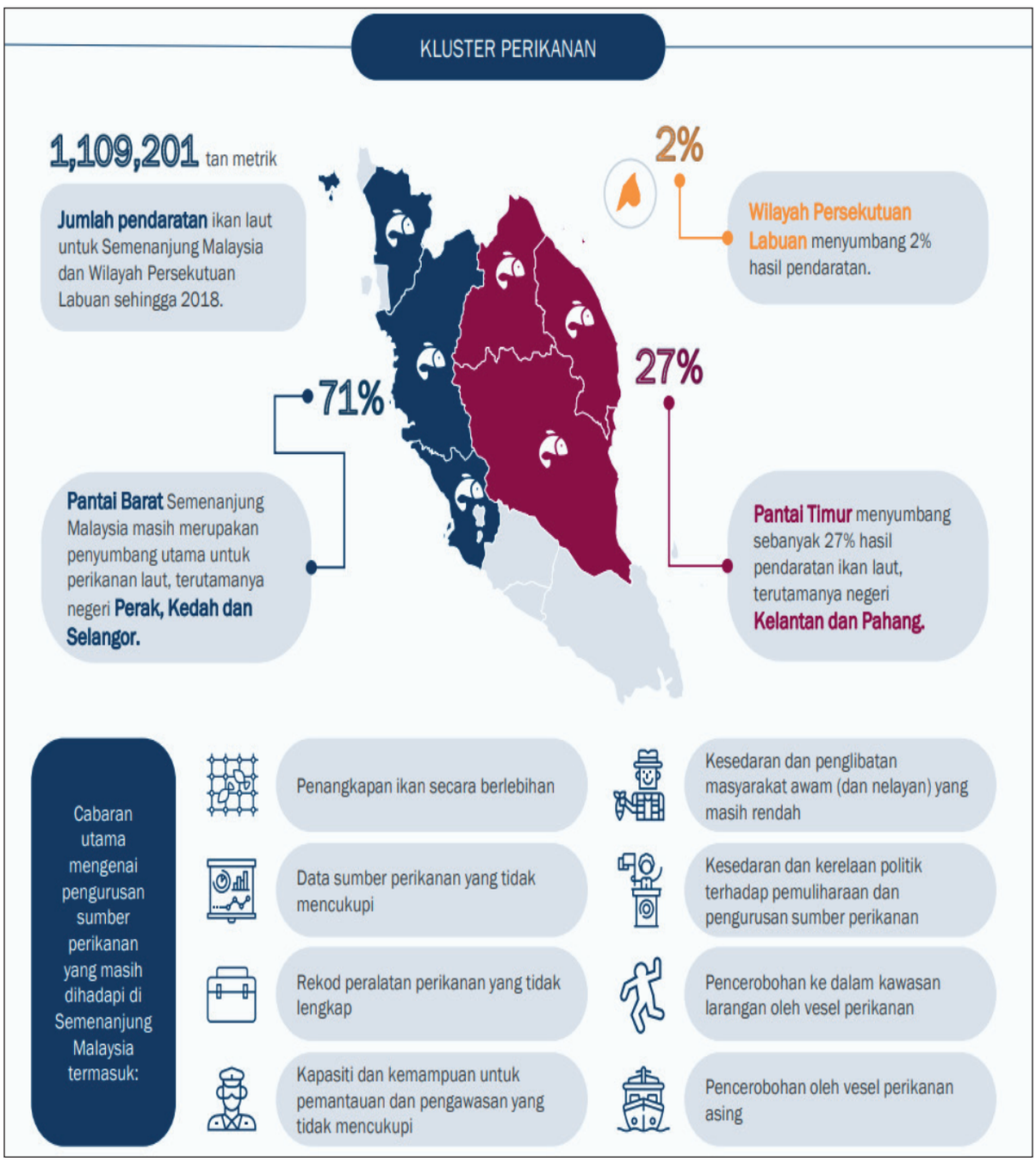


Figure 16: Challenges to Sustainable fisheries under the NCZFPP-2

CONCLUSION

Designating an MPA is a political process made by the government to effectively maintain the natural processes and support systems in the whole marine ecosystem. Marine parks in Malaysia are areas of the sea that has been zoned as sanctuaries for the coral reef community, with the aim to protect the health of the marine environment that includes all marine lives and their habitats.

After identifying the gaps in the current Malaysian governance framework in marine environmental management, and comparatively studying the best practices in other parts of the world, FOUR recommendations were made. These recommendations, which were targetted to improve the management of our marine environment and biodiversity as well as to address the identified gaps, are as follows:

I. MPA: Shifting to co-management in MPA designation and management to encourage more local participation from the community as well as civil societies, private individuals and businesses
II. MSP: Adoption and implementation of Marine Spatial Planning, which has been proven worldwide as a successful ecosystem-based management tool in managing and planning of marine space and uses in a sustainable manner.
III. MPA: Strengthening management of MPAs and other islands management to avoid damage to the marine ecosystem in line with the Ecotourism Guidelines; and
IV. FOOD SECURITY: Mainstreaming food security in marine biodiversity conservation promotes the importance of safeguarding the aesthetic value of the marine ecosystem as well as its ability to provide a safety net in food production

REFERENCES

A. David, Illegal foreign fishermen affecting livelihood of KT fishermen. NEW STRAIT TIMES, Dec. 14, 2017, available at https://www.nst.com.my/news/nation/2017/12/314349/ illegal-foreign-fishermen-affecting-livelihood-kt-fishermen (last visited on Feb. 25, 2019).

A. Tahindro, Sustainable Fisheries: The Legal Regime of the 1995 United Nations Fish Stocks Agreement and Its Contribution to Subsequent Developments Promoting Sustainable Fisheries. In Legal Order in the World's Oceans, pp. 325-326 (2017).

A. Yuliantiningsih, H. Hartiwiningsih, A. Suherman & E. Latifah. From Illegal, Unreported and Unregulated Fishing to Transnational Organised Crime in Fishery from an Indonesian Perspective, 11 JEAIL pg 335-336 (2018).

A.H Saharuddin, National Ocean Policy—New Opportunities for Malaysian Ocean Development 25:6 MARINE POLICY pg. 427-428 (2001).

Abesamis, R. A., Saenz-Agudelo, P., Berumen, M. L., Bode, M., Jadloc, C. R. L., Solera, L. A., Villanoy, C. L., Bernardo, L. P. C., Alcala, A. C. & Russ, G. R. (2017). Reef-fish larval dispersal patterns validate no-take marine reserve network connectivity that links human communities. Coral Reefs, 36(3), 791–801.

Affendi, Y. A., Ooi, J. L. S., Phang, S. M., Hussin, A., Rosman, F. R., & Fauzi, R. (2005). Dugongs in peril: the conservation and protection of dugongs in Johor, Malaysia. A scientific report for the United Nations Development Program, Kuala Lumpur, Malaysia, Universiti Malaya.

Aguirre, A. A., and Tabor, G. M. (2004). Introduction: marine vertebrates as sentinels of marine ecosystem health. EcoHealth, 1(3), 236-238.

Albrecht, J 2007, 'Guidelines for SEA in Marine Spatial Planning for the German Exclusive Economic Zone (EEZ) — with Special Consideration of Tiering Procedure for SEA and EIA', In Standards and Tresholds for Impact Assessment, Springer Publishing, pp. 157-170.

Alves, R. R. N. (2012). Relationships between fauna and people and the role of ethnozoology in animal conservation. Ethnobiology and Conservation, 1(2), 1-69.

ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain available at https://www.asean.org/wp-content/uploads/images/2015/November/AMAF/App%209%20-%20ASEAN%20Guidelines%20IUU%20SSOM36th%20AMAF%20final.pdf (last visited Oct. 20, 2019).

Aziz, N, Muhammad, Z, Farahdilah, G, Saputra, J & Talaat, WIAW 2020, A Study of the Socioeconomic Development Trends in Central Terengganu, Malaysia: Potentials of Marine Spatial Planning, Journal of Advance Research in Dynamical & Control Systems, vol 12, no. 6, pp. 776-785.

Aziz, N, Muhammad, Z, Farahdilah, G, Talaat, WIAW, & Saputra, J 2019, Marine Spatial Planning: The way forward for sustainable development of Central Terengganu, Malaysia, Journal of Southwest Jiaotong University, vol 54, no. 4, pp. 1–11.

Badalamenti, Fabio & Espla, Alfonso A. & Voultsiadou, Eleni & Sánchez Lizaso, José & D'Anna, Giovanni & Pipitone, Carlo & Mas, Julio & FERNANDEZ, J.A. & Whitmarsh, D. & Riggio, Silvano. (2000). Cultural and Socio-Economic Impacts of Mediterranean Marine Protected Areas. Environmental Conservation. 27. 110-125. 10.1017/S0376892900000163.

Bartel, S, & Janssen, G 2016, 'Underground spatial planning – Perspectives and current research in Germany', Tunnelling and underground space technology, vol 55, pp. 112–117.

Berkes, F. (1993). Traditional Ecological Knowledge in Perspective. Traditional Ecological Knowledge: Concepts and Case. (Ed: Inglis, J.T.). Retrieved from doi: 10.1641/0006-3568(2002)052[0432:WTEKIB]2.0.CO;2.Boesch, D. F. (1999). The role of science in ocean governance. Ecological Economics, 31(2), 189-198.

Bossart, G. D. (2006). Marine mammals as sentinel species for oceans and human health. Oceanography. 19(2), 134-137.

Bossart, G. D. (2007). Emerging diseases in marine mammals: from dolphins to manatees. Microbe-American Society for Microbiology. 2(11), 544.

C. Bellmann, A. Tipping, & U. R. Sumaila, Global trade in fish and fishery products: An overview, 69 MARINE POLICY, pg.181-182 (2016).

Chaigneau, T., & Daw, T. M. (2015). Individual and village-level effects on community support for Marine Protected Areas (MPAs) in the Philippines. Marine Policy, 51, 499-506.

Chilvers, B. L., Lawler, I. R., Macknight, F., Marsh, H., Noad, M., & Paterson, R. (2005). Moreton Bay, Queensland, Australia: an example of the co-existence of significant marine mammal populations and large-scale coastal development. Biological Conservation, 122(4), 559-571.

Cho, D. O. (2006). Evaluation of the ocean governance system in Korea. Marine Policy, 30(5), 570-579.

Christie, N, Smyth, K, Barnes, R, & Elliott, M 2014, 'Co-location of activities and designations : A means of solving or creating problems in marine spatial planning ?', Marine Policy, vol 43, pp. 254–261.

Christie, P., & White, A. T. (1997). Trends in Development of Coastal Area Management in Tropical Countries: From Central to Community Orientation. Coastal Management, 25(2), 155-181.

Christie, P., & White, A. T. (2006). Best Practices in Governance and Enforcement of Marine Protected Areas: An Overview. Paper presented at the FAO Expert Workshop on Marine Protected Areas and Fisheries Management: Review of Issues and Considerations, Food and Agriculture Organization (FAO), Rome, Italy, 12-14 June.

Cinner, J., (2005). Socioeconomic factors influencing customary marine tenure in the Indo-Pacific. Ecological Society, 10(1), 1-14.

Clapham, P. J., Young, S. B., & Brownell, R. L. (1999). Baleen whales: conservation issues and the status of the most endangered populations. Mammal review, 29(1), 37-62.

CTI-CFF, RPOA (CTI-CFF Regional Plan of Action) available at http://coraltriangleinitiative.org/rpoa (last visited Oct. 20, 2019).

D. Agnew, J. Pearce, G. Pramod, T. Peatman, R. Watson, J. R. Beddington & T. J. Pitcher, Estimating the Worldwide Extent of Illegal Fishing, 4:2 PloS One pg. 1-3 (2009).

D. Miller, N. Slicer & E. Sabourenkov, An Action Framework to Address Illegal, Unreported and Unregulated (IUU) Fishing, 6:2 AUST J MARIT OCEAN AFFAIRS pg. 78-82 (2014).

Dirhamsyah, IUU Fishing in Indonesia's Live Reef Fisheries, 4:2 AUST J MARIT OCEAN AFFAIRS pg. 44 (2012).

Domínguez-tejo, E, Metternicht, G, Johnston, E, & Hedge, L 2016, 'Marine Spatial Planning advancing the Ecosystem-Based Approach to coastal zone management : A review', Marine Policy, vol 72, pp. 115–130.

Ehler, C & Douvere, F 2009, 'Marine Spatial Planning: a step-by-step approach toward ecosystem-based management. Intergovernmental Oceanographic Commission and Man and the Biosphere Programme. IOC Manual and Guides No. 53', ICAM Dossier, no. 6, Paris: UNESCO.

Ehler, C, Zaucha, J, & Gee, K 2018, 'Maritime/Marine Spatial Planning at the Interface of Research and Practice', in J. Zaucha & K. Gee (Eds.), Marine Spatial Planning, Gewerbestrasse 11: Springer Nature Switzerland AG, 1–22 pp.

FAO, Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (1995) available at http://www.fao.org/3/X3130m/X3130E00.HTM (last visited on October 20, 2019).

FAO, Illegal, unreported and unregulated fishing, FAO (2016) available at http://www.fao.org/3/a-i6069e.pdf (last visited on Oct. 20, 2019).

FAO, International Plan of Action to prevent, deter and eliminate illegal, unreported and unregulated fishing. Rome, FAO (2001) available at http://www.fao.org/3/a-y1224e.pdf (last visited on Oct. 20, 2019).

Foley, M., Armsby, M.H., Prahler, E.E., Caldwell, M.R., Erickson A.L., Kittinger J.N., Crowder, L.B. & Levin, P.S., 'Improving Ocean Management Through the Use of Ecological Principles and Integrated Ecosystem Assessments', BioScience, vol. 63, no. 8, 2013, pp. 619–31

Friedlander, A. M., Wagner, D., Gaymer, C. F., Wilhelm, T. A., Lewis, N. A., Brooke, S., ... & Varmer, O. (2016). Co-operation between large-scale MPAs: successful experiences from the Pacific Ocean. Aquatic Conservation: Marine and Freshwater Ecosystems, 26, 126-141.

G. Petrossian, N. Marteache & J. Viollaz, Where Do "Undocumented" Fish Land? An Empirical Assessment of Port Characteristics for IUU Fishing, 21:3 EUR J CRIM POLICY RES. pg. 347 (2015).

Gaymer, C. F., Stadel, A. V., Ban, N. C., Cárcamo, P. F., Ierna Jr, J., & Lieberknecht, L. M. (2014). Merging top-down and bottom-up approaches in marine protected areas planning: experiences from around the globe. Aquatic Conservation: Marine and Freshwater Ecosystems, 24(S2), 128-144.

George, M, Sabaruddin, JSH, & Chong, VC 2016, 'Marine Spatial Planning: What Does It Have to Offer Malaysia?', International Journal of Marine and Coastal Law, vol 31, no. 2, pp. 242–278.

Grech, A., & Marsh, H. (2008).Rapid assessment of risks to a mobile marine mammal in an ecosystem-scale marine protected area. Conservation Biology, 22(3), 711-720.

Guidetti, P., Baiata, P., Ballesteros, E., Di Franco, A., Hereu, B., Macpherson, E., Micheli, F., Pais, A., Panzalis, P., Rosenberg, A.A., Zabala, M., Sala, E., 2014. Large-Scale Assessment of Mediterranean Marine Protected Areas Effects on Fish Assemblages. PLOS ONE 9, e91841.. doi:10.1371/journal.pone.0091841

Halpern, B. S., McLeod, K. L., Rosenberg, A. A. and Crowder, L. B. 2008, 'Managing for cumulative impacts in ecosystem-based management through ocean zoning', Ocean and Coastal Management, 51, 203–211.

Hamid, A. G. (2007). Malaysia's commitments under international conventions and the need for a harmonized legal regime regulating marine pollution. Malayan Law Journal (Lexis-Nexis), 6, 124-48.

Hansen, S. A. (2002). Intellectual Property and Traditional Ecological Knowledge: Institutionally Globalized Biopiracy? Professional Ethics Report, XV(3), 1-4.

Hill, R., Baird, A., & Buchanan, D. (1999). Aborigines and fire in the Wet Tropics of Queensland, Australia: Ecosystem management across cultures. Society & Natural Resources, 12(3), 205-223.

Hind, E. J. (2015). A review of the past, the present, and the future of fishers' knowledge research: a challenge to established fisheries science. ICES Journal of Marine Science, 72: 341–358.

Hiwasaki, L., Luna, E., Syamsidik, & Shaw, R. (2014). Process for Integrating Local and Indigenous Knowledge with Science for Hydro-Meteorological Disaster Risk Reduction and Climate Change Adaptation in Coastal and Small Island Communities. International Journal of Disaster Risk Reduction, 10(Pt. A), 15-27.

Hooker, S. K., & Gerber, L. R. (2004). Marine reserves as a tool for ecosystem-based management: the potential importance of megafauna. BioScience, 54(1), 27-39.

Hu, N. Integrated Oceans Policymaking: An Ongoing Process or a Forgotten Concept?, Coastal Management, vol. 40, no. 2, 2012, pp. 107–118.

I. Chapsos & S. Hamilton. Illegal Fishing and Fisheries Crime as a Transnational Organized Crime in Indonesia, TRENDS IN ORGANIZED CRIME pg. 1-19 (2018).

IOC-UNESCO nd, 'MSP Facts', viewed 30 August 2020, <http://msp.ioc-unesco.org/about/msp-facts/>.

Islam, G. M. N., Tai, S. Y., Kusairi, M. N., Ahmad, S., Aswani, F. M. N., Senan, M. K. A. M., & Ahmad, A. (2017). Community perspectives of governance for effective management of marine protected areas in Malaysia. Ocean & Coastal Management, 135, 34-42

J. Azmath & D. Grewal, A Perspective on Safety and Governance Issues of Fishing Vessels, 31:4 OCEAN YEARBOOK pg. 483-485 (2017).

Jaaman, S. A., & Bali J., (2010). Current Marine Mammal and Whale Shark Stranding Response Strategy In East Malaysia. MIMA Bulletin. 17 (4): 14-18

Jefferson T, Palomares MLD and Lundquist CJ (2022) Safeguarding Seafood Security, Marine Biodiversity and Threatened Species: Can We Have Our Fish and Eat It too? Front. Mar. Sci. 9:826587. doi: 10.3389/fmars.2022.826587

Jones, P. J. S., Qiu, W. & Santo, E. M. D. (2013). Governing marine protected areas: Social ecological resilience through institutional diversity. Marine Policy, 41, 5-13.

Kaur, C.R. NATIONAL ECOTOURISM PLAN: Assessing Implementation of the Guidelines for Marine Parks. MIMA Publication Online. Retrived on 22 September 2022 from https://www.researchgate.net/publication/317086409_NATIONAL_ECOTOURISM_PLAN_Assessing_Implementation_of_the_Guidelines_for_Marine_Parks.

K. Riskas, R. Tobin, M. Fuentes & M. Hamann, Evaluating the Threat of IUU Fishing to Sea Turtles in the Indian Ocean and Southeast Asia Using Expert Elicitation, 217 BIOL CONSERV. pg. 233 (2018).

Kyriazi, Z, Maes, F, & Degraer, S 2016, 'Coexistence dilemmas in European marine spatial planning practices. The case of marine renewables and marine protected areas', Energy Policy, vol 97, pp. 391–399.

Leopold, M., Herrenschmidtb, J. B., & Thamanc, R. (2008). The Relevance of Traditional Ecological Knowledge for Modern Management of Coral Reef Fisheries in Melanesia. In Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida, 7-11 July.

M. Hall, E. Gilman, H. Minami, T. Mituhasi, & E. Carruthers, Mitigating bycatch in tuna fisheries, 27:4, REV FISH BIOL FISH pg. 882 (2017).

M. Johns, Enhancing Responsible Fishing Practices in South East Asia to Combat Illegal, Unreported and Unregulated (IUU) Fishing, 5:3 AUST J MARIT OCEAN AFFAIRS pg. 112-113 (2013).

M. Noonan & E. Williams, Combating Maritime Transnational Crime: An Australian Perspective, 12:1 J THE INDIAN OCEAN REGION pg. 47-48 (2016).

Malaxi: Terengganu map. http://www.malaxi.com/terengganu/terengganu_map.html. Retrieved on 30/12/18.

Martin, K. S., McCay, B. J., Murray, G. D., Johnson, T. R., & Oles, B. (2007). Communities, knowledge and fisheries of the future. International Journal of Global Environmental Issues, 7(2-3), 221-239.

McClanahan, T. R., Marnane, M. J., Cinner, J. E., & Kiene, W. E. (2006). A comparison of marine protected areas and alternative approaches to coral-reef management. Current Biology, 16(14), 1408-1413.

Mizuta, D. D., & Vlachopoulou, E. I. (2017). Satoumi concept illustrated by sustainable bottom-up initiatives of Japanese Fisheries Cooperative Associations. Marine Policy, 78, 143-149.

Mokhtar, M. B., & Aziz, S. A. B. A. G. (2003).Integrated coastal zone management using the ecosystems approach, some perspectives in Malaysia. Ocean & Coastal Management, 46(5), 407-419.

Mustafa, M. (2011). The Environmental Quality Act 1974: A significant legal instrument for implementing environmental policy directives of Malaysia. IIUM Law Journal, 19(1).

N.A, Majid, Malaysia loses RM6b annually due to illegal fishing in South China Sea, NEW STRAIT TIMES, June 19, 2017, available at

https://www.nst.com.my/news/nation/2017/06/250427/malaysia-loses-rm6b-annually-due-illegal-fishing-south-china-sea (last visited on Feb. 28, 2019).

NIC, Global Implications of Illegal, Unreported, and Unregulated (IUU) Fishing (Sept. 19, 2016) available at https://fas.org/irp/nic/fishing.pdf (last visited on Oct. 23, 2019).

Ogden, JC 2010, 'Marine spatial planning: A first step to ecosystem-based management in the Wider Caribbean', vol 58, no. 3, pp. 71–79.

Omar, A.H., Abdullah, N.M., Rambat, S., Yahaya, N.A.Z., Rahibulsadri, R., Abdullah, A., Yahya, R., Jamil, H., Hua, T.C. and Lim, C.K. (2017). Sustainable Marine Space Managements: Malaysian Perspective. In Cadastre: Geo-Information Innovations in Land Administration (pp. 309-332). Springer International Publishing.

Pınarbaşı, K, Galparsoro, I, Borja, Á, Stelzenmüller, V, Ehler, CN, & Gimpel, A 2017, 'Decision support tools in marine spatial planning : Present applications , gaps and future perspectives', Marine Policy, vol 83, pp. 83–91.

Pollnac, R., & Pomeroy, R. S. (2005). Factors Affecting the Long-term Sustainability of Integrated Coastal Management Projects in the Philippines and Indonesia. Ocean and Coastal Management, 48(3-6), 33-51.

Pomeroy, R., Lani, M. W., John, E. P., & Gonzalo, A. C. (2005). How is your MPA doing? A methodology for evaluating the management effectiveness of marine protected areas. Ocean Coastal Management, 48(7-8), 485-502.

Potts, T., Burdon, D., Jackson, E., Atkins, J., Saunders J., Hastings E. & Langmead O. Do marine protected areas deliver flows of ecosystem services to support human welfare? Marine Policy, 44 (2014), pp. 139–148.

Qiu, W, & Jones, PJS 2013, 'The emerging policy landscape for marine spatial planning in Europe', Marine Policy, vol 39, pp. 182–190.

R. Pedrason, Y. Kurniawan & Purwasandi, Handling of Illegal, Unreported and Unregulated (IUU) Fishing, 2:1 J PERTAHANAN pg. 72 (2016).

R. Pomeroy, J. Parks, K. Courtney & N. Mattich, Improving Marine Fisheries Management in Southeast Asia: Results of A Regional Fisheries Stakeholder Analysis, 65 MARINE POLICY pg. 25 (2016).

Rabinowitz, P.M., Gordon, Z., Holmes, R., Taylor, B., Wilcox, M., Chudnov, D., Nadkarni, P. and Dein, F.J. (2005). Animals as sentinels of human environmental health hazards: an evidence-based analysis. EcoHealth, 2(1), 26-37.

Rahman, M.A.A., Gjazali, F., Rusli, M.H.M, Aziz, N. & Talaat, W.I.A.W. Marine Protected Areas in Peninsular Malaysia: Shifting from Political Process to Co-Management. ournal of Politics and Law; Vol. 12, No. 4; 2019.

Rajamani, L., Rodriquez-Vaga, L. H., & Oii, S. L. (2014). Local Community Knowledge of Penang's Marine Mammals. In E. Norizan, L. Rajamani & M. Y. Zuraidah (Eds.), Reengineering Local Knowledge: Life, Science and Technology (pp. 73-89). Pulau Pinang: Penerbit USM.

Ross, P. S. (2002). The role of immunotoxic environmental contaminants in facilitating the emergence of infectious diseases in marine mammals. Human and Ecological Risk Assessment, 8(2), 277-292.

Ruiz-Frau, A., Edwards-Jones, G., & Kaiser, M. J. (2011). Mapping stakeholder values for coastal zone management. Marine Ecology Progress Series, 434, 239-249.

S. A. R. Nova, Illegal, Unreported and Unregulated Fishing: The Impacts and Policy for Its Completion in Coastal West of Sumatera, 14 INDONESIAN J INT'L LAW pg. 237 (2016).

Saharuddin, A. H. (2001). National ocean policy—new opportunities for Malaysian ocean development. Marine Policy, 25(6), 427-436.

Sala, E., & Giakoumi, S. (2018). No-take marine reserves are the most effective protected areas in the ocean. ICES Journal of Marine Science, 75(3), 1166-1168. Retrieved from https://doi.org/10.1093/icesjms/fsx059.

Santos, CF, Ehler, C. N, Agardy, T, Andrade, F, & Orbach, MK 2019, 'Marine Spatial Planning', In World Seas: An Environmental Evaluation.Volume III: Ecological Issues and Environmental Impacts (2nd ed.). Elsevier Ltd.

Schrandt, M, Powers, S, Scott Rikard, F, Thongda, W, & Peatman, E 2018, 'Short-term low salinity mitigates effects of oil and dispersant on juvenile eastern oysters: A laboratory experiment with implications for oil spill response activities', PLoS ONE, vol 13, no. 9, pp. 1–16.

Scouts 2009, 'Project orion plants 1,000 mangroves in malaysia', viewed 24 August 2020, <https://www.scout.org/id/node/6249>.

SEAFDEC, ASEAN Catch Documentation Scheme for Marine Capture Fisheries (Sept. 28, 2019), available at https://asean.org/wp-content/uploads/2012/05/16.-ASEAN-Catch-Documentation-Scheme.pdf (last visited Oct. 20, 2019).

SEAFDEC, Establishment of the "Regional Fishing Vessels Record (RFVR)" available at http://www.seafdec.org/documents/2014/03/wp051-2.pdf (last visited Oct. 20, 2019).

Selig, ER, Mckinnon, M., Turner, WR, Hole, DG, Chu, J, Allison, EH, ... Holland, MB 2019, 'Mapping global human dependence on marine ecosystems', vol 12, no. 2, pp. 1–10.

Setiati, N., Peniati, E., & Partaya. (2018). Diversity and Conservation Knowledge of Chondrichthyans in Northern Coastal Areas of Central Java. Biosaintifika: Journal of Biology & Biology Education, 10(2), 471-476.

Sheppard, J.K., Preen, A.R., Marsh, H., Lawler, I.R., Whiting, S.D. and Jones, R.E., 2006. "Movement heterogeneity of dugongs, Dugong dugon Müller), over large spatial scales." Journal of Experimental Marine Biology and Ecology 334(1): 64–83.

Slooten, E., Fletcher, D., & Taylor, B. L. (2000). Accounting for uncertainty in risk assessment: case study of Hector's dolphin mortality due to gillnet entanglement. Conservation Biology, 14(5), 1264-1270.

Stacey, N., Acciaioli, G., Clifton, J., & Steenbergen, D. J. (2017). Impacts of marine protected areas on livelihoods and food security of the Bajau as an indigenous migratory people in maritime Southeast Asia. In L. Westlund, A. Charles, S. M. Garcia & J. Sanders (Eds.), Marine protected areas: Interactions with fishery livelihoods and food security (pp. 113-126). Rome: Food and Agriculture Organisation of the United Nations. Retrieved from http://www.fao.org/policy-support/resources/resources-details/en/c/853709/

Stephenson, J., Berkes, F., Turner, N. J., & Dick, J. (2014). Biocultural conservation of marine ecosystems: examples from New Zealand and Canada. Indian Journal of Traditional Knowledge, 13(2), 257–265.

Stephenson, R. L., Paul, S., Pastoors, M. A., Kraan, M., Holm, P., Wiber, M., ... & Benson, A. (2016). Integrating fishers' knowledge research in science and management. ICES Journal of Marine Science, 73(6), 1459-1465.

Talaat, W. I. A. W., Tahir, N. M., & Husain, M. L. (2013). The Laws and Policies for the Sustainable Management of Biodiversity in Malaysia. Journal of Sustainability Science and Management, 8(2), 276-289.

Talaat, W.I.A.W., Charting Passage Forward towards a Maritime Nation. New Straits Times 3 Sep 2019.

Talaat, W.I.A.W. & Kaur, C. R.. A Brief on the Legal and Management of Marine Spatial Planning in Ocean Governance. MIMA Bulletin, Vol 26/2 (2019), pp 13-16.

Thornton, T., & Scheer, A. (2012). Collaborative engagement of local and traditional knowledge and science in marine environments: a review. Ecology and Society, 17(3).

Tonin, S. (2018). Citizens' perspectives on marine protected areas as a governance strategy to effectively preserve marine ecosystem services and biodiversity. Ecosystem Services, 34(Pt. B), 189-200. Retrieved from https://doi.org/10.1016/j.ecoser.2018.03.023

Tourism Malaysia. Malaysia Truly Asia-Diving in Malaysia. (13 July 2010). https://blog.tourism.gov.my/diving-in-malaysia/. Retrieved on 30/12/18.

Tran Yen Hoang, The South China Sea Arbitral Award: Legal Implications for Fisheries Management and Cooperation in the South China Sea, 6:1 CAMBRIDGE INT'L LAW J pg. 94 (2017).

Tsurita, I., Horib, J., Kuniedac, T., Horid, M., & Makino, M. (2018). Marine protected areas, Satoumi, and territorial use rights for fisheries: A case study from Hinase, Japan. Marine Policy, 91, 41–48.

Underdal, A., Integrated Marine Policy: What? Why? How?, Marine Policy, vol. 4, no. 3, 1980, pp. 159–69.

United Nations, The 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, U.N. Doc. A/CONF.164/CRP.8 (Aug. 2, 1995) available at https://www.un.org/Depts/los/fish_stocks_conference/fish_stocks_conference.htm# Agreement (last visited on October 20, 2019).

United Nations Decade of Ocean Science for Sustainable Development (2021-2030): Implementation Plan, 2021. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000377082.

Valdes, Jorge & Hatcher, Bruce. (2010). A new typology of benefits derived from marine protected areas. Marine Policy. 34. 635-644. 10.1016/j.marpol.2009.12.002.

Vicziany, M., Chattopadhyay, D., & Bhattacharyya, S. (2017). Food from sewage: fish from the east Kolkata wetlands and the limits of traditional knowledge. South Asia: Journal of South Asian Studies, 40(3), 619-644.

Waycott, M., Duarte, C.M., Carruthers, T.J., Orth, R.J., Dennison, W.C., Olyarnik, S., Calladine, A., Fourqurean, J.W., Heck, K.L., Hughes, A.R. & Kendrick, G.A. (2009). Accelerating loss of seagrasses across the globe threatens coastal ecosystems. Proceedings of the National Academy of Sciences, 106 (30), 12377-12381.

Williams, R., Hall, A., & Winship, A. (2008). Potential limits to anthropogenic mortality of small cetaceans in coastal waters of British Columbia. Canadian Journal of Fisheries and Aquatic Sciences, 65(9), 1867-1878.

WWF 2015, 'First Marine Spatial Planning in Sabah Launched to Further Protect Semporna Priority Conservation Area (PCA)', viewed 18 June 2020 <https://www.wwf.org.my/?19725/First-Marine-Spatial-Planning-in-Sabah-Launched-to-Further-Protect-Semporna-Priority-Conservation-Area-PCA#:~:text=%E2%80%9CMarine%20Spatial%20Planning%20is%20a,the%20SMSP%20a%20pioneer%20approach.&text=Jointly%20Organised%20by%20TRPD%20and,Sabah%20State%20Government's%20regulatory%20framework>.

Yatim, MHM, Omar, AH, Abdullah, NM, & Sarip, A 2018, 'Extending the concept of institutional analysis to the marine spatial planning practice', IOP Conference Series: Earth and Environmental Science, vol 169, no. 1.

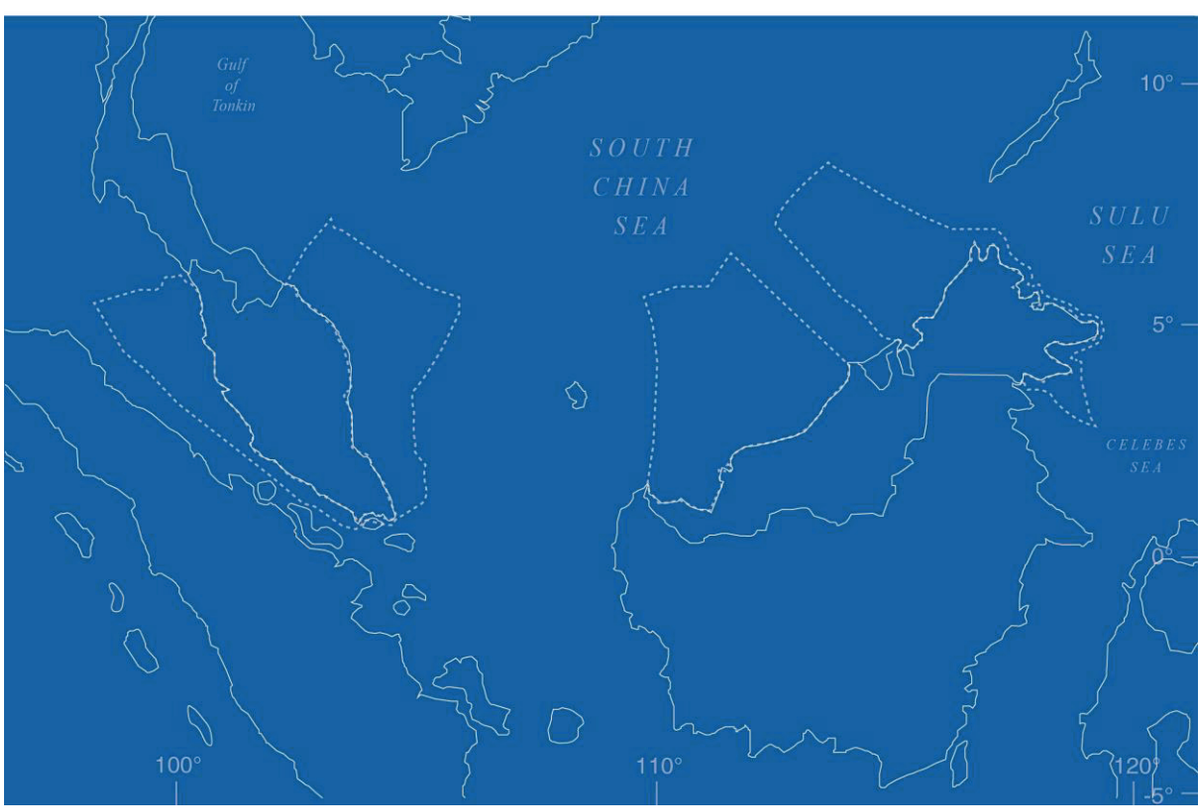
Z. M. Zakariah, Illegal, unreported and unregulated fishing (IUU) in Malaysian waters, MIMA (2004) available at http://www.mima.gov.my /component/category/10-presentation-repository (last visited Oct. 21, 2019).

Zhang Hongzhou, Fisheries Cooperation in the South China Sea: Evaluating the Options, 89 MAR POLICY pg. 72 (2018).

CHAPTER 7

GEOGRAPHIC INFORMATION SYSTEM

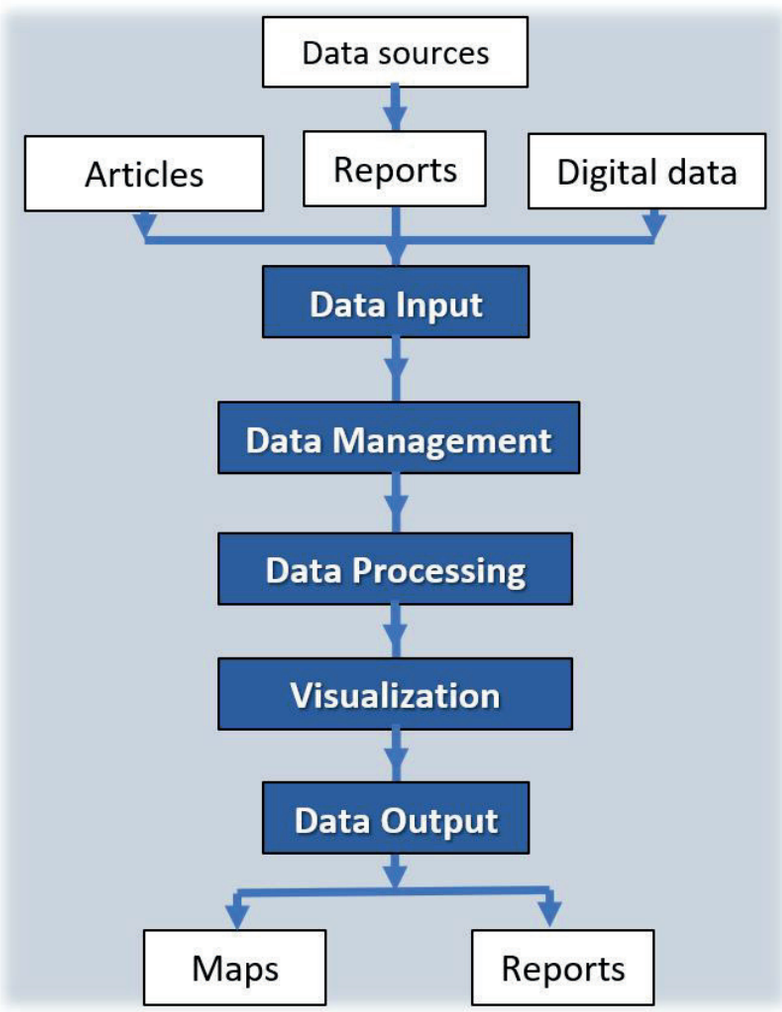
Idham Khalil
Aidy @ Mohamed Shawal Muslim
Mohd Nasir Mohamad
Eleanor Daniella Lokman'
Hadzley Harith



1.0 INTRODUCTION

The Geographic Information System, or GIS, has been used as a support system to collect and display digital data for this project (Projek Pengumpulan Data/Maklumat Ekosistem Dan Biodiversiti Marin Di Perairan Malaysia). This project successfully acquired geographic digital data from six major sectors through desktop research, and it then identified gaps in this data. The six primary areas of research are coral reefs, marine plants, marine invertebrates, marine environment and ecological processes, law and policy, and socioeconomics.

GIS is used in this project for data entry from multiple sources, data processing, management, and data storage into digital data layers. The digital data produced are from Malaysia's Exclusive Economic Zone. It incorporates data from PLANMalaysia's National Coastal Zone Physical Plan (RFZPPN2) for inland areas.



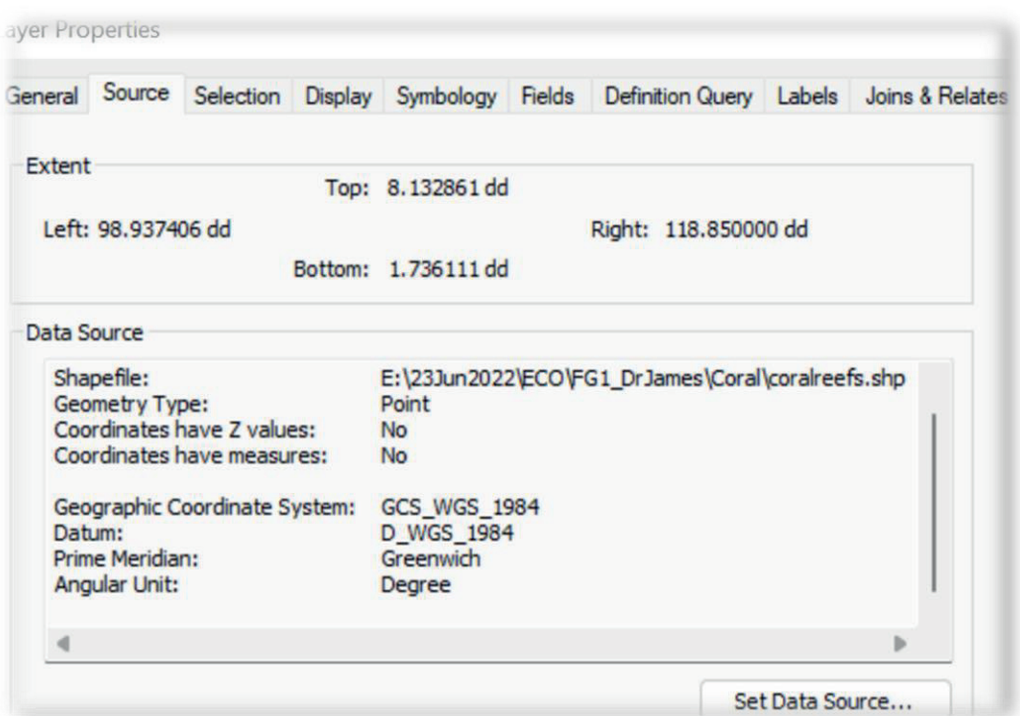
2.0 DATA STORAGE FORMAT AND SOFTWARE

The majority of the GIS data in this project is stored digitally in ESRI shapefile format, which is commonly used in ArcGIS and QGIS software. The shapefile format is used to store geometrically shaped location data such as point data, lines, and polygons that are linked to an attribute table that describes the characteristics of the data. The following files must be present in this shapefile format: *.shp, *.shx, and *.dbf. Furthermore, there are *.prj, *.sbn, *.xml, and *.cpg files.

Other formats, such as Geotiff raster data, are also stored in this project's data storage. The *.mxd file format is used in ArcGIS software to store map layouts. Coordinate reference system

3.0 COORDINATE REFERENCE SYSTEM

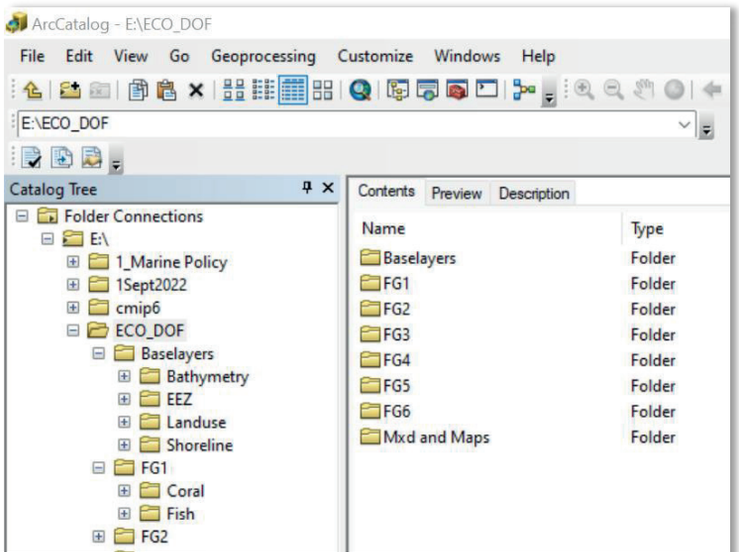
The information obtained from this project's desktop study comes from a variety of sources that employ various projection maps. All digital data layers have been converted to the WGS84 geographic coordinate system for standardisation purposes.

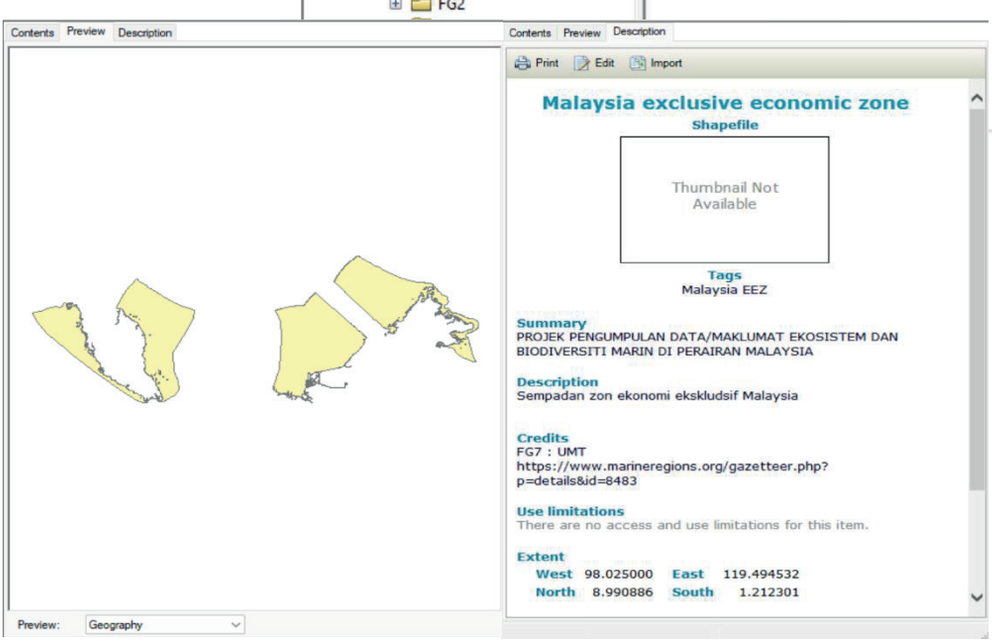


4.0 FILES DIRECTORY

The files directory system in ArcCatalog in ArcGIS software, as shown in the image below, can be used to easily access data search in this project. Bathymetry, economic exclusive zone (EEZ), land use, and shoreline boundary are examples of baselayers. The other layers of digital data are organised into folders based on their focus groups (FG).

More information about the data is available as follows.





5.0 DATA LAYERS

The figure below summarises the general overview of GIS layers in this project.

5.1 Basemap layers (5)

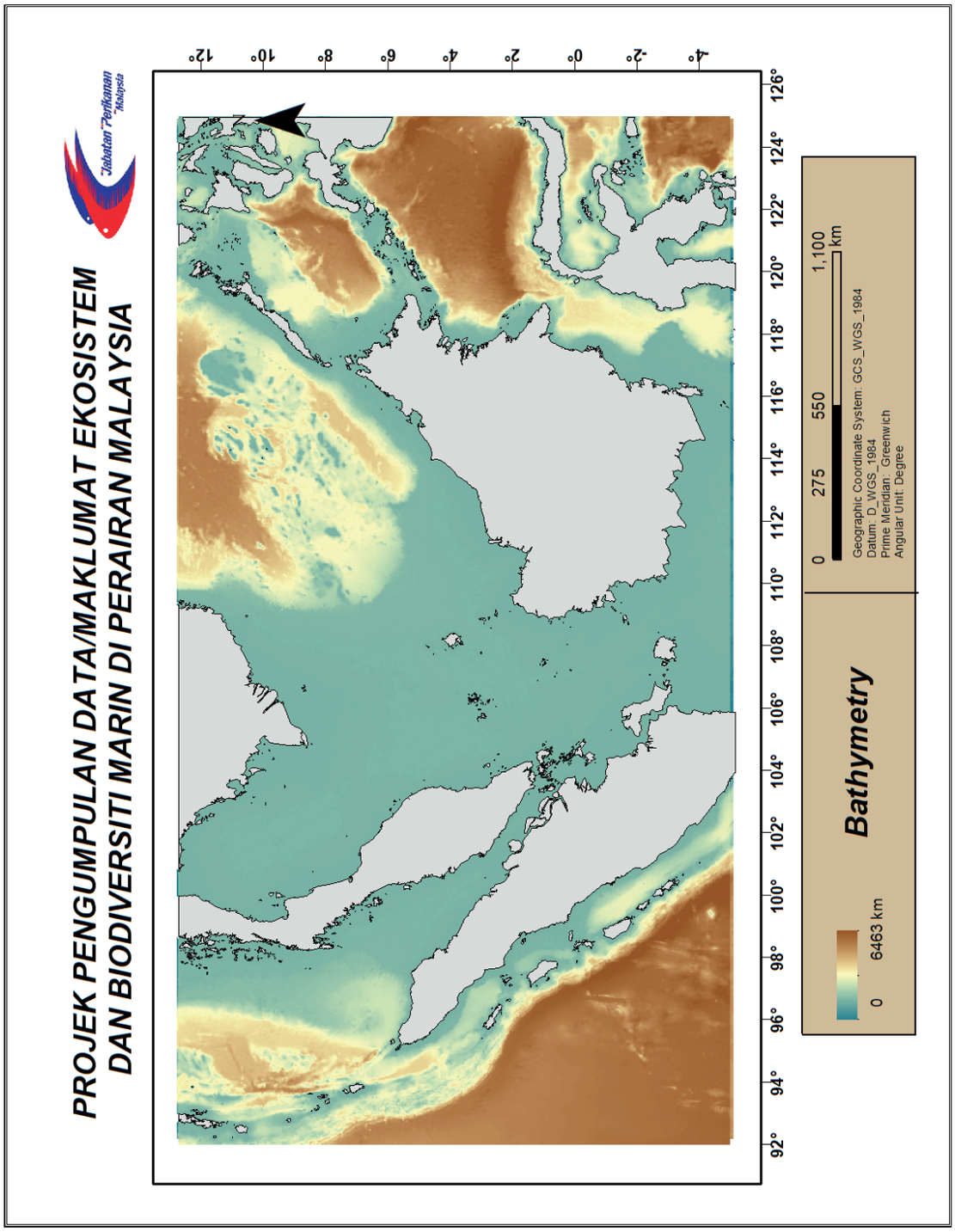
1. Bathymetry
2. Shoreline
3. Malaysia exclusive economic zone (EEZ)
4. Landuse (Peninsular Malaysia and Labuan)
5. Coastal zone limit (land and sea)

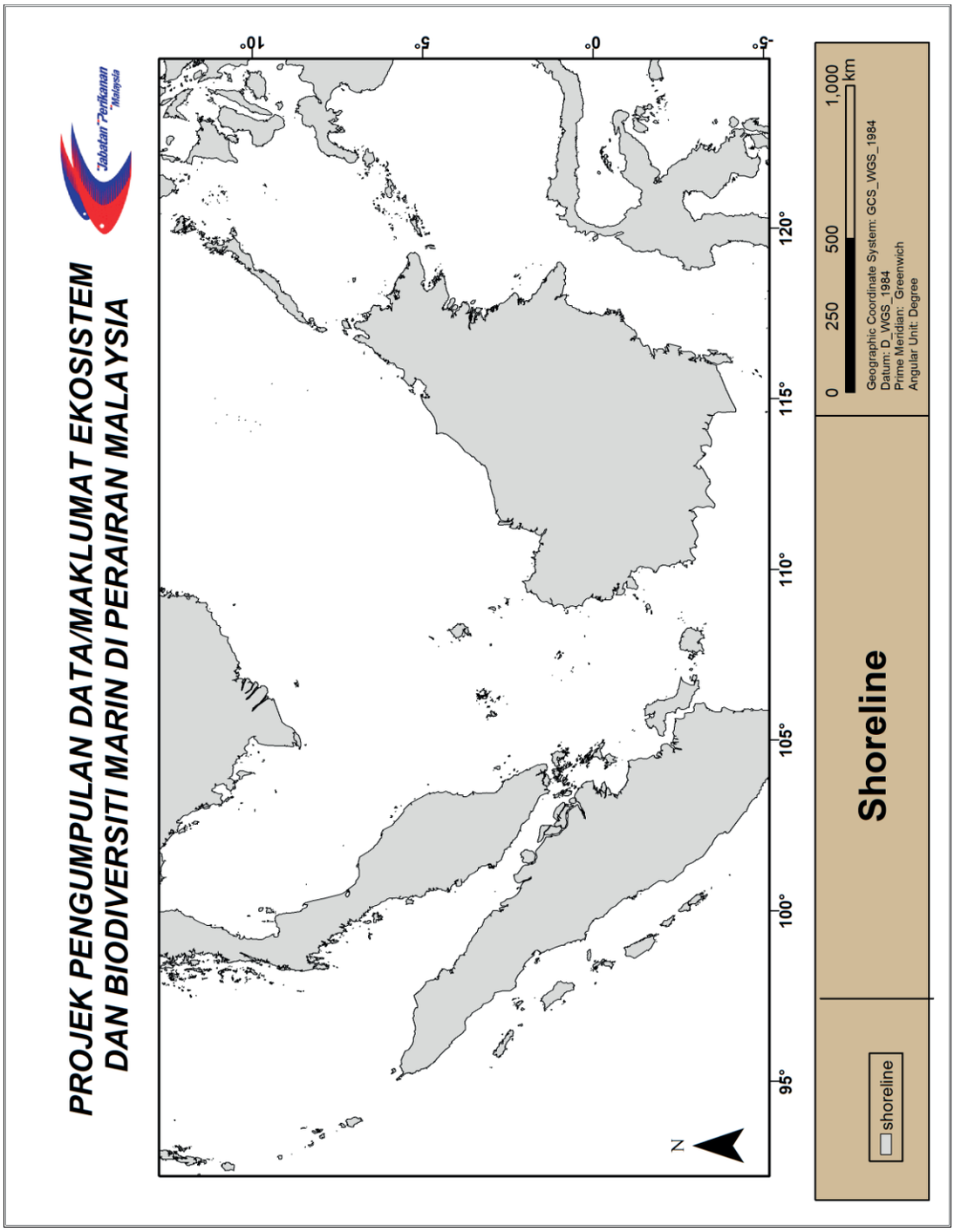
5.2 Marine ecosystem and biodiversity layers (28)

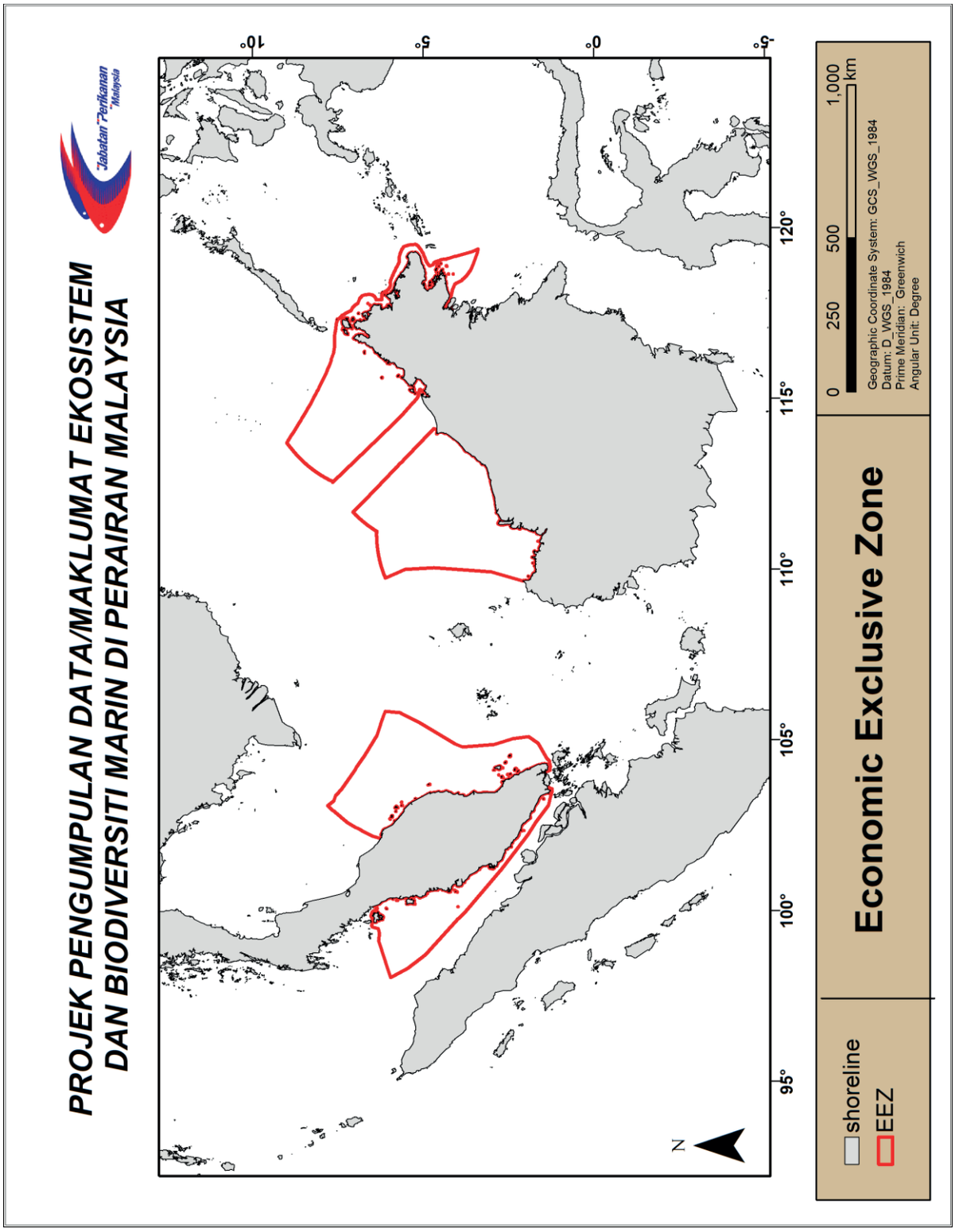
1. Coral Reefs
2. Fish
3. Marine Invertabrate
4. Marine Habitat
5. Marine Inverterbrate Total Abundance
6. Marine Inverterbrate Total number of species

7. Marine Inverterbrate Most Dominance species
8. Marine Inverterbrate Red List
9. Marine Inverterbrate Methods
10. Marine Inverterbrate Abundance
11. Marine Inverterbrate Percentage
12. Marine Organism sighting frequency
13. Marine Organism sighting location (UMT)
14. Marine Organism sighting location (NonUMT)
15. Marine Organism number of individuals (UMT)
16. Marine Organism number of individuals (NonUMT)
17. Marine Habitat and Ecological Processes
18. Ecological Processes
19. Field of study
20. Marine Species of concern
21. Mangrove Habitat
22. Mangrove coverage area
23. Mangrove threats
24. Mangrove height
25. Mangrove coverage
26. Marine Seaweed
27. Marine Microalgae
28. Marine Seagrass

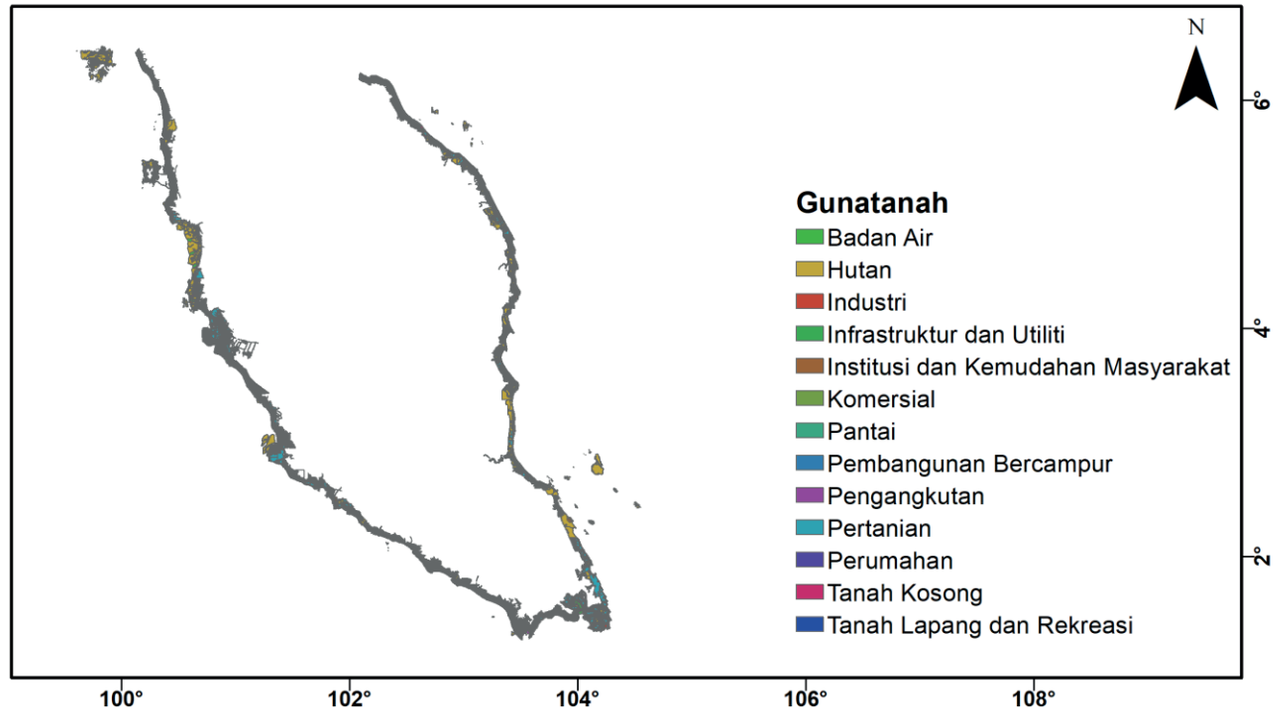
5.3 Baselayer Maps




PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
10°
5°
0°
-5°
95°
100°
105°
110°
115°
120°
N
shoreline
Shoreline
0
250
500
1,000
km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree


PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
N
95°
100°
105°
110°
115°
120°
10°
5°
0°
-5°
shoreline
EEZ
Economic Exclusive Zone
0
250
500
1,000
km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

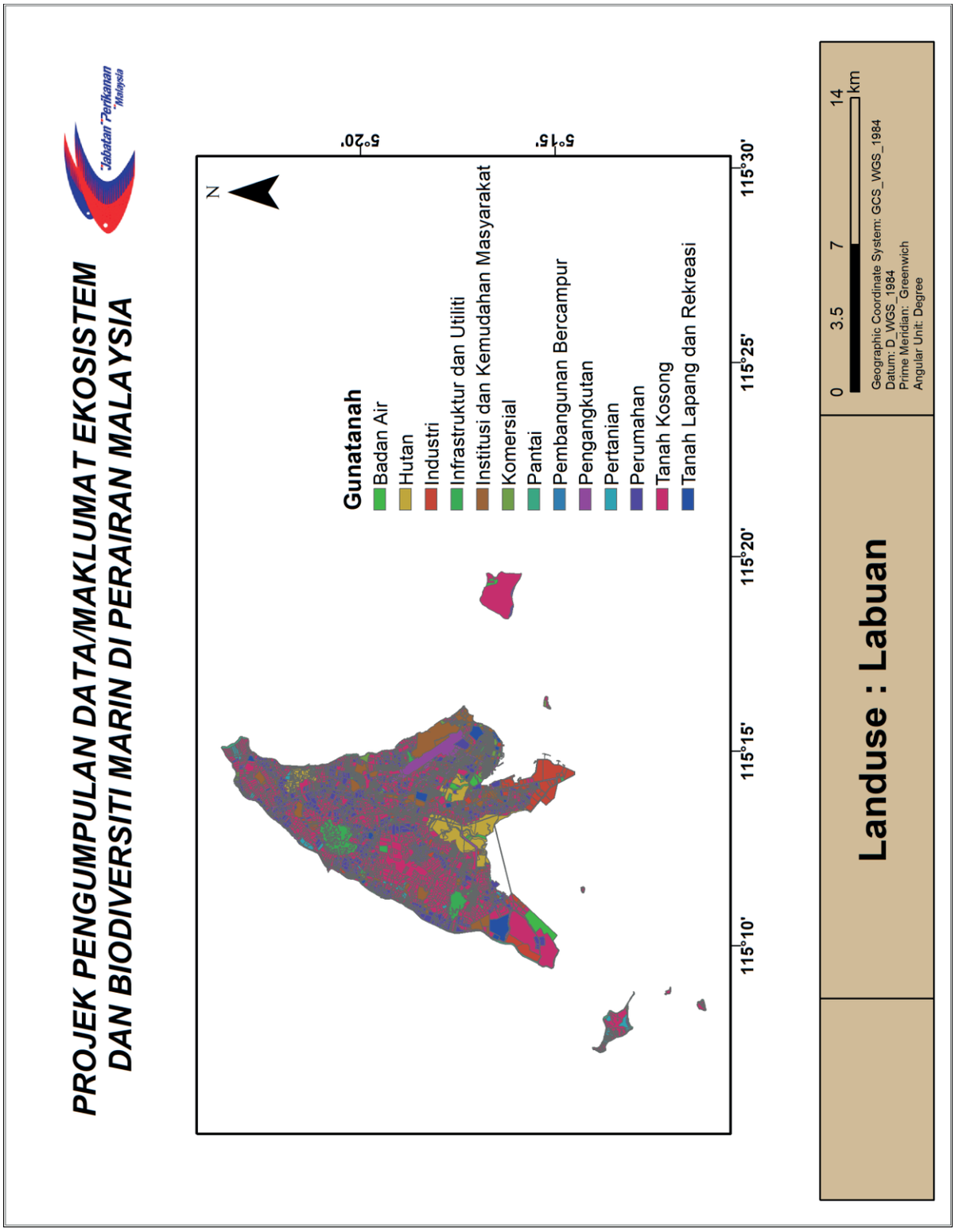
PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA

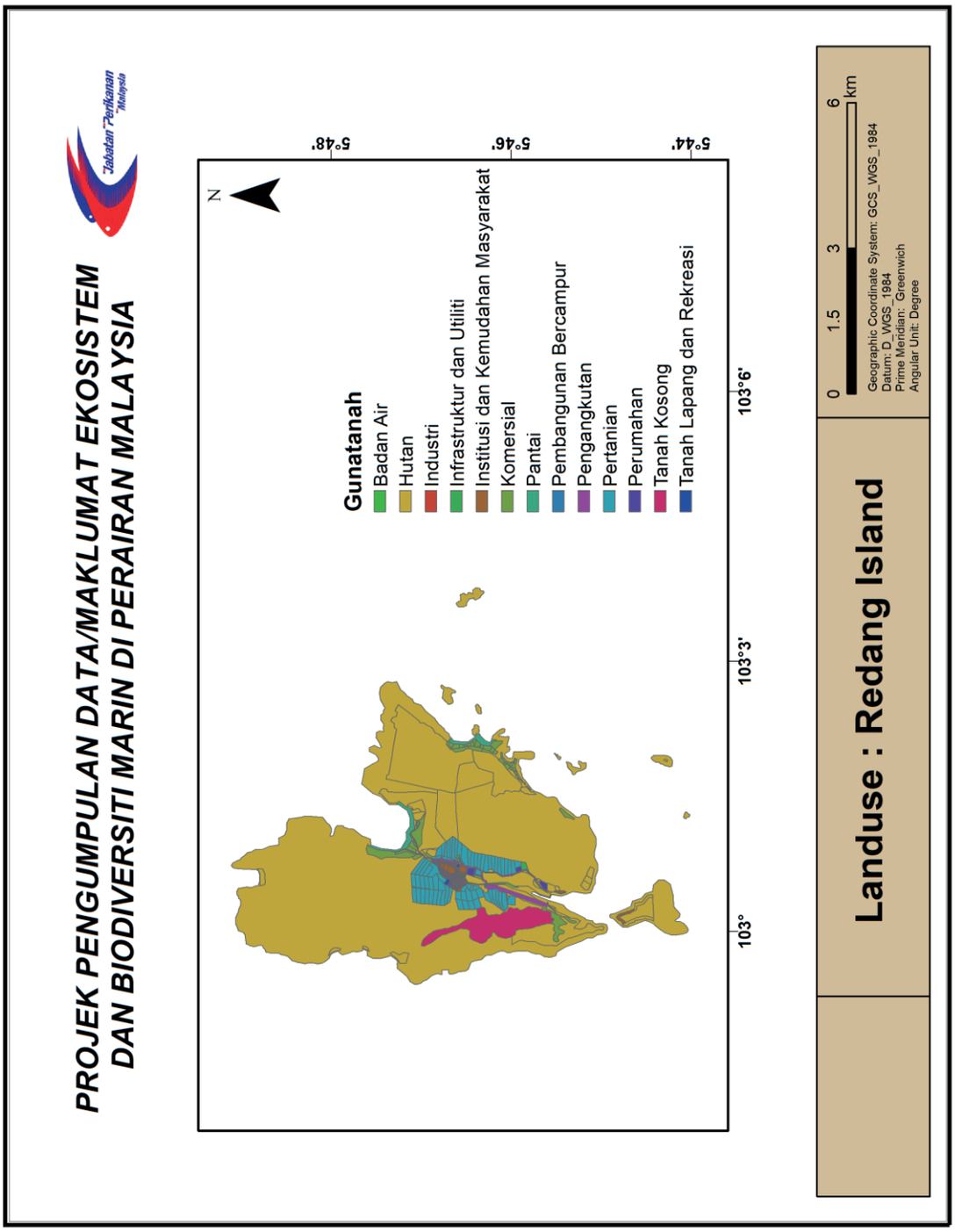


Landuse : Peninsular Malaysia

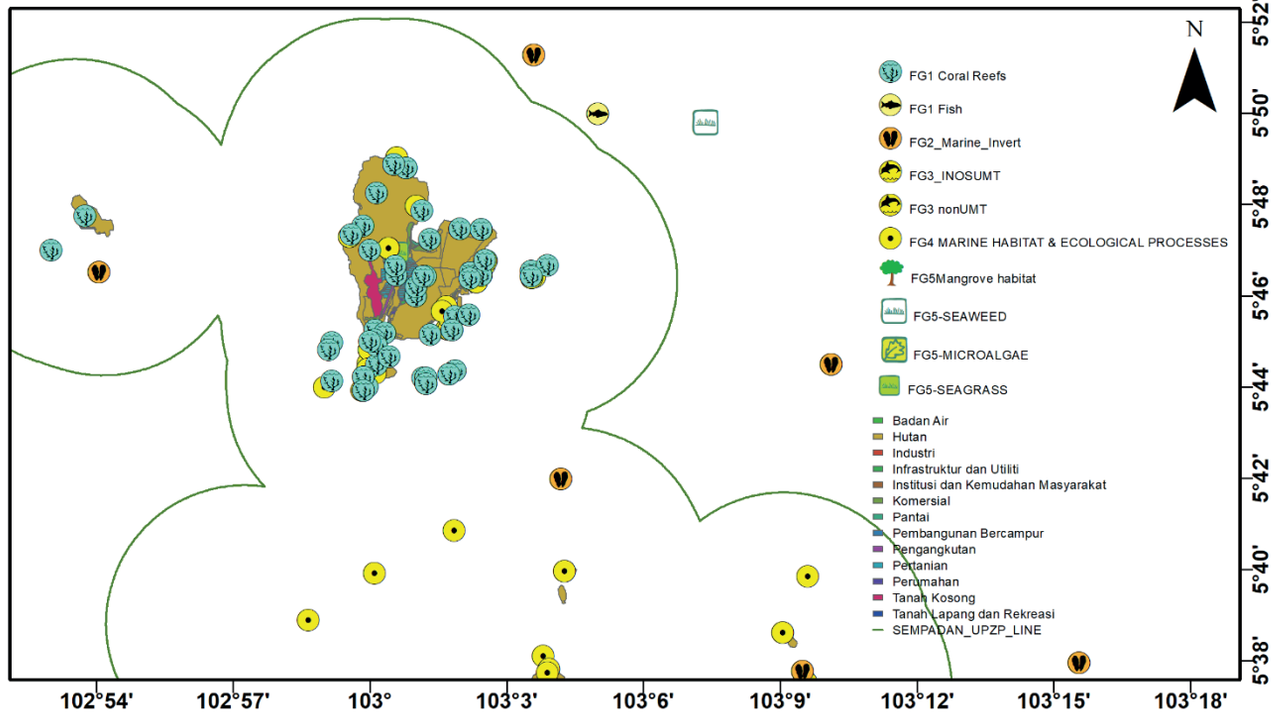
0 95 190 380 km

Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree


PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
N
5°20'
5°15'
115°10'
115°15'
115°20'
115°25'
115°30'
Gunatanah
Badan Air
Hutan
Industri
Infrastruktur dan Utiliti
Institusi dan Kemudahan Masyarakat
Komersial
Pantai
Pembangunan Bercampur
Pengangkutan
Pertanian
Perumahan
Tanah Kosong
Tanah Lapang dan Rekreasi
Landuse : Labuan
0 3.5 7 14 km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree


PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
N
5°48'
5°46'
5°44'
103°
103°3'
103°6'
Gunatanah
Badan Air
Hutan
Industri
Infrastruktur dan Utiliti
Institusi dan Kemudahan Masyarakat
Komersial
Pantai
Pembangunan Bercampur
Pengangkutan
Pertanian
Perumahan
Tanah Kosong
Tanah Lapang dan Rekreasi
Landuse : Redang Island
0 1.5 3 6 km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

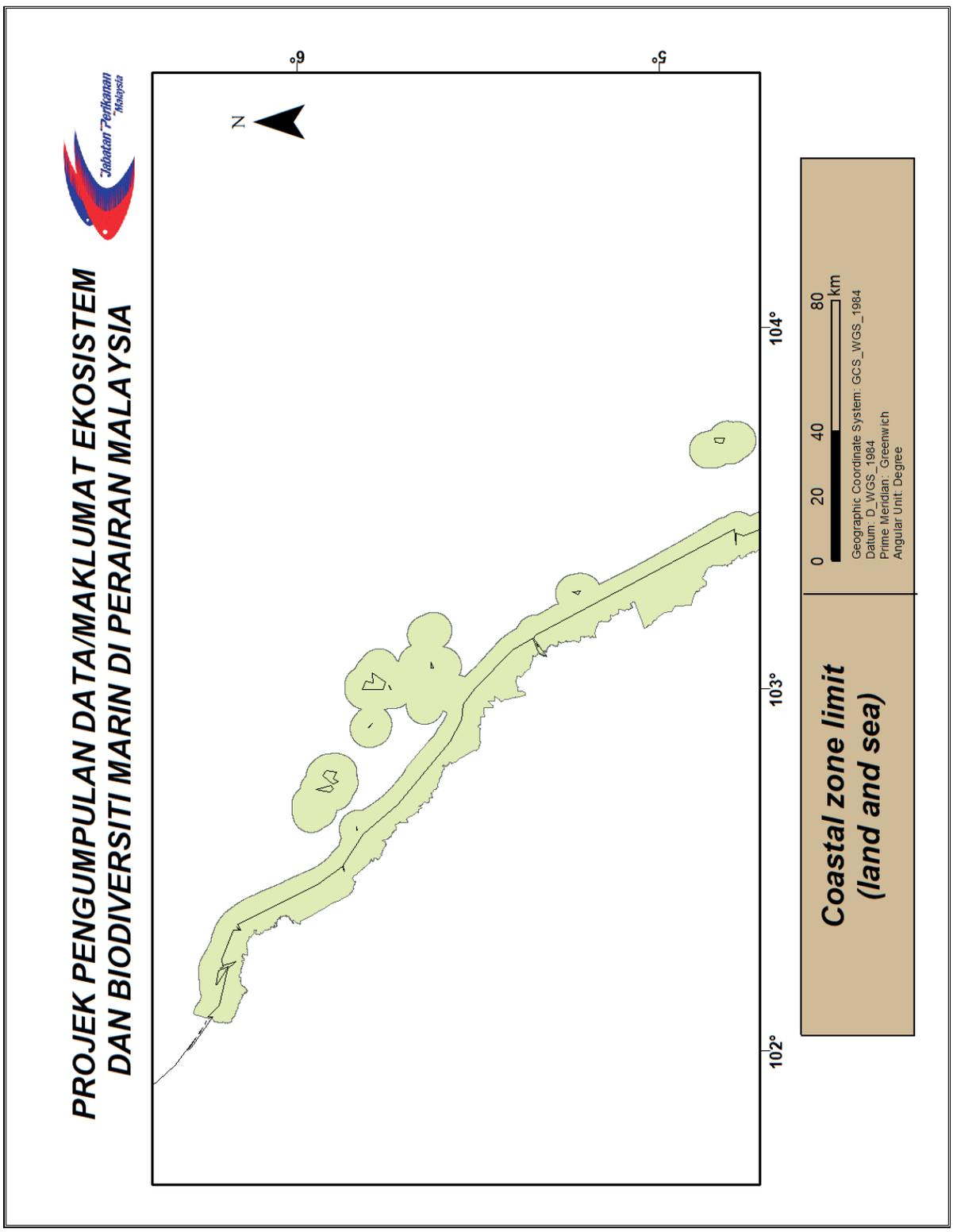
PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA



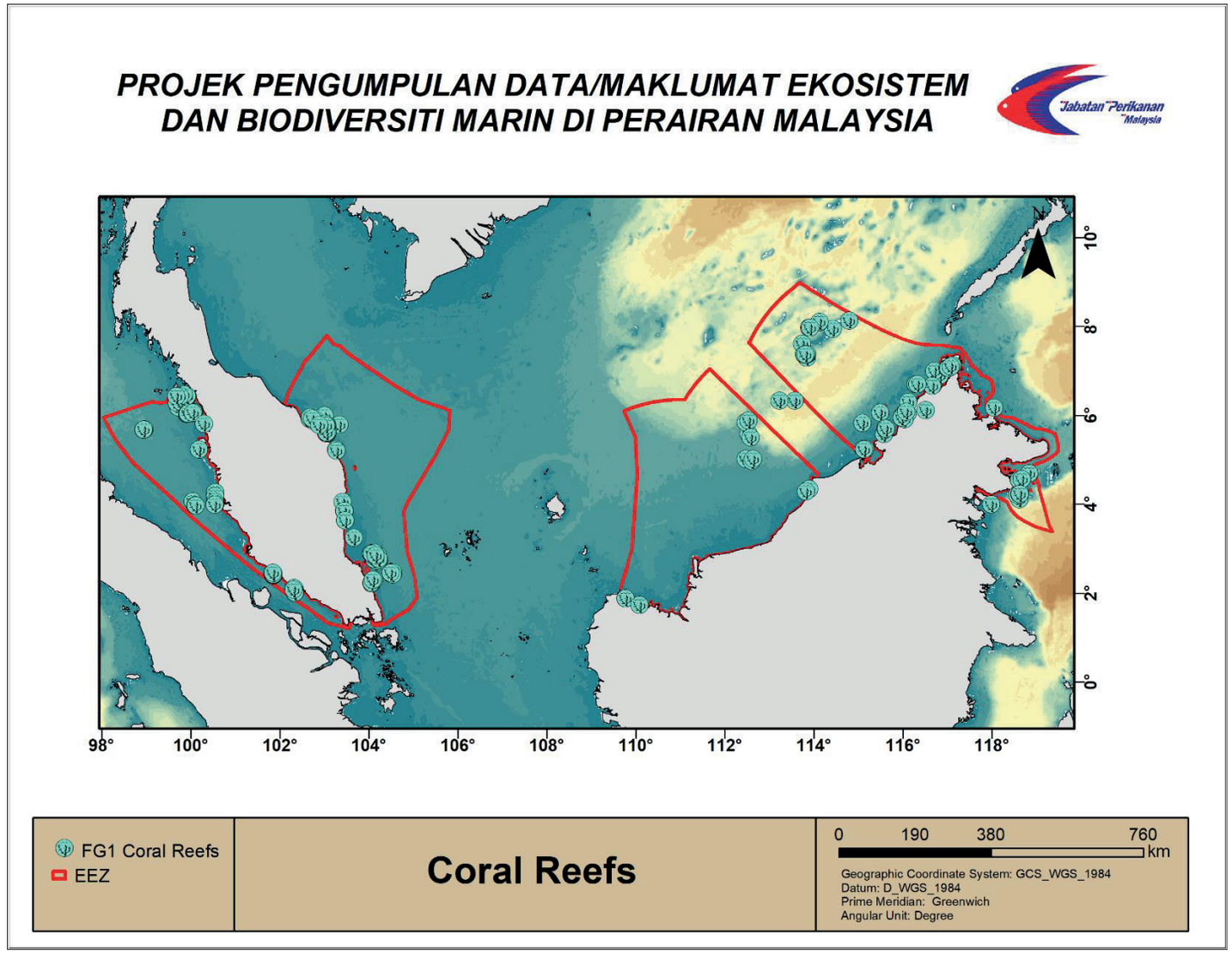
Landuse and other datasets: Redang Island

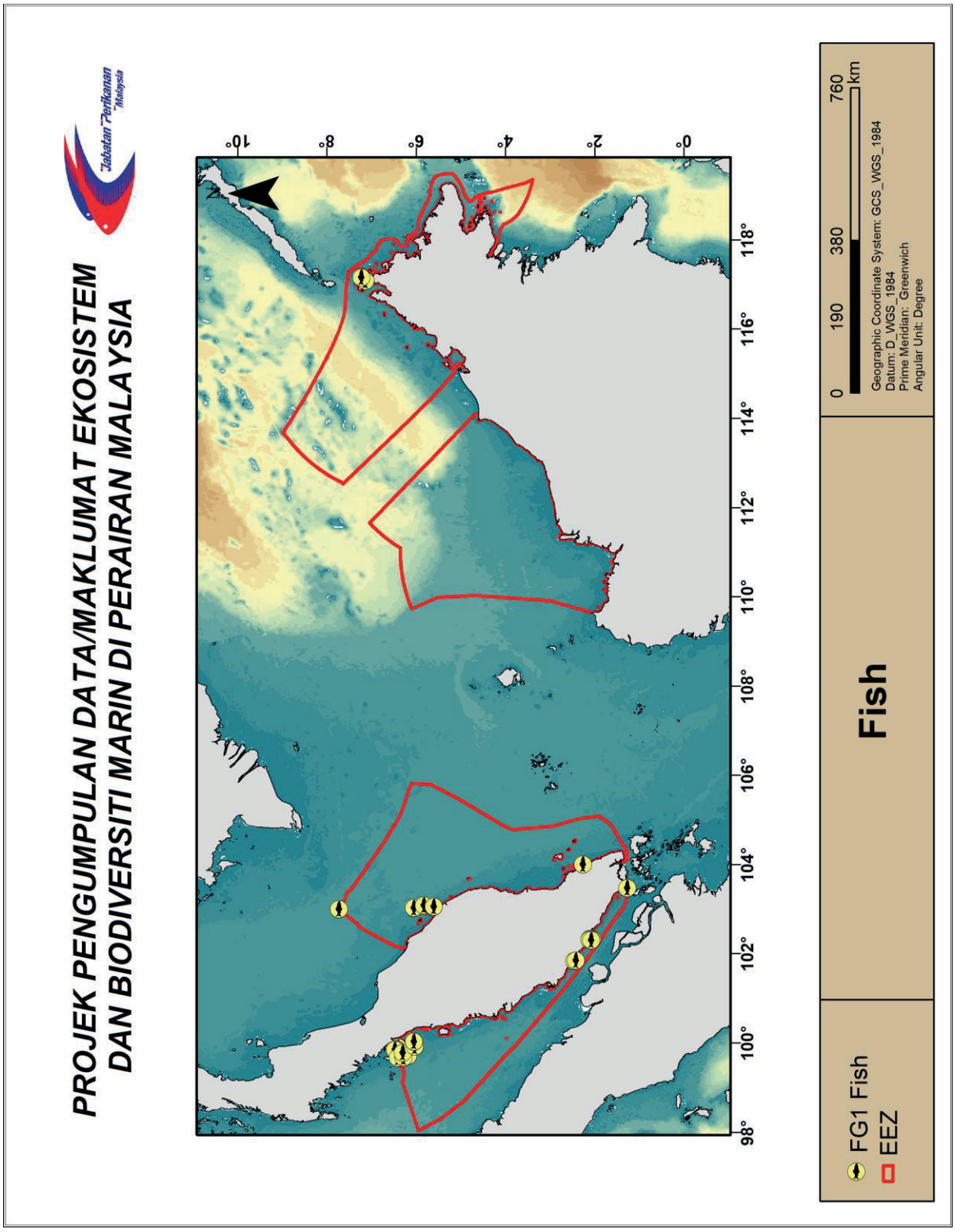
0 3.75 7.5 15 km

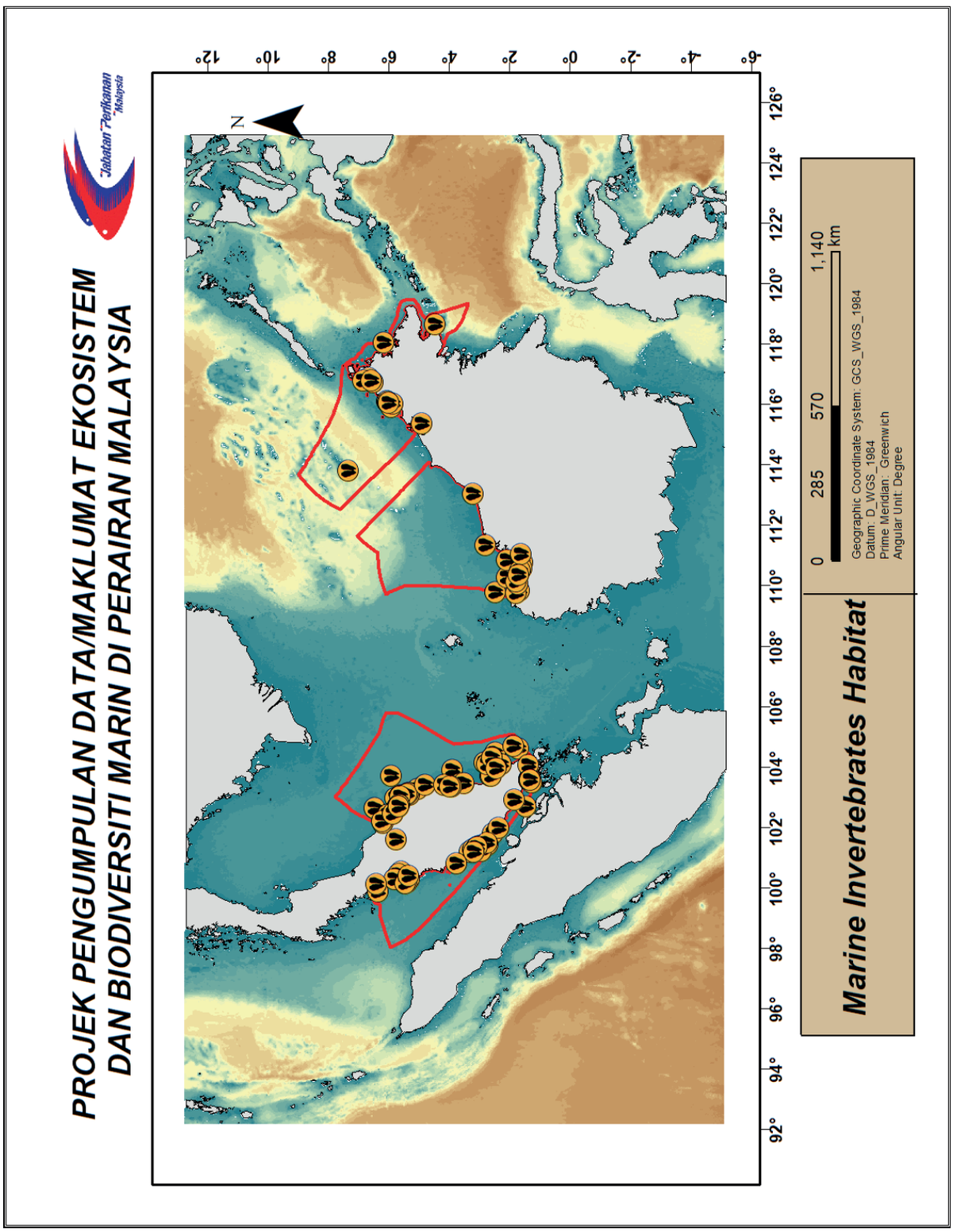
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

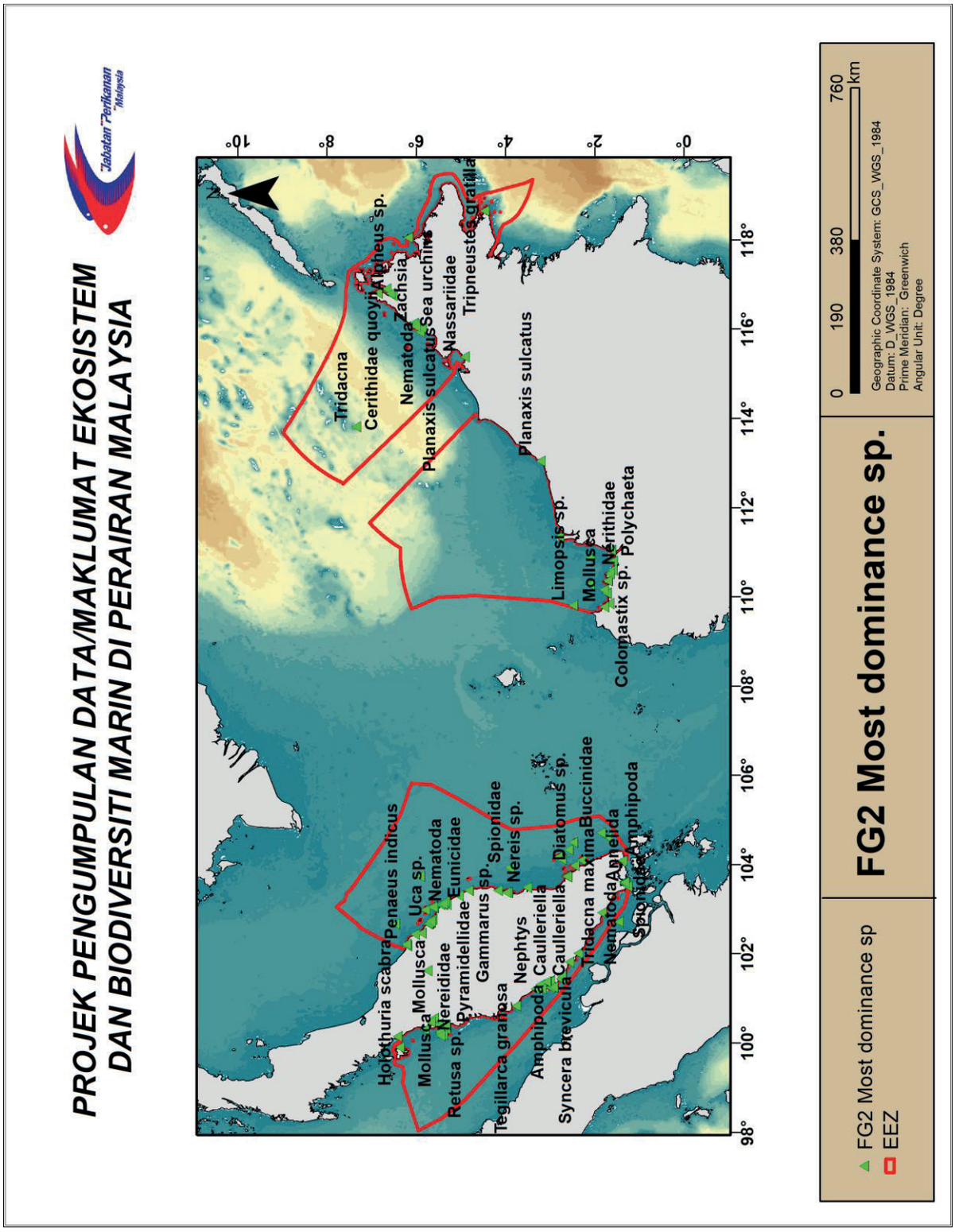

PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
6°
5°
N
102°
103°
104°
Coastal zone limit
(land and sea)
0 20 40 80
km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

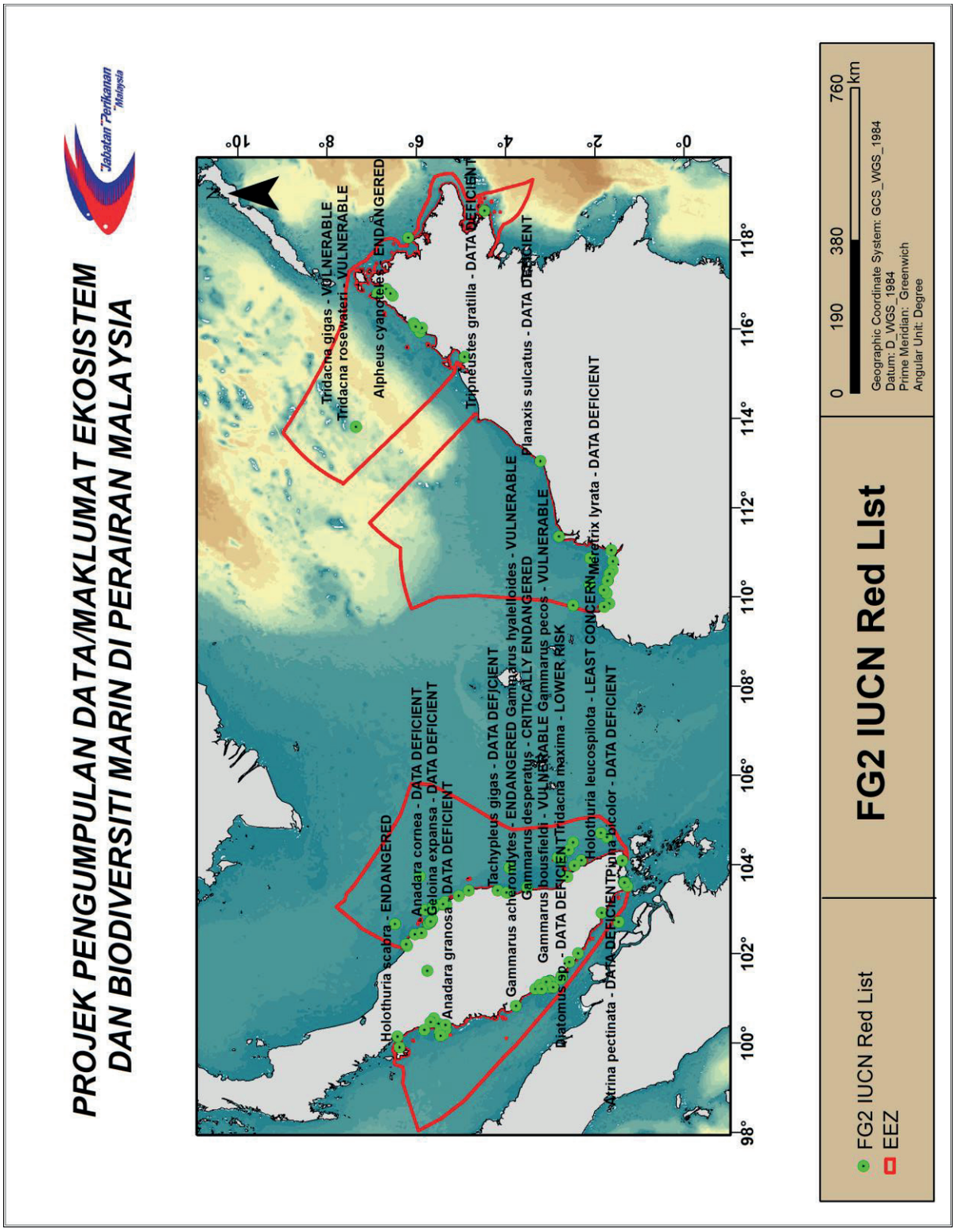
5.4 Marine ecosystem and biodiversity layers (28)

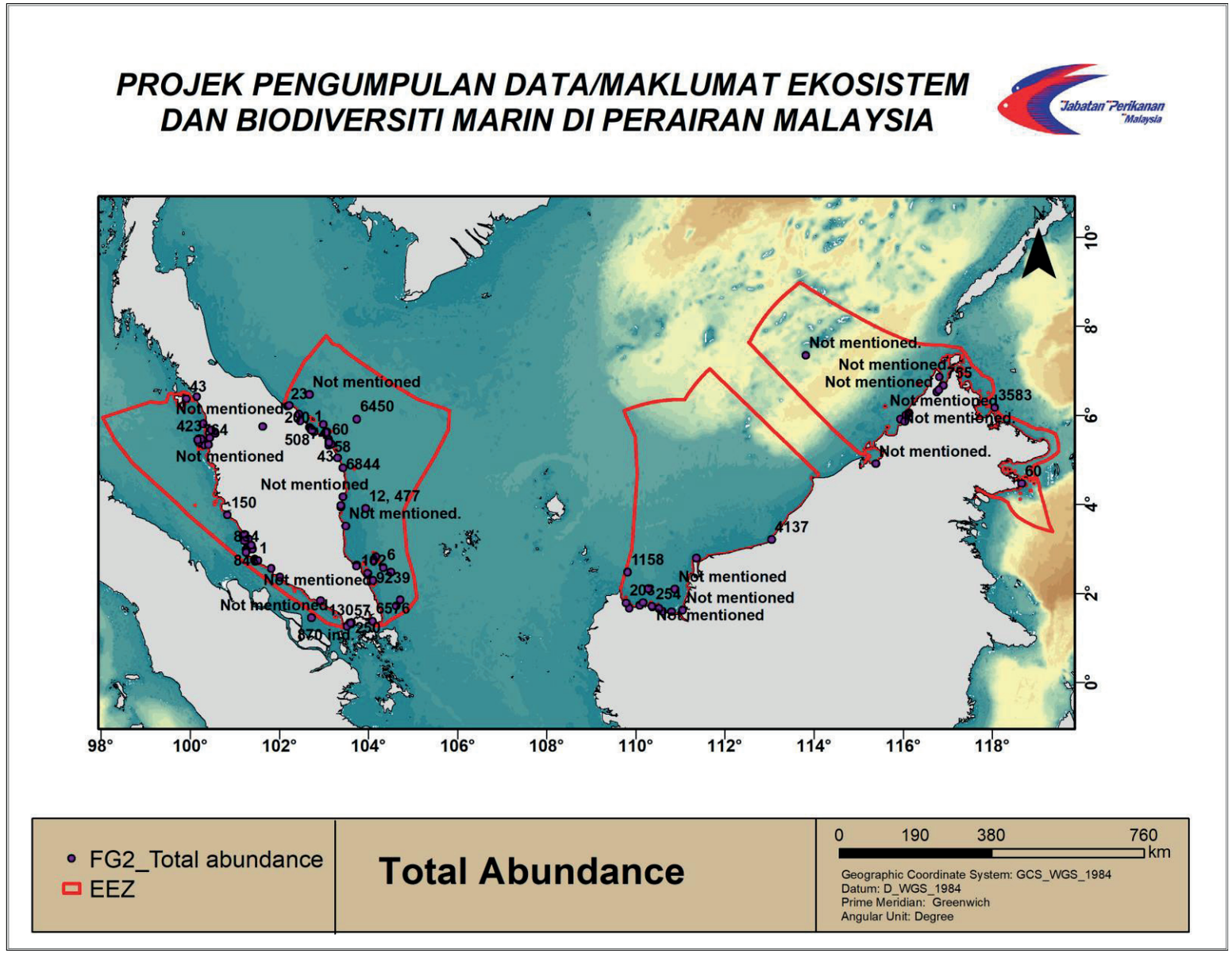


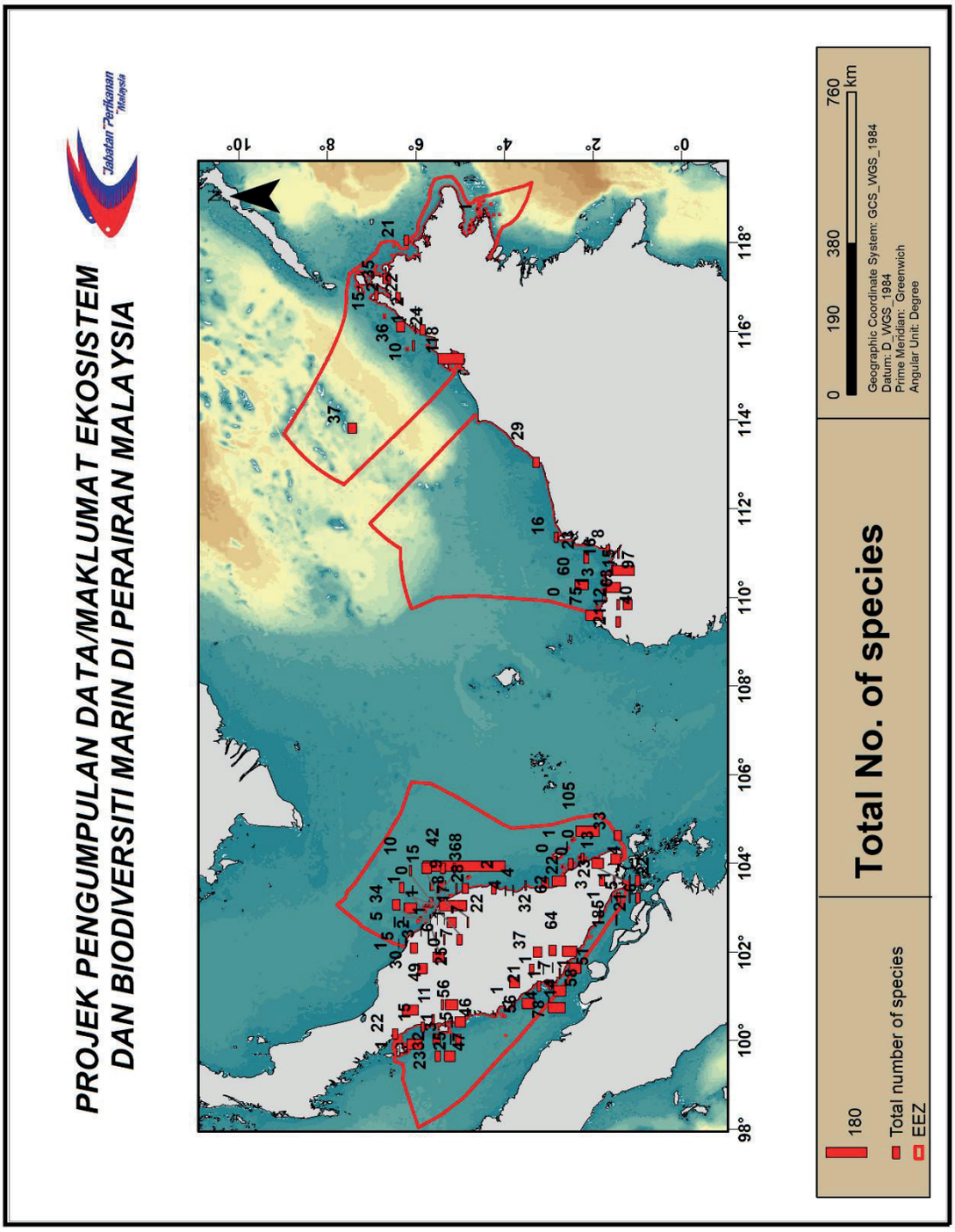

PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
98°
100°
102°
104°
106°
108°
110°
112°
114°
116°
118°
0°
2°
4°
6°
8°
10°
FG1 Fish
EEZ
Fish
0
190
380
760
km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

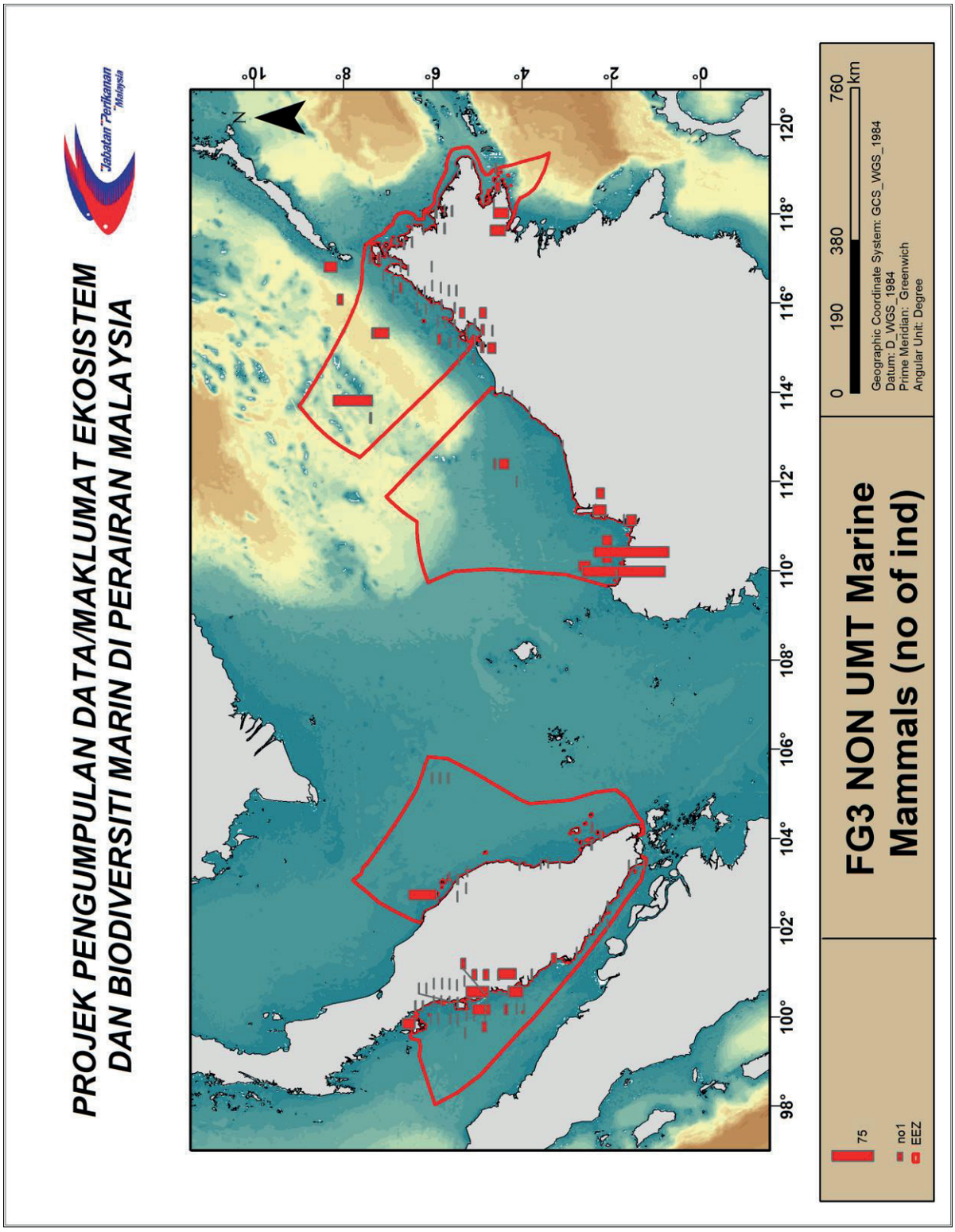

PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
N
92° 94° 96° 98° 100° 102° 104° 106° 108° 110° 112° 114° 116° 118° 120° 122° 124° 126°
12° 10° 8° 6° 4° 2° 0° -2° -4° -6°
Marine Invertebrates Habitat
0 285 570 1,140 km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

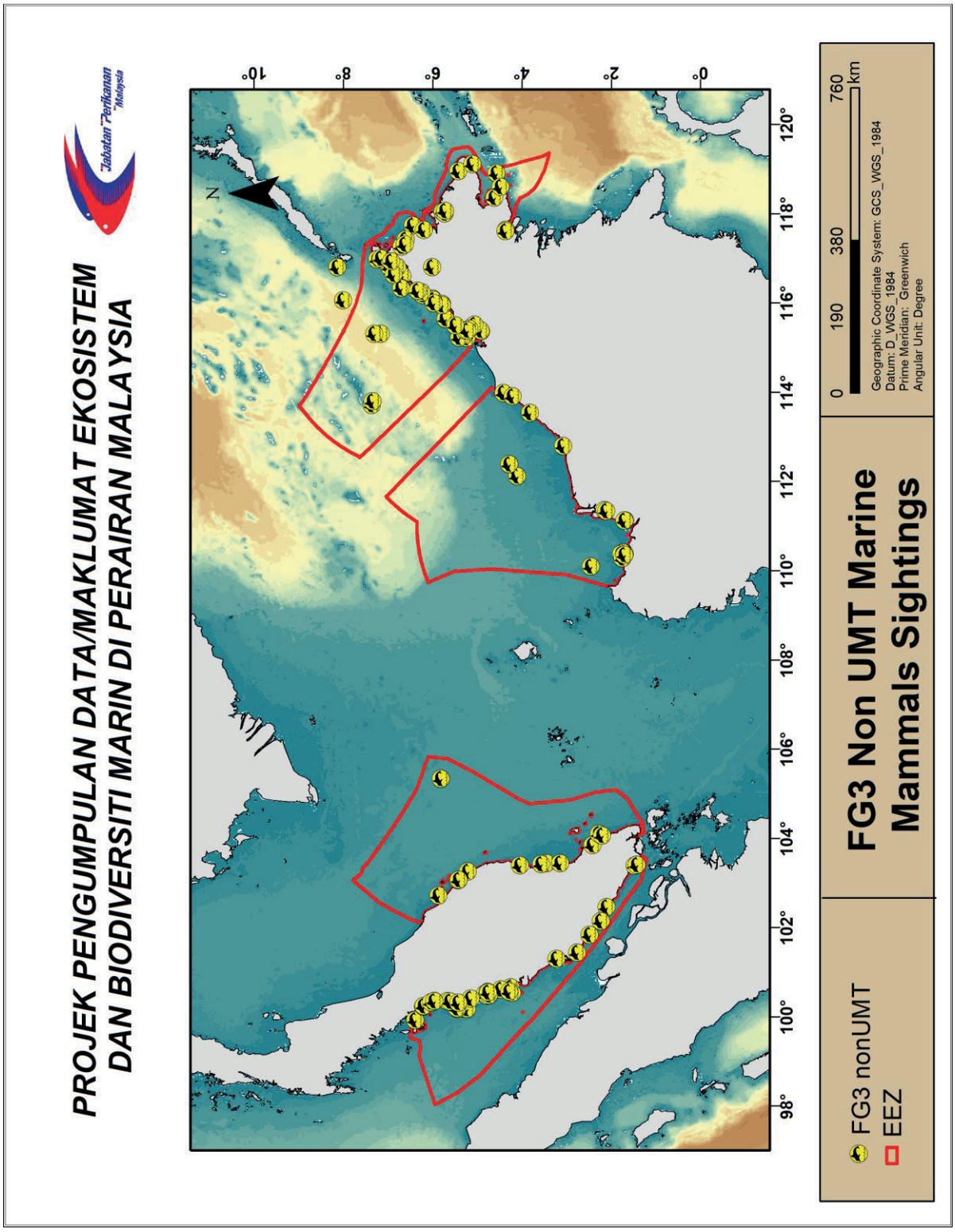

PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
Tridacna
Cerithidae quoyii
Alpheus sp.
Zachsia
Sea urchins
Nematoda
Planaxis sulcatus
Nassariidae
Tripneustes gratilla
Planaxis sulcatus
Limopsis sp.
Mollusca
Nerithidae
Polychaeta
Colomastix sp.
Holothuria scabra
Penaeus indicus
Mollusca
Uca sp.
Nematoda
Nereididae
Eunicidae
Retusa sp.
Pyramidellidae
Gammarus sp.
Spionidae
Tegillarca granosa
Nereis sp.
Nephtys
Amphipoda
Caulleriella
Diatomus sp.
Syncera brevicula
Caulleriella
Tridacna maxima
Buccinidae
Nematoda
Amelida
Spionidae
Amphipoda
FG2 Most dominance sp
EEZ
FG2 Most dominance sp.
0 190 380 760 km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

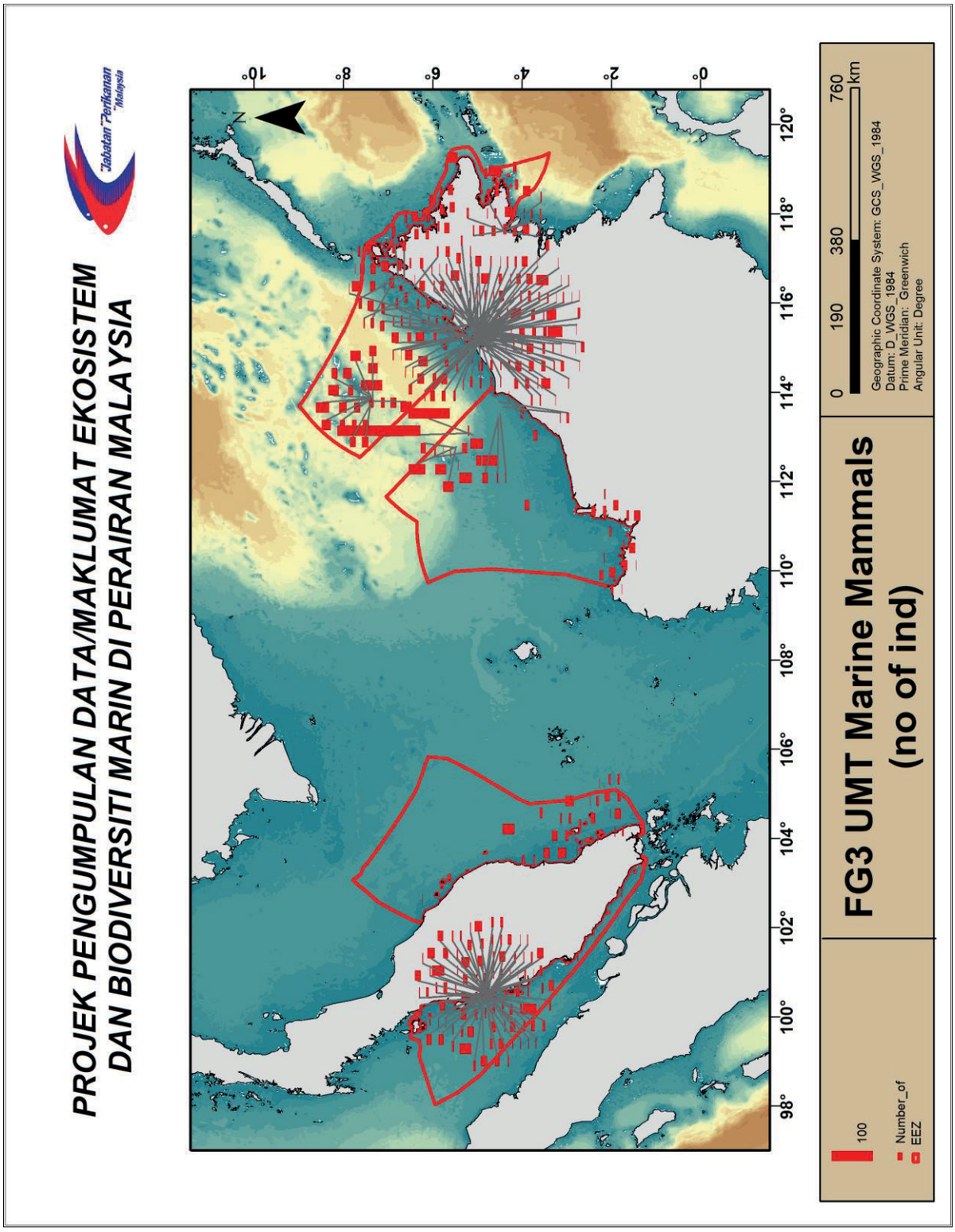

PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
Holothuria scabra - ENDANGERED
Anadara cornea - DATA DEFICIENT
Geloina expansa - DATA DEFICIENT
Anadara granosa - DATA DEFICIENT
Gammarus acheronytes - ENDANGERED
Tachypleus gigas - DATA DEFICIENT
Gammarus hyaleloides - VULNERABLE
Gammarus desperatus - CRITICALLY ENDANGERED
Gammarus bousfieldi - VULNERABLE
Gammarus pecos - VULNERABLE
Tridacna maxima - LOWER RISK
Diatomus sp. - DATA DEFICIENT
Holothuria leucospilota - LEAST CONCERN
Atrina pectinata - DATA DEFICIENT
Trigona bicolor - DATA DEFICIENT
Tridacna gigas - VULNERABLE
Tridacna rosewateri - VULNERABLE
Alpheus cyanotes - ENDANGERED
Tripneustes gratilla - DATA DEFICIENT
Planaxis sulcatus - DATA DEFICIENT
Meretrix lyrata - DATA DEFICIENT
98°
100°
102°
104°
106°
108°
110°
112°
114°
116°
118°
10°
8°
6°
4°
2°
0°
FG2 IUCN Red List
EEZ
FG2 IUCN Red List
0
190
380
760
km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

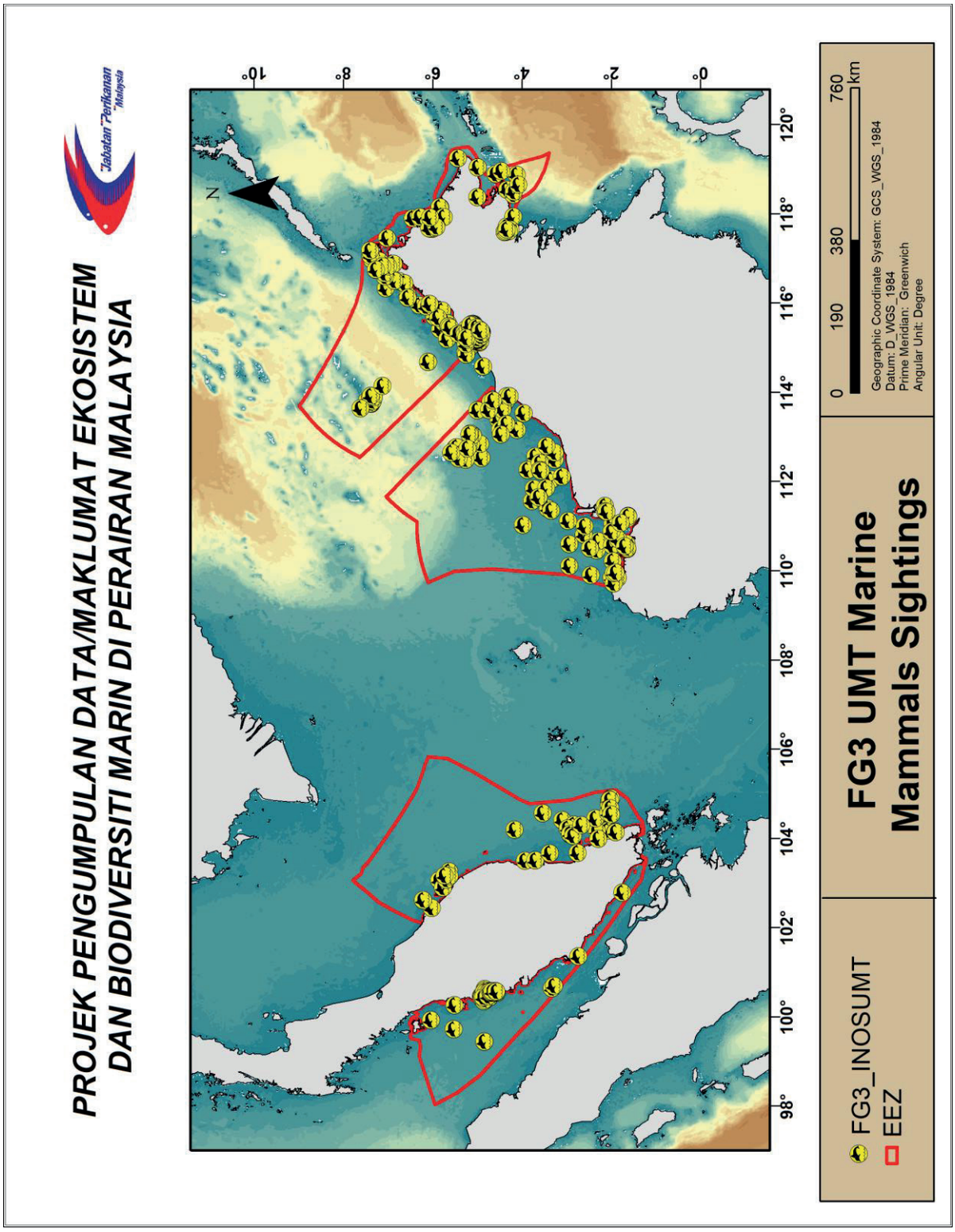

PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
Not mentioned
6450
6844
12, 477
Not mentioned.
150
9239
13057
6576
870 ind.
1158
4137
3583
755
60
98°
100°
102°
104°
106°
108°
110°
112°
114°
116°
118°
0°
2°
4°
6°
8°
10°
FG2_Total abundance
EEZ
Total Abundance
0
190
380
760
km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

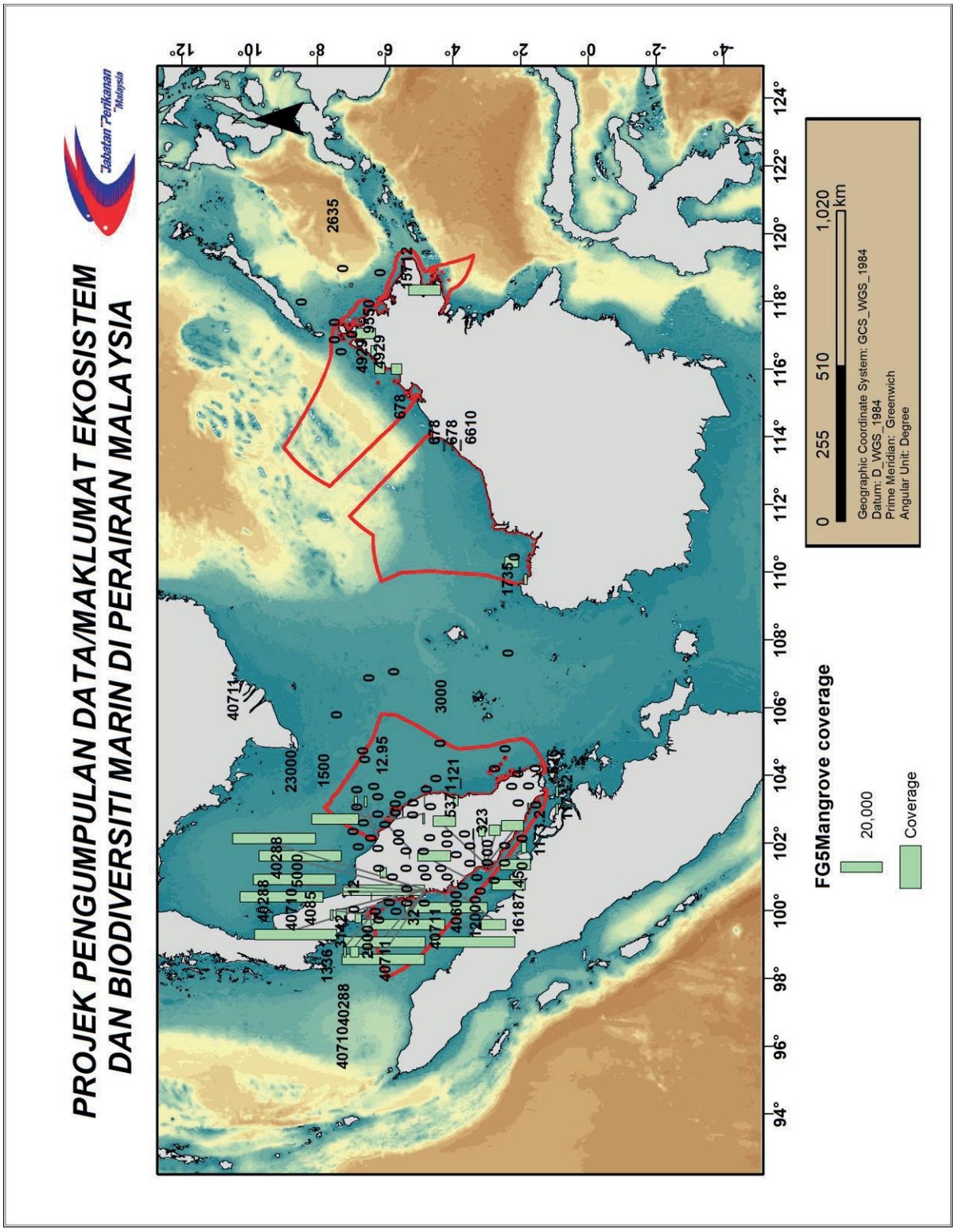

PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
Total No. of species
180
Total number of species
EEZ
0 190 380 760 km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

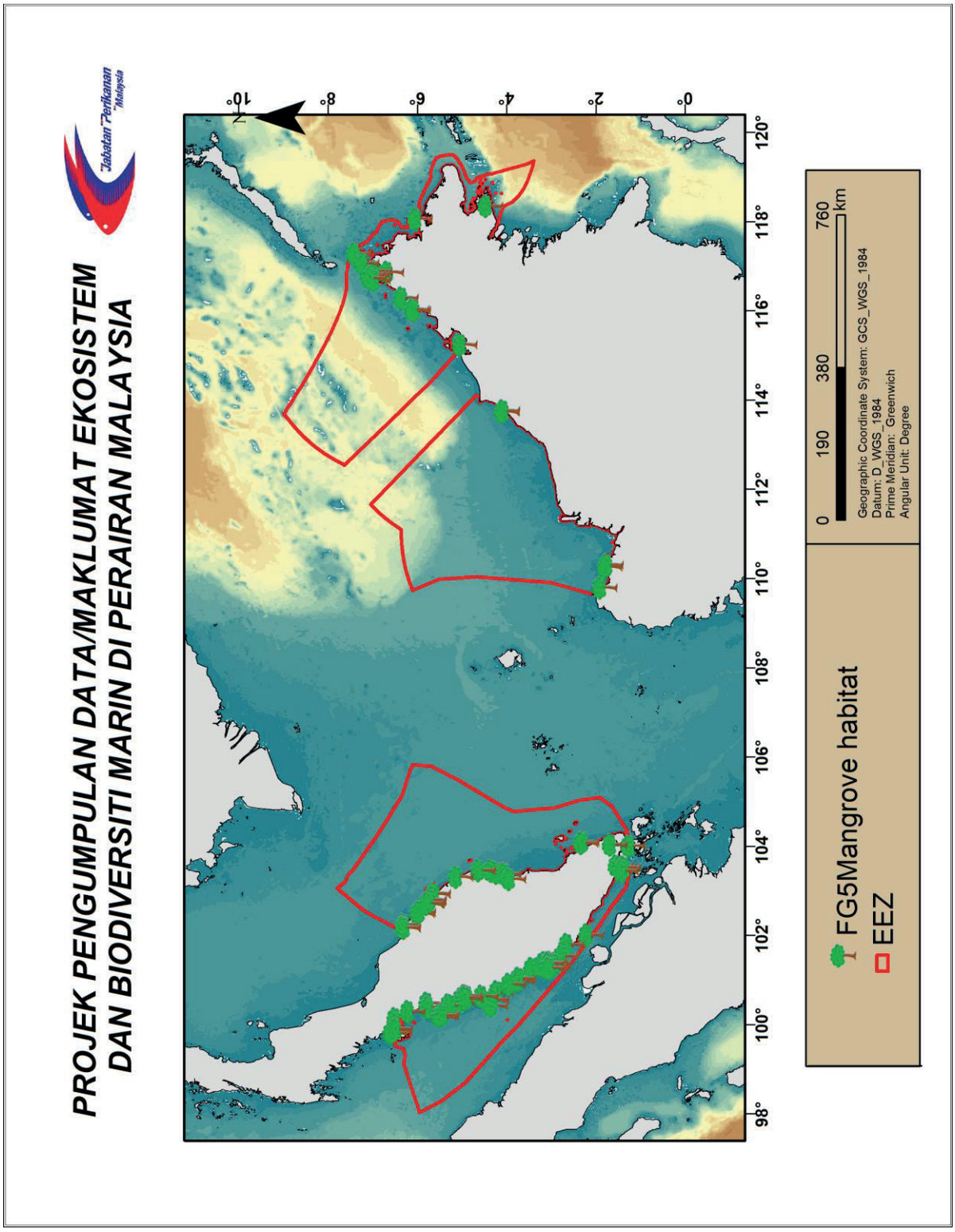

PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
FG3 NON UMT Marine
Mammals (no of ind)
75
no1
EEZ
0 190 380 760 km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree
98° 100° 102° 104° 106° 108° 110° 112° 114° 116° 118° 120°
0° 2° 4° 6° 8° 10°
N

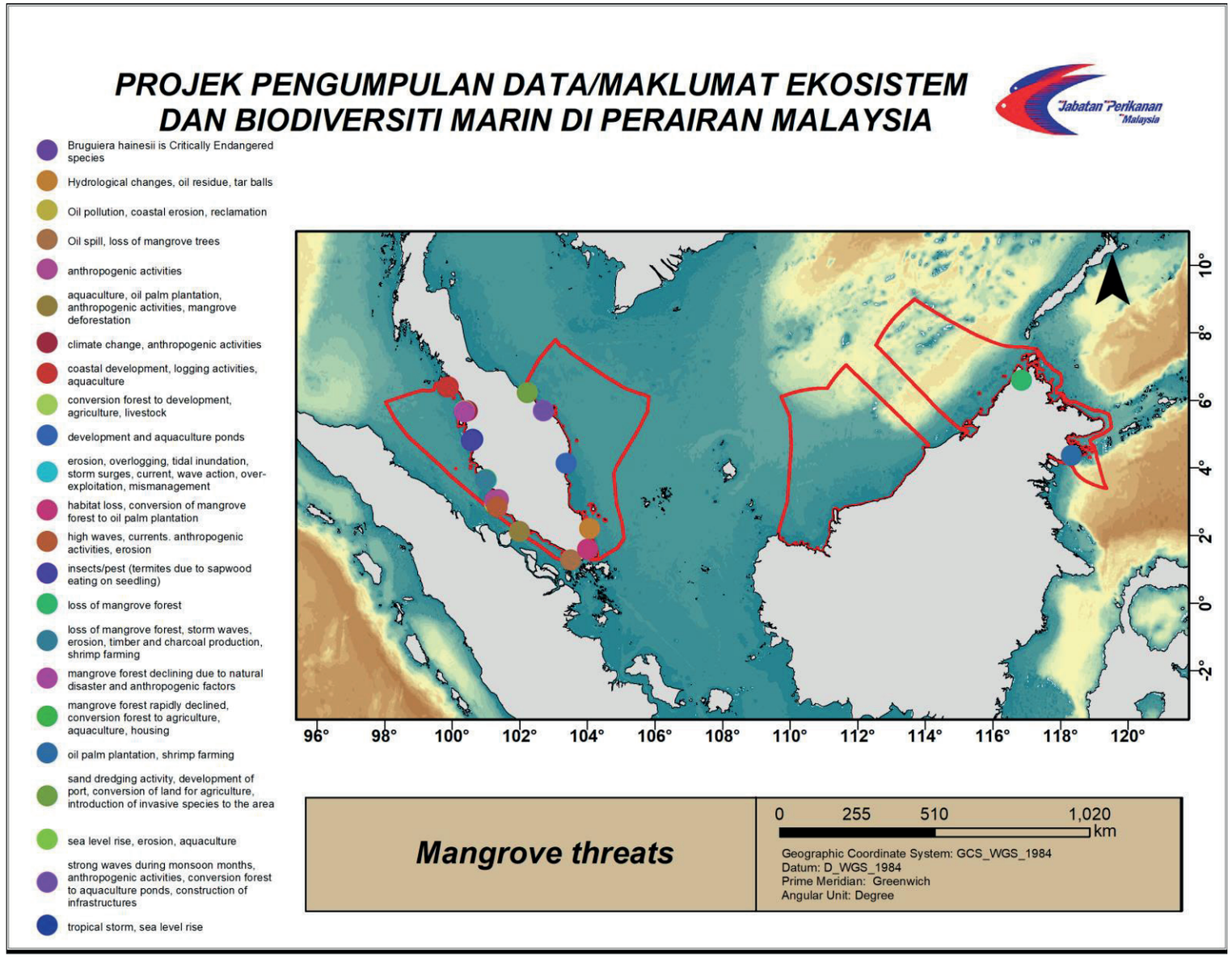

PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
N
98°
100°
102°
104°
106°
108°
110°
112°
114°
116°
118°
120°
0°
2°
4°
6°
8°
10°
FG3 nonUMT
EEZ
FG3 Non UMT Marine
Mammals Sightings
0
190
380
760
km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

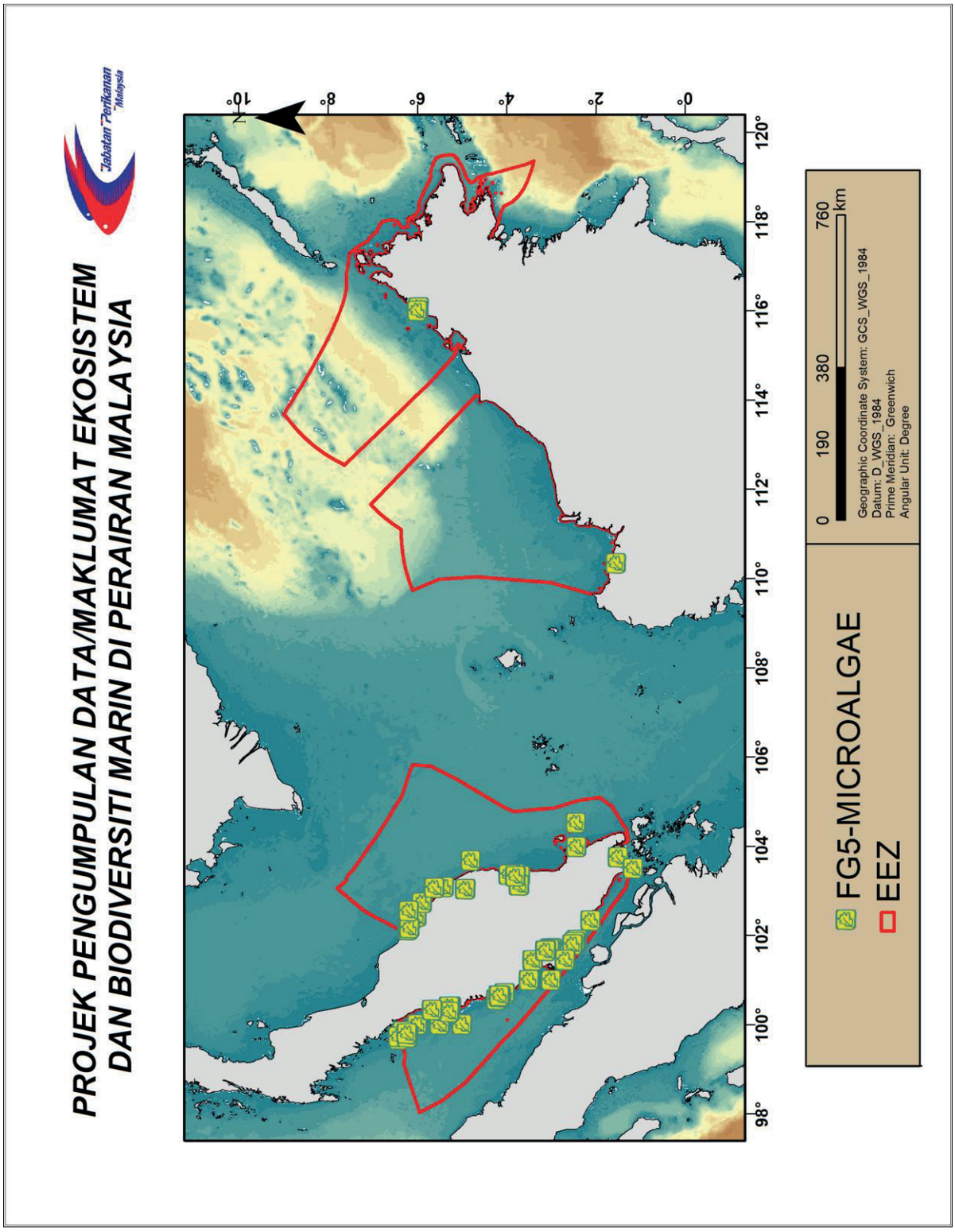

PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
FG3 UMT Marine Mammals
(no of ind)
100
Number_of
EEZ
0 190 380 760 km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree
98° 100° 102° 104° 106° 108° 110° 112° 114° 116° 118° 120°
0° 2° 4° 6° 8° 10°
N

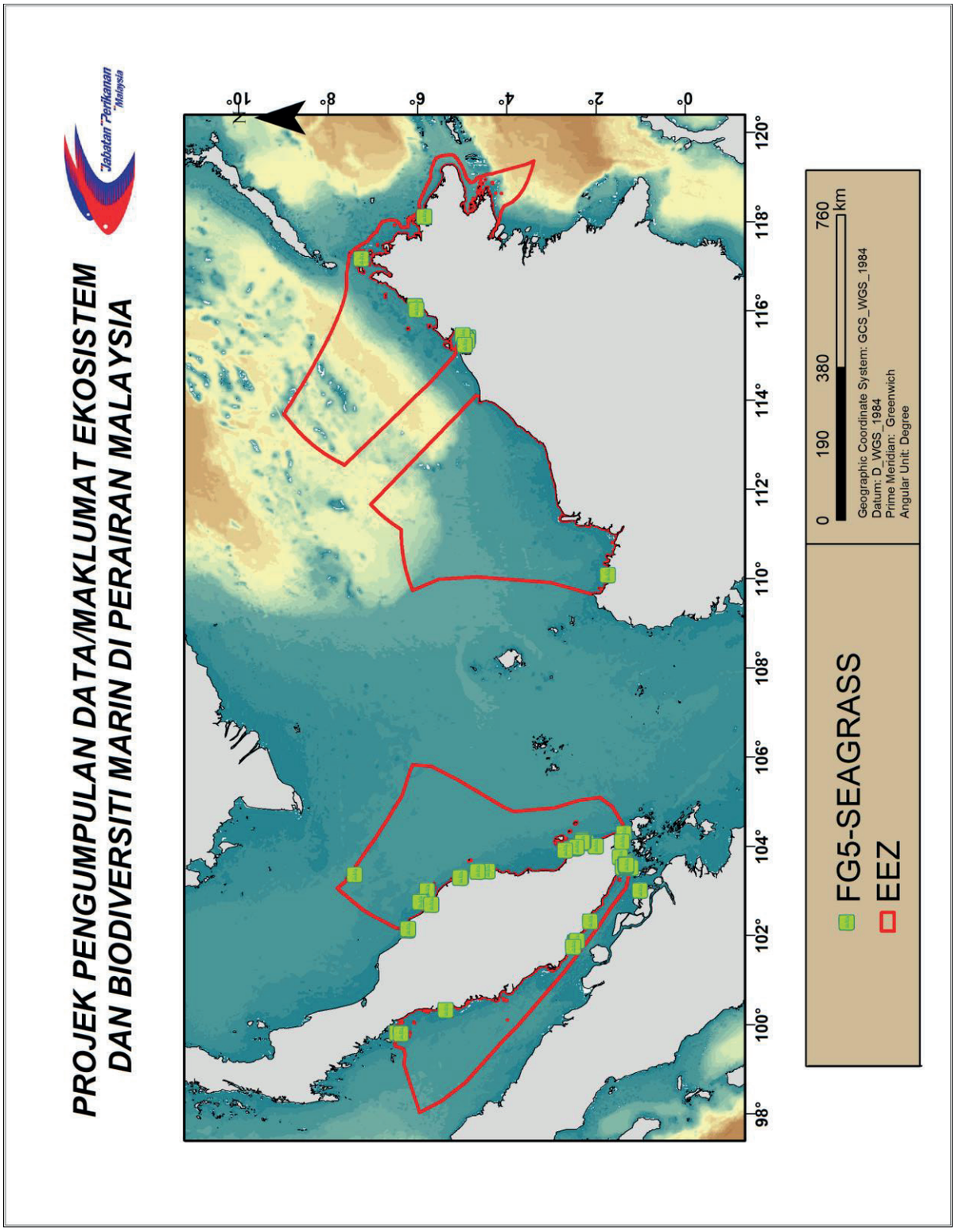

PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
N
98°
100°
102°
104°
106°
108°
110°
112°
114°
116°
118°
120°
0°
2°
4°
6°
8°
10°
FG3_INOSUMT
EEZ
FG3 UMT Marine
Mammals Sightings
0
190
380
760
km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

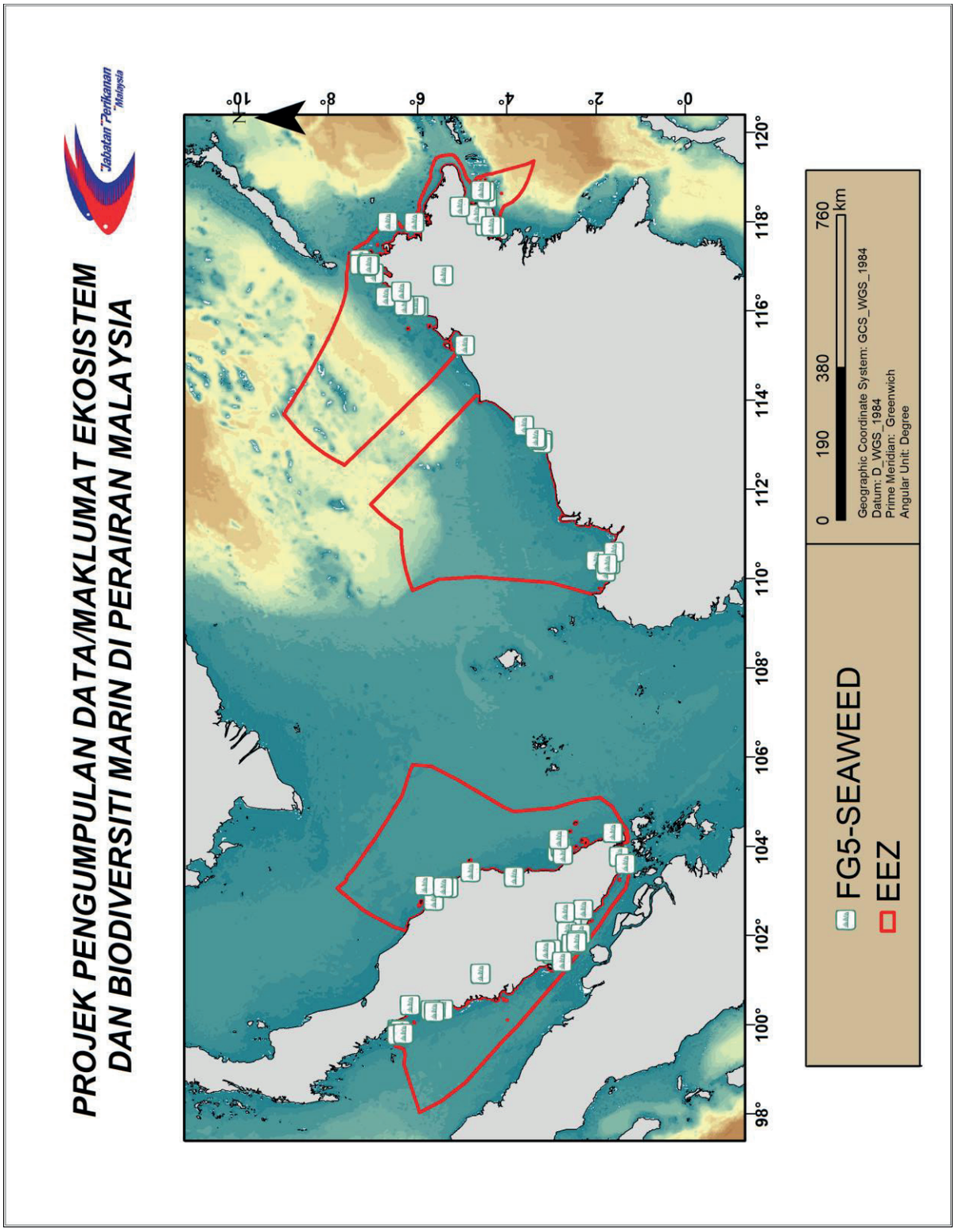

PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
FG5Mangrove coverage
20,000
Coverage
0
255
510
1,020
km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

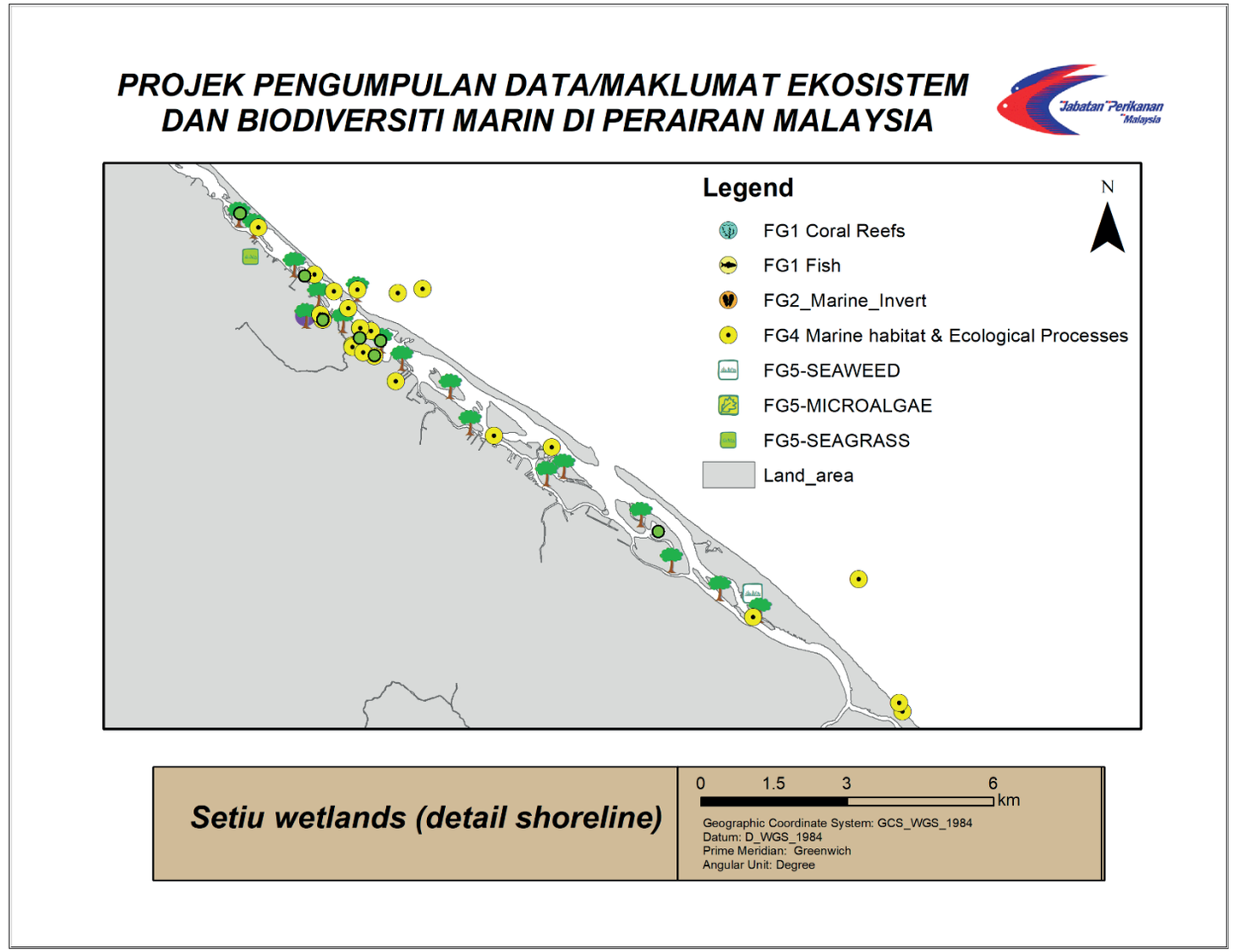

PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
98°
100°
102°
104°
106°
108°
110°
112°
114°
116°
118°
120°
10°
8°
6°
4°
2°
0°
FG5Mangrove habitat
EEZ
0
190
380
760
km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

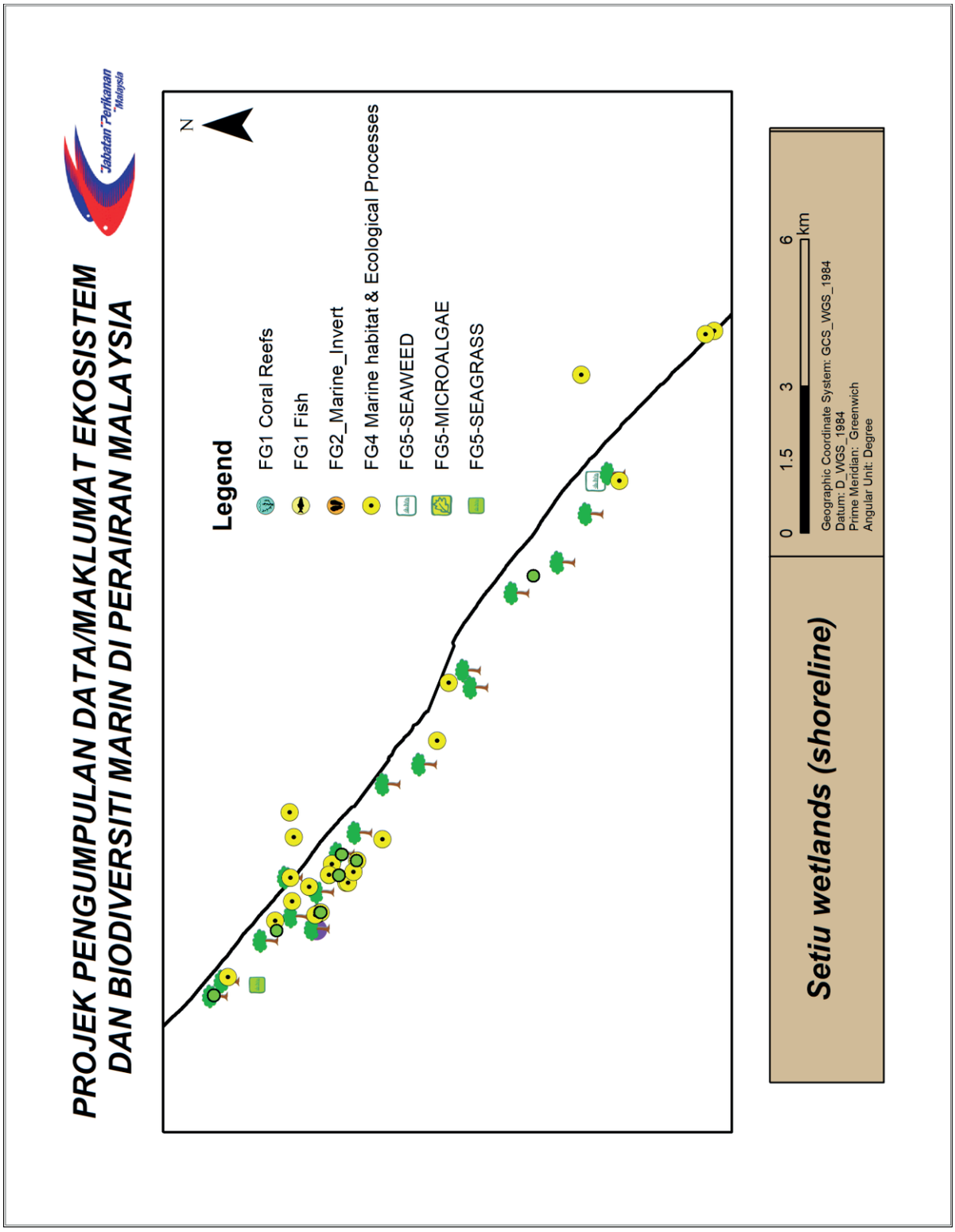

PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
Bruguiera hainesii is Critically Endangered species
Hydrological changes, oil residue, tar balls
Oil pollution, coastal erosion, reclamation
Oil spill, loss of mangrove trees
anthropogenic activities
aquaculture, oil palm plantation, anthropogenic activities, mangrove deforestation
climate change, anthropogenic activities
coastal development, logging activities, aquaculture
conversion forest to development, agriculture, livestock
development and aquaculture ponds
erosion, overlogging, tidal inundation, storm surges, current, wave action, over-exploitation, mismanagement
habitat loss, conversion of mangrove forest to oil palm plantation
high waves, currents. anthropogenic activities, erosion
insects/pest (termites due to sapwood eating on seedling)
loss of mangrove forest
loss of mangrove forest, storm waves, erosion, timber and charcoal production, shrimp farming
mangrove forest declining due to natural disaster and anthropogenic factors
mangrove forest rapidly declined, conversion forest to agriculture, aquaculture, housing
oil palm plantation, shrimp farming
sand dredging activity, development of port, conversion of land for agriculture, introduction of invasive species to the area
sea level rise, erosion, aquaculture
strong waves during monsoon months, anthropogenic activities, conversion forest to aquaculture ponds, construction of infrastructures
tropical storm, sea level rise
96° 98° 100° 102° 104° 106° 108° 110° 112° 114° 116° 118° 120°
10° 8° 6° 4° 2° 0° -2°
Mangrove threats
0 255 510 1,020 km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree


PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
FG5-MICROALGAE
EEZ
0 190 380 760 km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree
98° 100° 102° 104° 106° 108° 110° 112° 114° 116° 118° 120°
10° 8° 6° 4° 2° 0°

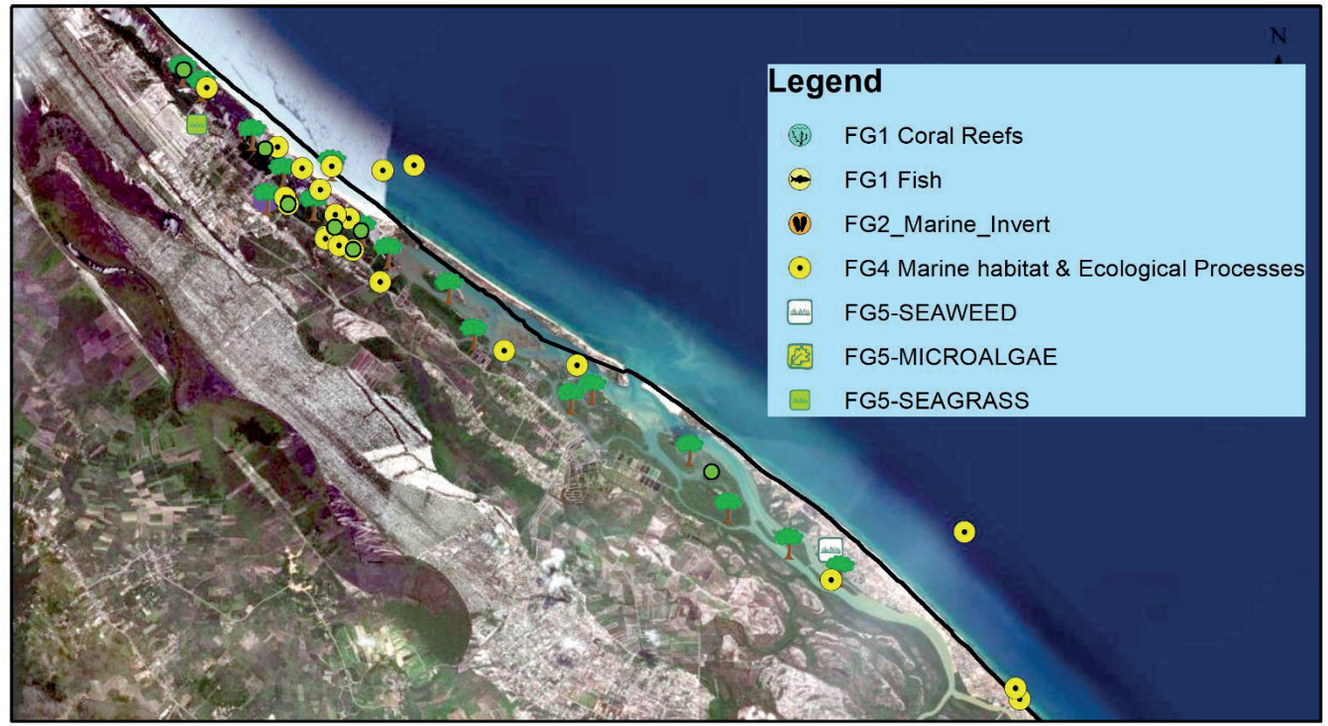

PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
98°
100°
102°
104°
106°
108°
110°
112°
114°
116°
118°
120°
10°
8°
6°
4°
2°
0°
FG5-SEAGRASS
EEZ
0
190
380
760
km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree


PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
FG5-SEAWEED
EEZ
0 190 380 760 km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree
98° 100° 102° 104° 106° 108° 110° 112° 114° 116° 118° 120°
10° 8° 6° 4° 2° 0°


PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
Legend
N
FG1 Coral Reefs
FG1 Fish
FG2_Marine_Invert
FG4 Marine habitat & Ecological Processes
FG5-SEAWEED
FG5-MICROALGAE
FG5-SEAGRASS
Land_area
Setiu wetlands (detail shoreline)
0 1.5 3 6
km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree


PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
N
Legend
FG1 Coral Reefs
FG1 Fish
FG2_Marine_Invert
FG4 Marine habitat & Ecological Processes
FG5-SEAWEED
FG5-MICROALGAE
FG5-SEAGRASS
Setiu wetlands (shoreline)
0 1.5 3 6 km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

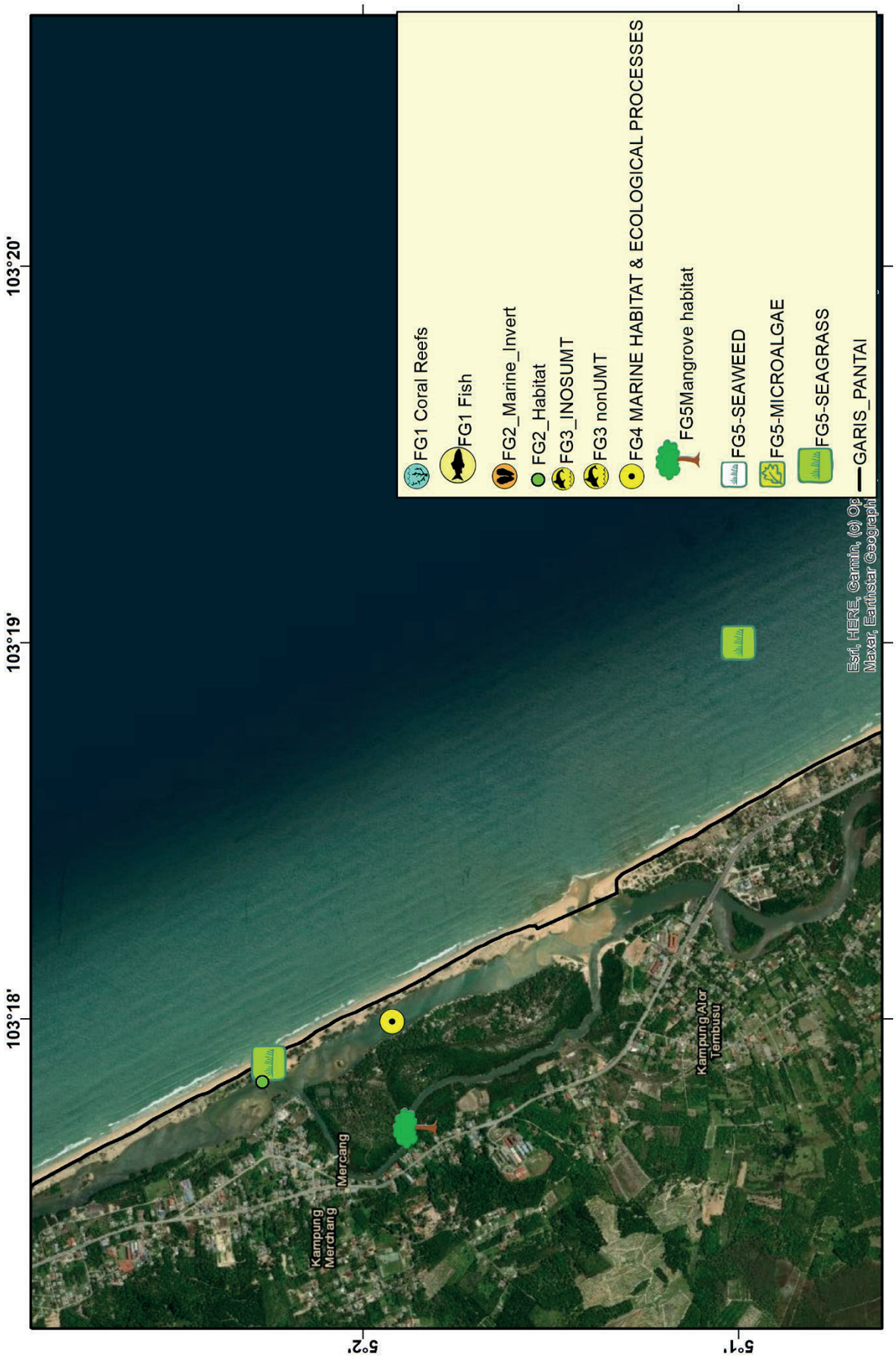
PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA

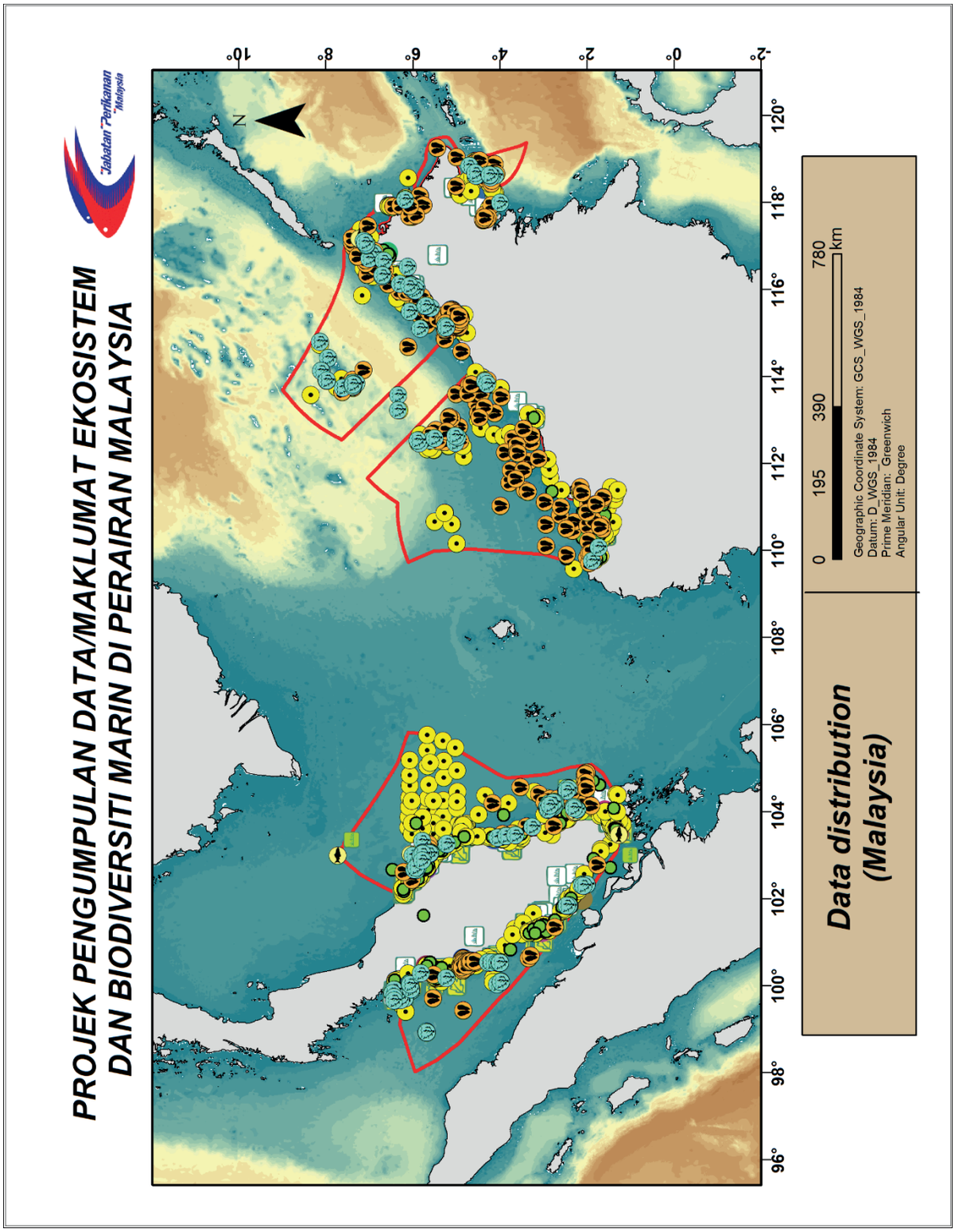


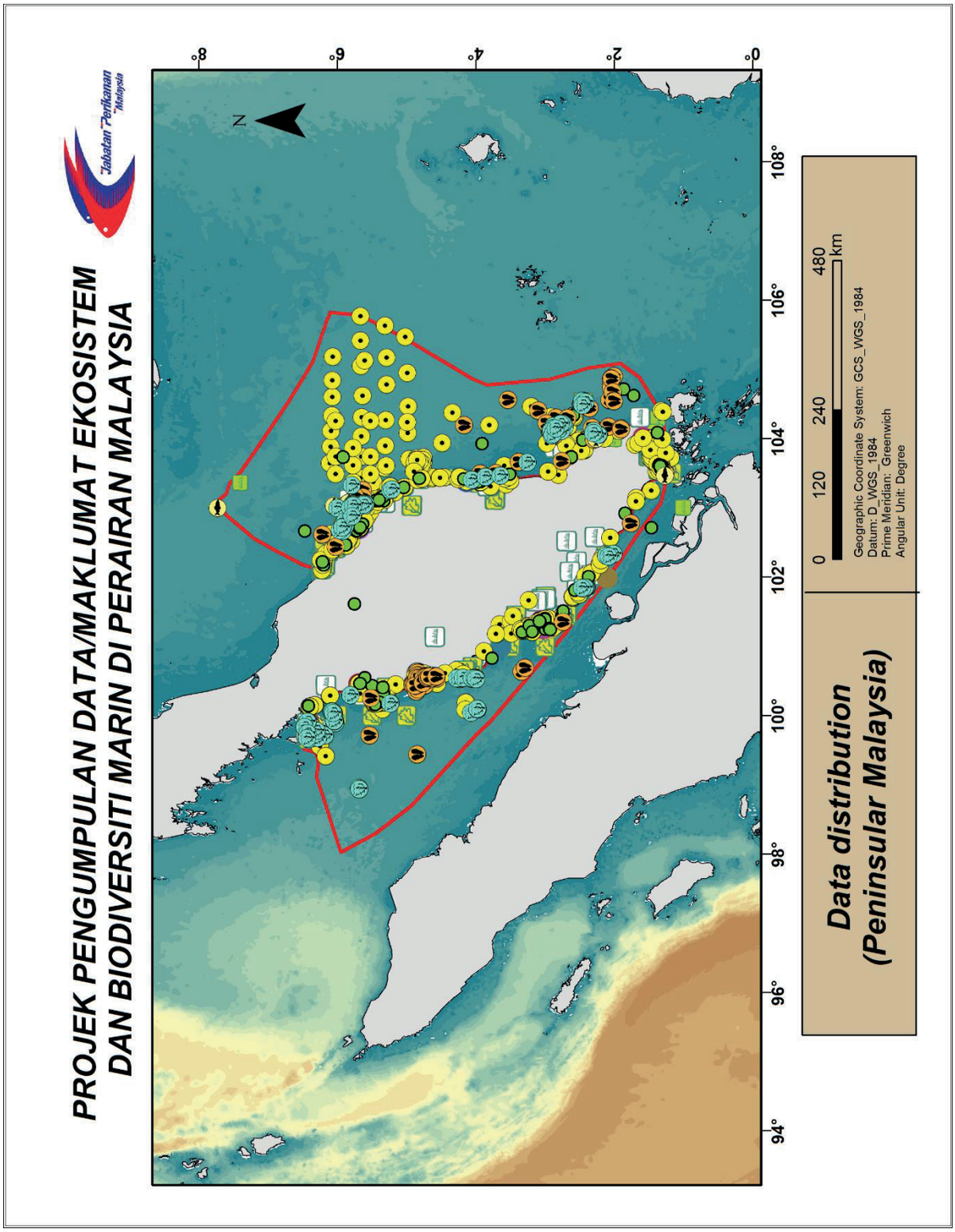
Setiu wetlands (shoreline)

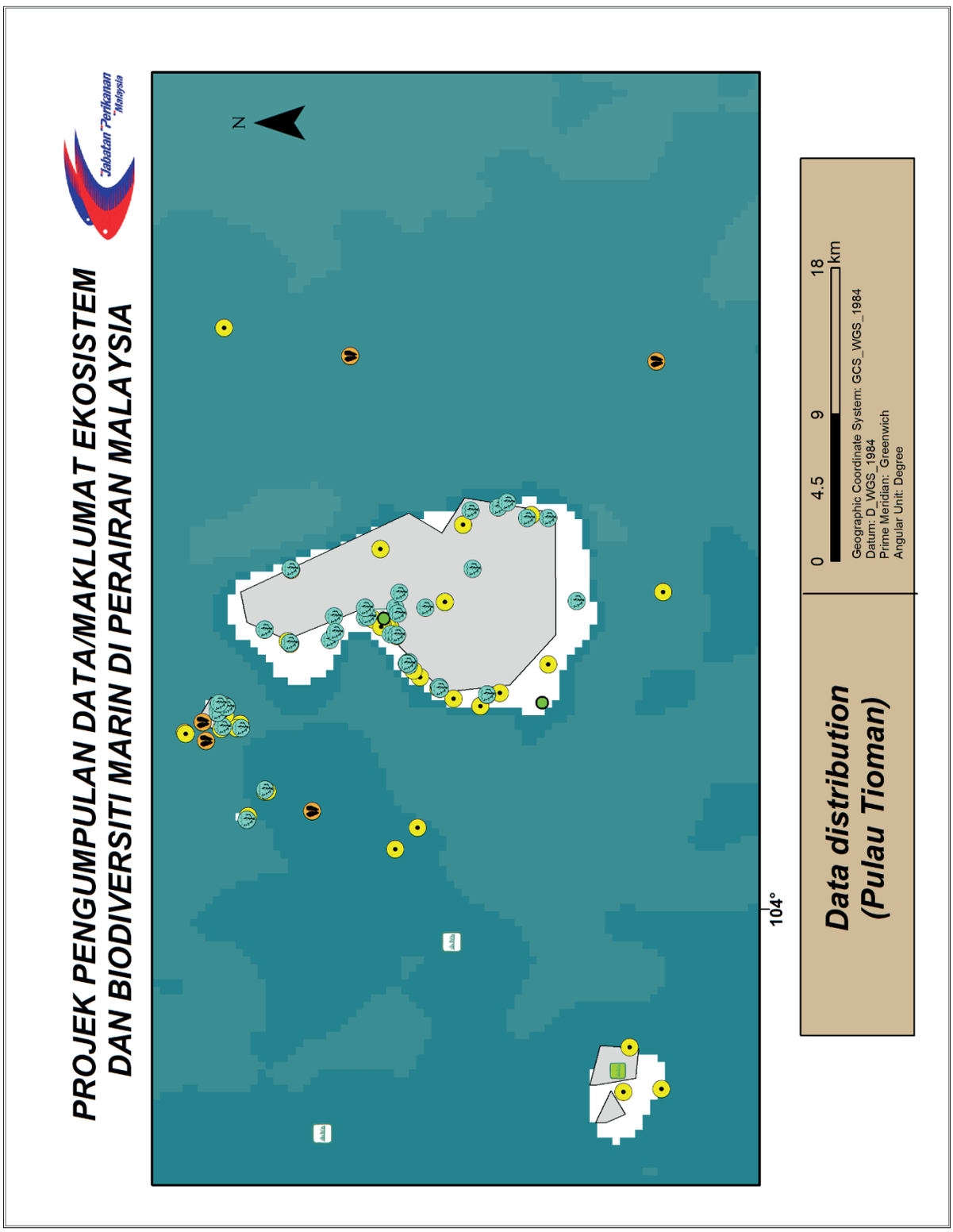
0 1.5 3 6 km

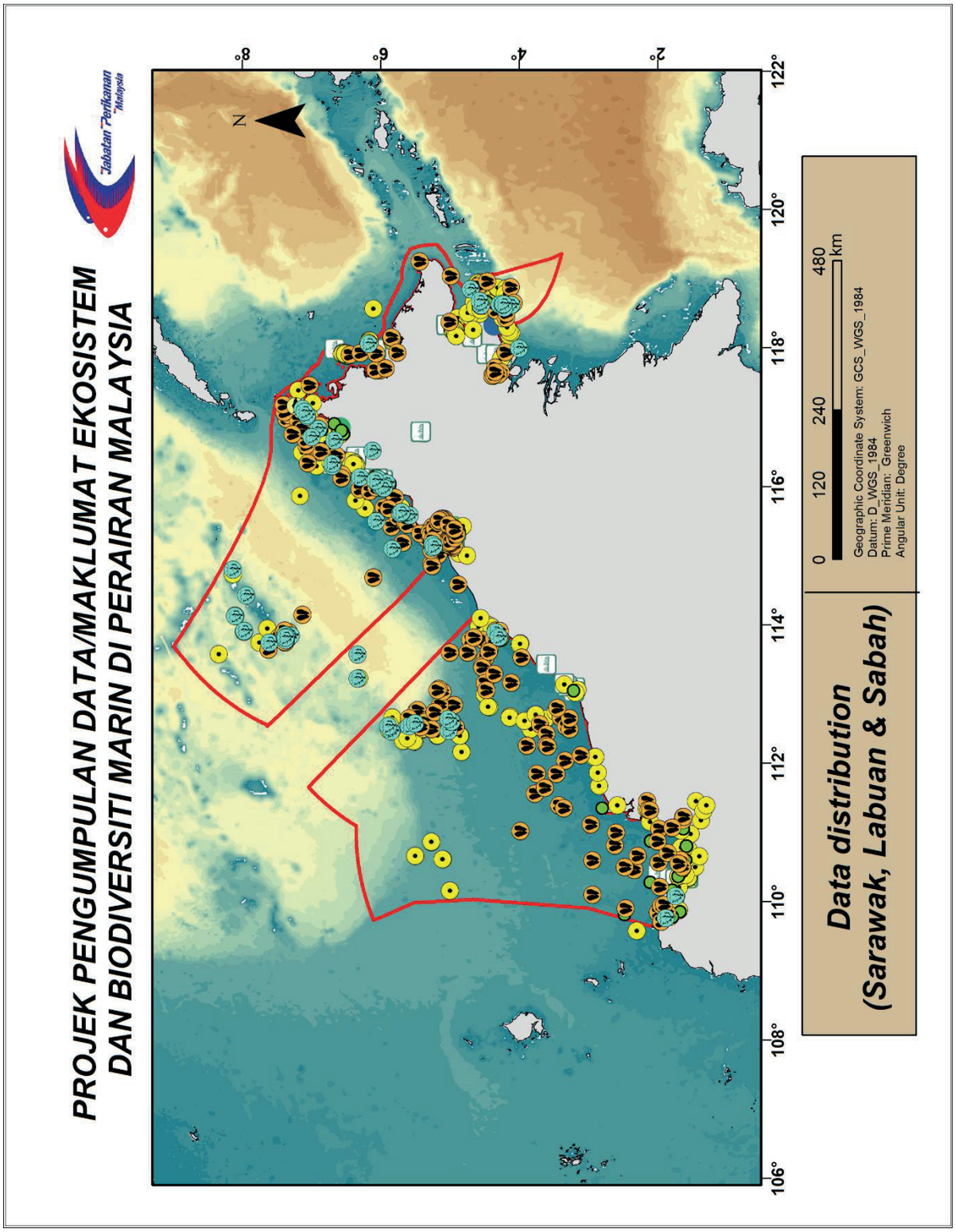
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree


103°18'
103°19'
103°20'
5°2'
5°1'
Kampung Merchang
Mercang
Kampung Alor Tembusu
FG1 Coral Reefs
FG1 Fish
FG2_Marine_Invert
FG2_Habitat
FG3_INOSUMT
FG3 nonUMT
FG4 MARINE HABITAT & ECOLOGICAL PROCESSES
FG5Mangrove habitat
FG5-SEAWEED
FG5-MICROALGAE
FG5-SEAGRASS
GARIS_PANTAI
Esri, HERE, Garmin, (c) Op
Maxar, Earthstar Geographi


PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
N
96°
98°
100°
102°
104°
106°
108°
110°
112°
114°
116°
118°
120°
10°
8°
6°
4°
2°
0°
-2°
Data distribution
(Malaysia)
0
195
390
780
km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree


PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
Data distribution
(Peninsular Malaysia)
0 120 240 480 km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree
N
94°
96°
98°
100°
102°
104°
106°
108°
0°
2°
4°
6°
8°


PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
N
104°
Data distribution
(Pulau Tioman)
0 4.5 9 18
km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree


PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM
DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA
Jabatan Perikanan Malaysia
N
8°
6°
4°
2°
106°
108°
110°
112°
114°
116°
118°
120°
122°
Data distribution
(Sarawak, Labuan & Sabah)
0
120
240
480
km
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

7.0 METADATA

Metadata has been provided for each layer of digital data produced. The metadata content for each GIS data layer includes the file name, file format, projection system, data source and year, data layer types and attribute. All metadata is located in the Appendices.

REFERENCES

Afanador Franco, F., Molina Jiménez, M. P., Pusquin Ospina, L. T., Guevara Cañas, N., González Bustillo, M. J., Martínez Uparela, K. I., Banda Lepesquer, C., Escobar Olaya, G. A., & Castro Mercado, I. (2021). Coastal Marine Planning: Vision of the Maritime Authority. Case of the Department of Bolivar, Colombia. *Revista Costas*, *6*(Vol Esp. 2). https://doi.org/10.26359/costas.e0721

Al-Umar, M., Fall, M., & Daneshfar, B. (2020). GIS-based modeling of snowmelt-induced landslide susceptibility of sensitive marine clays. *Geoenvironmental Disasters*, *7*(1). https://doi.org/10.1186/s40677-020-0142-8

Al-Umar, M., Fall, M., & Daneshfar, B. (2021). GIS based assessment of rainfall-induced landslide susceptibility of sensitive marine clays: a case study. *Geomechanics and Geoengineering*. https://doi.org/10.1080/17486025.2021.1955152

Arc Marine – GIS for a Blue Planet. (2008). *Marine Biology Research*, *4*(4). https://doi.org/10.1080/17451000802126712

Baldwin, K., & Mahon, R. (2014). A participatory GIS for marine spatial planning in the Grenadine Islands. *Electronic Journal of Information Systems in Developing Countries*, *63*(1). https://doi.org/10.1002/j.1681-4835.2014.tb00452.x

Brown, G., Strickland-Munro, J., Kobryn, H., & Moore, S. A. (2016). Stakeholder analysis for marine conservation planning using public participation GIS. *Applied Geography*, *67*. https://doi.org/10.1016/j.apgeog.2015.12.004

Costanza, A. B., Guidino, C., Mangel, J. C., Alfaro-Shigueto, J., Verutes, G., Caillat, M., Samanta, A., & Hines, E. (2021). Participatory Risk Assessment of Humpback Whale (Megaptera novaeangliae) and Leatherback Turtle (Dermochelys coriacea) Bycatch in Northern Peru. *Frontiers in Marine Science*, *8*. https://doi.org/10.3389/fmars.2021.776965

Ding, X. (2021a). GIS-based marine atmospheric environment and fishery company governance structure. *Arabian Journal of Geosciences*, *14*(15). https://doi.org/10.1007/s12517-021-07713-z

Ding, X. (2021b). Retraction Note: GIS-based marine atmospheric environment and fishery company governance structure. *Arabian Journal of Geosciences*, *14*(23). https://doi.org/10.1007/s12517-021-09103-x

Ding, X., & Li, F. (2021a). Application of GIS real-time monitoring system in the ecological impact of marine tourism industry development and marine resource protection. *Arabian Journal of Geosciences*, *14*(10). https://doi.org/10.1007/s12517-021-07210-3

Ding, X., & Li, F. (2021b). Retraction Note to: Application of GIS real-time monitoring system in the ecological impact of marine tourism industry development and marine resource protection. *Arabian Journal of Geosciences*, *14*(23). https://doi.org/10.1007/s12517-021-09071-2

Drackett, L., & Dragićević, S. (2021). Suitability Analysis of Acoustic Refugia for Endangered Killer Whales (Orcinus orca) Using the GIS-based Logic Scoring of Preference Method. *Environmental Management*, *68*(2). https://doi.org/10.1007/s00267-021-01481-y

Fauzi, A. I., Sakti, A. D., Robbani, B. F., Ristiyani, M., Agustin, R. T., Yati, E., Nuha, M. U., Anika, N., Putra, R., Siregar, D. I., Prasetyo, B. A., Julzarika, A., & Wikantika, K. (2021). Assessing potential climatic and human pressures in indonesian coastal ecosystems using a spatial data-driven approach. *ISPRS International Journal of Geo-Information*, *10*(11). https://doi.org/10.3390/ijgi10110778

Fernández-Salvador, S., García Sanabria, J., & García-Onetti, J. (2021). Basis for Marine Spatial Planning (MSP). An interpretation for the Gulf of Cadiz. *Revista Costas*, *6*(Vol Esp. 2). https://doi.org/10.26359/costas.e1321

Fustes, D., Cantorna, D., Dafonte, C., Arcay, B., Iglesias, A., & Manteiga, M. (2014). A cloud-integrated web platform for marine monitoring using GIS and remote sensing. Application to oil spill detection through SAR images. *Future Generation Computer Systems*, *34*. https://doi.org/10.1016/j.future.2013.09.020

Gold, C. M., Goralski, R., & Ledoux, H. (2003). {D}evelopment of a `{Marine GIS}'. *Proceedings 21st International Cartographic Conference*, *August*.

Gregory, D. J., Bennike, O., Jensen, J. B., Rasmussen, P., & Al-Hamdani, Z. (2021). Development of Predictive Geoarchaeological Models to Locate and Assess the Preservation Potential of Submerged Prehistoric Sites Using Remote Sensing, Palaeoenvironmental Analysis, and GIS. *Heritage*, *4*(4). https://doi.org/10.3390/heritage4040258

Haghshenas, E., Gholamalifard, M., Mahmoudi, N., & Kutser, T. (2021). Developing a gis-based decision rule for sustainable marine aquaculture site selection: An application of the ordered weighted average procedure. *Sustainability (Switzerland)*, *13*(5). https://doi.org/10.3390/su13052672

Hamdani, Y., Thibaud, R., & Claramunt, C. (2021). A hybrid data model for dynamic GIS: application to marine geomorphological dynamics. *International Journal of Geographical Information Science*, *35*(8). https://doi.org/10.1080/13658816.2020.1829628

Hidayah, Z., & Wiyanto, D. B. (2021). Pemodelan Sistem Informasi Geografis untuk Pemetaan Kesesuaian Wilayah Perairan dan Pesisir Selat Madura. *Rekayasa*, *14*(1). https://doi.org/10.21107/rekayasa.v14i1.9987

Jarvis, C. (2019). Bureau of Ocean Energy Management Uses GIS to Manage Marine Minerals. *ArcNews*.

Jurkus, E., Taminskas, J., Povilanskas, R., Kontautienė, V., Baltranaitė, E., Dailidė, R., & Urbis, A. (2021). Delivering tourism sustainability and competitiveness in seaside and marine resorts with gis. *Journal of Marine Science and Engineering*, *9*(3). https://doi.org/10.3390/jmse9030312

Kao, S. L., Chang, K. Y., & Hsu, T. W. (2021). A marine gis-based alert system to prevent vessels collision with offshore platforms. *Journal of Marine Science and Technology (Taiwan)*, *29*(5). https://doi.org/10.51400/2709-6998.2462

Katselis, G., Tsolakos, K., & Theodorou, J. A. (2022). Mapping of Greek Marine Finfish Farms and Their Potential Impact on the Marine Environment. *Journal of Marine Science and Engineering*, *10*(2). https://doi.org/10.3390/jmse10020286

Kaymaz, Ş. M., & Yabanlı, M. (2017). A REVIEW: APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN MARINE AREAS. *Journal of Aquaculture Engineering and Fisheries Research*. https://doi.org/10.3153/jaefr170021

Koski, C., Rönneberg, M., Kettunen, P., Armoškaitė, A., Strake, S., & Oksanen, J. (2021). User experiences of using a spatial analysis tool in collaborative GIS for maritime spatial planning. *Transactions in GIS*, *25*(4). https://doi.org/10.1111/tgis.12827

Laskin, D. N., & Duffus, D. (2007). A Marine GIS Case Study of Micro-scale Gray Whale (Eschrichtius robustus) Habitat-use Off Vancouver Island, British Columbia. *Department of Geography*.

Liu, B., Wu, X., Liu, X., & Gong, M. (2021). Assessment of ecological stress caused by maritime vessels based on a comprehensive model using AIS data: Case study of the Bohai Sea, China. *Ecological Indicators*, *126*. https://doi.org/10.1016/j.ecolind.2021.107592

Liu, Q., Zhai, G., & Lu, X. (2021). Integrated land-sea surveying and mapping of intertidal zone based on high-definition remote sensing images and GIS technology. *Microprocessors and Microsystems*, *82*. https://doi.org/10.1016/j.micpro.2021.103937

Ma, H., Wang, P., Wen, Y., & Yang, C. (2021). Research on key technologies of 3D visualization of marine environmental field. *Journal of Physics: Conference Series*, *2006*(1). https://doi.org/10.1088/1742-6596/2006/1/012042

Malawani, M. N., Marfai, M. A., Yoga, A. G. H., Handayani, T., Cahyadi, A., Sadali, M. I., Mahasin, M. Z., Hendratmoro, Suadi, & Wiyono, M. B. (2021). Rapid Land Assessment for Salt Farming Development in the Coastal Area of the Special Region of Yogyakarta, Indonesia. *ASEAN Journal on Science and Technology for Development*, *38*(3). https://doi.org/10.29037/ajstd.694

Marcelli, M., Frattarelli, F. M., Piermattei, V., Scanu, S., Bonamano, S., Piazzolla, D., & Zappalà, G. (2021). SEA USE MAP: GIS SUPPORTING MARINE AREA'S SUSTAINABLE DEVELOPMENT. *WIT Transactions on Engineering Sciences*, *130*. https://doi.org/10.2495/CMEM210021

Mugo, R., Saitoh, S.-I., Nihira, A., & Kuroyama, T. (2011). Application of multi-sensor satellite and fishery data, statistical models and marine-GIS to detect habitat preferences of skipjack tuna. *Handbook of Satellite Remote Sensing Image Interpretation: Applications for Marine Living Resources Conservation and Management.*

Mutia, D., & Sailale, I. (2021). Application of Remote Sensing and GIS to Identifying Marine Fisheries off the Coasts of Kenya and Tanzania. In *Oceanography* (Vol. 34, Issue 4). https://doi.org/10.5670/oceanog.2021.supplement.02-18

Nikolakopoulos, K. G., Koukouvelas, I. K., & Lampropoulou, P. (2022). UAV, GIS, and Petrographic Analysis for Beachrock Mapping and Preliminary Analysis in the Compressional Geotectonic Setting of Epirus, Western Greece. *Minerals*, *12*(4). https://doi.org/10.3390/min12040392

Noble, M. M., Harasti, D., Pittock, J., & Doran, B. (2019). Linking the social to the ecological using GIS methods in marine spatial planning and management to support resilience: A review. *Marine Policy*, *108*. https://doi.org/10.1016/j.marpol.2019.103657

Noble, M. M., Harasti, D., Pittock, J., & Doran, B. (2021). Using GIS fuzzy-set modelling to integrate social-ecological data to support overall resilience in marine protected area spatial planning: A case study. *Ocean and Coastal Management*, *212*. https://doi.org/10.1016/j.ocecoaman.2021.105745

Norman, S. A. (2008). Spatial epidemiology and GIS in marine mammal conservation medicine and disease research. In *EcoHealth* (Vol. 5, Issue 3). https://doi.org/10.1007/s10393-008-0185-x

PLANMalaysia (2021) Rancangan Fizikal Zon Persisir Pantai Negara 2 (RFZPPN2). Jilid 1.

PLANMalaysia (2021) Rancangan Fizikal Zon Persisir Pantai Negara 2 (RFZPPN2). Jilid 2

PLANMalaysia (2021) Rancangan Fizikal Zon Persisir Pantai Negara 2 (RFZPPN2). Jilid 3

PLANMalaysia (2021) Rancangan Fizikal Zon Persisir Pantai Negara 2 (RFZPPN2). Ringkasan Eksekutif

Pataki, Z., & Kitsiou, D. (2022). Marine Spatial Planning: Assessment of the intensity of conflicting activities in the marine environment of the Aegean Sea. *Ocean and Coastal Management*, *220*. https://doi.org/10.1016/j.ocecoaman.2022.106079

Perea-Ardila, M. A., Oviedo-Barrero, F., Monsalve-Rocha, S., & Ocampo-Rojas, M. A. (2021). Identification of Synergies and Conflicts in Coastal and Marine uses in Colombian Pacific: a Spatial Multi-Criteria Analysis. *Revista Costas*, *6*(Vol Esp. 2). https://doi.org/10.26359/costas.e0821

Polo-Castañeda, M., Gómez-Rojas, J., & Linero-Cueto, J. (2021). Application of AHP and GIS for Determination of Suitable Wireless Sensor Network Zones for Oceanographic Monitoring in the South Caribbean Sea Upwelling Zone. *International Journal on Advanced Science, Engineering and Information Technology*, *11*(5). https://doi.org/10.18517/ijaseit.11.5.14293

Saitoh, S. I., Mugo, R., Radiarta, I. N., Asaga, S., Takahashi, F., Hirawake, T., Ishikawa, Y., Awaji, T., In, T., & Shima, S. (2011). Some operational uses of satellite remote sensing and marine GIS for sustainable fisheries and aquaculture. *ICES Journal of Marine Science*, *68*(4). https://doi.org/10.1093/icesjms/fsq190

Scully-Engelmeyer, K. M., Granek, E. F., Nielsen-Pincus, M., & Brown, G. (2021). Participatory GIS mapping highlights indirect use and existence values of coastal resources and marine conservation areas. *Ecosystem Services*, *50*. https://doi.org/10.1016/j.ecoser.2021.101301

Shih, Y.-C. (2021). Studies on Integrated GIS and AHP for Marine Aquaculture Site Selection in Penghu Cove in Taiwan. In *Modern Advances in Geography, Environment and Earth Sciences Vol. 5*. https://doi.org/10.9734/bpi/magees/v5/8723d

st. Martin, K. (2004). GIS in Marine Fisheries Science and Decision-Making. *GIS in Fisheries*, *June*.

Stancheva, M., Stanchev, H., Young, R., & Parlichev, G. (2021). Coastal erosion driven Land-Sea Interactions in Maritime Spatial Planning - a case of Bulgaria. *Journal of Coastal Conservation*, *25*(6). https://doi.org/10.1007/s11852-021-00841-4

Sudo, K., Quiros, T. E. A. L., Prathep, A., Luong, C. van, Lin, H. J., Bujang, J. S., Ooi, J. L. S., Fortes, M. D., Zakaria, M. H., Yaakub, S. M., Tan, Y. M., Huang, X., & Nakaoka, M. (2021). Distribution, Temporal Change, and Conservation Status of Tropical Seagrass Beds in Southeast Asia: 2000–2020. *Frontiers in Marine Science*, *8*. https://doi.org/10.3389/fmars.2021.637722

Sunkur, R., & Bokhoree, C. (2021). APPLICATION OF A GIS BASED APPROACH TO ASSESS THE ENVIRONMENTAL IMPACTS OF THE MV WAKASHIO OIL SPILL IN THE SOUTHEAST OF MAURITIUS. *International Journal of Engineering Applied Sciences and Technology*, *6*(4). https://doi.org/10.33564/ijeast.2021.v06i04.002

Tarmidi, Z., Rashid, A., Shariff, M., Zaiton, Z., & Mahmud, A. R. (2021). Collaboration Model to Enable Marine Spatial Data Sharing Implementation in Malaysia. *Singapore SG May*, *June*.

Triana, K., & Wahyudi, A. J. (2020). GIS Developments for Ecosystem-based Marine Spatial Planning and the Challenges Faced in Indonesia. *ASEAN Journal on Science and Technology for Development*, *36*(3). https://doi.org/10.29037/ajstd.587

Valavanis, V. D., Katara, I., & Palialexis, A. (2005). Marine GIS: Identification of mesoscale oceanic thermal fronts. *International Journal of Geographical Information Science*, *19*(10). https://doi.org/10.1080/13658810500391206

Wang, J. (2021). Marine atmospheric anomaly detection-based on GIS and research on process product design. In *Arabian Journal of Geosciences* (Vol. 14, Issue 17). https://doi.org/10.1007/s12517-021-07895-6

Wang, J., Yang, X., Wang, Z., Ge, D., & Kang, J. (2022). Monitoring Marine Aquaculture and Implications for Marine Spatial Planning—An Example from Shandong Province, China. *Remote Sensing*, *14*(3). https://doi.org/10.3390/rs14030732

Wright, D., & Heyman, W. (2008). Introduction to the special issue: Marine and Coastal GIS for Geomorphology, habitat mapping, and marine reserves. In *Marine Geodesy* (Vol. 31, Issue 4). https://doi.org/10.1080/01490410802466306

Xu, J., & Yan, P. (2022). GIS-Based Remote Sensing Image Information Analysis of the South Atlantic Ecological Environment and Diversity of Deep-Sea Microorganism with Antifungal Effects. *Advances in Mathematical Physics*, *2022*. https://doi.org/10.1155/2022/1677858

Yang, S., Fang, Q., Ikhumhen, H. O., Meilana, L., & Zhu, S. (2022). Marine spatial planning for transboundary issues in bays of Fujian, China: A hierarchical system. *Ecological Indicators*, *136*. https://doi.org/10.1016/j.ecolind.2022.108622

Yulianda, F., & Mazaya, A. F. A. (2021). Potential carrying capacity of marine ecotourism in Sub-region III of Seribu Islands Marine National Park. *IOP Conference Series: Earth and Environmental Science*, *744*(1). https://doi.org/10.1088/1755-1315/744/1/012106

Zhen, R., Shao, Z., & Pan, J. (2021). Advance in Character Mining and Prediction of Ship Behavior based on AIS Data. *Journal of Geo-Information Science*, *23*(12). https://doi.org/10.12082/dqxxkx.2021.210495

Zilio, L., Hammond, H., Karampaglidis, T., Sánchez-Romero, L., Blasco, R., Rivals, F., Rufà, A., Picin, A., Chacón, M. G., Demuro, M., Arnold, L. J., & Rosell, J. (2021). Examining Neanderthal and carnivore occupations of Teixoneres Cave (Moià, Barcelona, Spain) using archaeostratigraphic and intra-site spatial analysis. *Scientific Reports*, *11*(1). https://doi.org/10.1038/s41598-021-83741-9

2.0 Appendices (metadata)

Contents | Preview | Description

Print | Edit | Validate | Export | Import

Bathymetry

Raster Dataset

Thumbnail Not Available

Tags
Bathymetry

Summary
PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA

Description
Kedalaman laut dalam meter

Credits
FG7 : UMT

Use limitations
There are no access and use limitations for this item.

Extent

West	92.194789	**East**	124.919789
North	12.767422	**South**	-5.103411

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

ArcGIS Metadata ▶

Topics and Keywords ▶

Contents | Preview | Description

Print | Edit | Validate | Export | Import

Malaysia exclusive economic zone

Shapefile

Thumbnail Not Available

Tags
Malaysia EEZ

Summary
PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA

Description
Sempadan zon ekonomi ekskludsif Malaysia

Credits
FG7 : UMT
https://www.marineregions.org/gazetteer.php?p=details&id=8483

Use limitations
There are no access and use limitations for this item.

Extent

West	98.025000	**East**	119.494532
North	8.990886	**South**	1.212301

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

ArcGIS Metadata ▶

Contents | Preview | Description

Print | Edit | Validate | Export | Import

G0118_UPZP_JOHOR

Shapefile

Thumbnail Not Available

Tags
Gunatanah Semasa

Summary
Kajian Rancangan Fizikal Zon Persisiran Pantai Negara (RFZPPN Ke-2)

Description
Gunatanah Semasa mengikut sempadan Unit Perancangan Zon Persisiran Pantai Negeri Johor. Tarikh akhir kemaskini data pada tahun 2018

Credits
PLANMalaysia@Bahagian Maklumat Guna tanah Negara (BMGN), APUDG

Use limitations
There are no access and use limitations for this item.

Extent

West	102.487947	**East**	104.550741
North	2.663678	**South**	1.265780

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

ArcGIS Metadata ▶

Contents | Preview | Description

Print | Edit | Validate | Export | Import

G0218_UPZP_KEDAH

Shapefile

Thumbnail Not Available

Tags
Gunatanah Semasa

Summary
Kajian Rancangan Fizikal Zon Persisiran Pantai Negara Ke-2 (RFZPPN Ke-2)

Description
Gunatanah Semasa mengikut sempadan Unit Perancangan Zon Persisiran Pantai Negeri Kedah. Tarikh akhir kemaskini data pada tahun 2018

Credits
PLANMalaysia@Bahagian Maklumat Gunatanah Negara (BMGN), APUDG

Use limitations
There are no access and use limitations for this item.

Extent

West	99.603421	**East**	100.482491
North	6.477623	**South**	5.568563

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

ArcGIS Metadata ▶

Topics and Keywords ▶

Contents | Preview | Description

Print | Edit | Validate | Export | Import

Shoreline

Shapefile

Thumbnail Not Available

Tags
shoreline

Summary
Shoreline

Description
PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA

Credits
https://shoreline.noaa.gov/data/datasheets/medres.html

Use limitations
There are no access and use limitations for this item.

Extent

West	92.221366	**East**	124.950852
North	12.715979	**South**	-5.165671

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

ArcGIS Metadata ▶

Topics and Keywords ▶

Contents | Preview | Description

Print | Edit | Validate | Export | Import

SEMPADAN_UPZP

Shapefile

Thumbnail Not Available

Tags
SEMPADAN_UPZP

Summary
Sempadan Unit Perancangan Zon Pesisiran Pantai Semenanjung Malaysia dan WP Labuan

Description
There is no description for this item.

Credits
PLANMalaysia

Use limitations
There are no access and use limitations for this item.

Extent

West	98.884100	**East**	115.336335
North	6.523029	**South**	1.212394

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

ArcGIS Metadata ▶

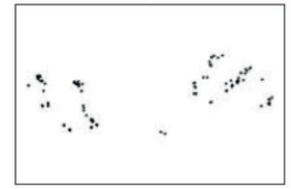
Topics and Keywords ▶

Contents | Preview | Description

Print | Edit | Validate | Export | Import

Coral Reefs

Shapefile



Tags
Coral Reefs Distribution

Summary
PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA

Description
Taburan lokasi terumbu karang di dalam perairan Malaysia.

Credits
FG1 : UMT

Use limitations
There are no access and use limitations for this item.

Extent

West	98.937406	**East**	118.850000
North	8.132861	**South**	1.736111

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

ArcGIS Metadata ▶

Topics and Keywords ▶

Contents | Preview | Description

Print | Edit | Validate | Export | Import

Fish

Shapefile

Thumbnail Not Available

Tags
fish

Summary
PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA

Description
Taburan lokasi ikandi dalam perairan Malaysia.

Credits
FG1: UMT

Use limitations
There are no access and use limitations for this item.

Extent

West	99.666667	**East**	117.166667
North	7.730000	**South**	1.268833

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

ArcGIS Metadata ▶

Topics and Keywords ▶

Contents | Preview | Description

Print | Edit | Validate | Export | Import

F2_Marine_Invert

Shapefile

Thumbnail Not Available

Tags
marine invertebrate

Summary
Lokasi marine invertabrate di dalam perairan Malaysoia

Description
PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA

Credits
FG2

Use limitations
There are no access and use limitations for this item.

Extent

West	99.905899	**East**	118.667500
North	7.347778	**South**	1.265908

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

ArcGIS Metadata ▶

Topics and Keywords ▶

Contents | Preview | Description

Print | Edit | Validate | Export | Import

UMT marine mammal sightings

Shapefile

Thumbnail Not Available

Tags
marine mammal sightings

Summary
UMT marine mammal sightings

Description
PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA

Credits
FG3

Use limitations
There are no access and use limitations for this item.

Extent

West	99.443410	**East**	119.253170
North	7.622550	**South**	1.625840

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

ArcGIS Metadata ▶

Topics and Keywords ▶

Contents | Preview | Description

Print | Edit | Validate | Export | Import

Other_Marine_Mammals_Database

Shapefile

Thumbnail Not Available

Tags

There are no tags for this item.

Summary

Non UMT marine mammal sightings record

Description

PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA

Credits

FG3

Use limitations

There are no access and use limitations for this item.

Extent

West	99.930507	**East**	119.124627
North	8.140000	**South**	1.427215

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

ArcGIS Metadata ▶

Topics and Keywords ▶

Contents | Preview | Description

Print | Edit | Validate | Export | Import

Marine habitat and ecological processes

Shapefile

Thumbnail Not Available

Tags
Marine habitat and ecological processes

Summary
Marine habitat and ecological processes

Description
PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA

Credits
FG4 UMT

Use limitations
There are no access and use limitations for this item.

Extent

West	98.938450	**East**	118.956917
North	8.340980	**South**	1.182551

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

ArcGIS Metadata ▶

Topics and Keywords ▶

Contents | Preview | Description

Print | Edit | Validate | Export | Import

Mangrove dataset

Shapefile

Thumbnail Not Available

Tags
mangrove

Summary
mangrove

Description
PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA

Credits
FG5

Use limitations
There are no access and use limitations for this item.

Extent

West	99.800094	**East**	118.335265
North	7.310227	**South**	1.158206

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

ArcGIS Metadata ▶

Topics and Keywords ▶

Contents | Preview | Description

Print | Edit | Validate | Export | Import

Marine microalgae

Shapefile

Thumbnail Not Available

Tags
marine microalgae

Summary
marine microalgae

Description
PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA

Credits
FG5

Use limitations
There are no access and use limitations for this item.

Extent

West	99.670510	**East**	11222222.000000
North	6.430740	**South**	1.166670

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

ArcGIS Metadata ▶

Topics and Keywords ▶

Contents | Preview | Description

Print | Edit | Validate | Export | Import

Marine seagrass

Shapefile

Thumbnail Not Available

Tags
marine seagrass

Summary
marine seagrass

Description
PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA

Credits
FG5

Use limitations
There are no access and use limitations for this item.

Extent

West	99.802430	**East**	118.117900
North	7.400040	**South**	1.005590

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

ArcGIS Metadata ▶

Topics and Keywords ▶

Contents Preview Description

Print Edit Validate Export Import

Marine seaweed

Shapefile

Thumbnail Not Available

Tags
marine seaweed

Summary
Marine seaweed in Malaysia

Description
PROJEK PENGUMPULAN DATA/MAKLUMAT EKOSISTEM DAN BIODIVERSITI MARIN DI PERAIRAN MALAYSIA

Credits
FG5

Use limitations
There are no access and use limitations for this item.

Extent

West	99.776940	**East**	118.697390
North	7.284170	**South**	1.338190

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

ArcGIS Metadata ▶

Topics and Keywords ▶

CHAPTER 8

SOCIAL AND ECONOMICS

Nur Azura Sanusi
Nazli Aziz
Yogesswary Segar
Mohd Fikri Mohamad

1.0 INTRODUCTION

The coastal area is the meeting point of land and sea (Longhorn, 2004; Rosly et al., 2020). Except for Laos, all of Southeast Asia's countries are sea-bound. Coastal areas worldwide are dynamic ecosystems at the intersection of terrestrial, marine, and freshwater systems. Nearly 2.4 billion people, or 40% of the world population, reside in coastal areas (United Nations, 2017; Milon & Alvarez, 2019). We have historically used the seas and oceans as a source of wealth, opportunity, and plenty. The ocean is a vital contributor to long-term economic growth since more than three billion people worldwide rely on marine and coastal biodiversity for a living. Malaysia is in Southeast Asia, between latitudes 1° and 7° North and longitudes 100° and 119° East. Malaysia is divided into four regions: the west coast of peninsular Malaysia, the east coast of peninsular Malaysia, Sarawak, and Sabah. The Malacca Strait, which runs along the west coast of peninsular Malaysia, is a vital link between Europe, the Middle East, and South Asia on one side and Southeast and East Asia on the other. Figure 1 depicts Malaysia's coastline, which encompasses Peninsular Malaysia, Sabah, and Sarawak, with a total length of 4,809 km. As a result, Malaysia's coastline resources are abundant in natural biodiversity (F. A. Mohd et al., 2021)

Figure 2 Malaysia's Coastline

As a developing country, Malaysia's population of 32.7 million in 2021 (DOSM, 2021) will increase to approximately 37.4 million in 2030 (Nazri et al., 2018). According to official statistics, 70 percent of Malaysia's population lives in the coastal zone. The bulk of communities in Malaysia's coastal zone is made up of fishermen and farmers, the majority of whom are older adults aged 40 to 65 years (Mohamed Shaffril, D'Silva, et al., 2015) who have lived in the region permanently for more than 15 years (Sah et al., 2021). Malaysia lies in Southeast Asia near the equator, and its important ports are on international marine and commerce routes (Chen et al., 2016; Rashidi et al., 2021). Therefore, the coastal area is important because it supports a wide range of human activities such as fishing, industrialization, natural resource exploration, tourism and recreation, and transportation (Rosly et al., 2020). Moreover, the exploitation of coastal resources and habitats is determined by the size of the human population and its level of socio-economic development.

Human populations benefit from a wide range of services provided by marine and coastal ecologies. Marine and coastal ecosystems supply medical resources such as food, fish, and raw materials, while genetic resources govern floods, storms, erosion, and climate change. Marine and coastal environments are also liable for cultural services such as tourism and other sectors of the economy such as travel and entertainment, history, social and customary traditions, science, learning and education, and ancillary administrations including such, choice production, nutrient cycle, species conservation, and ecosystem protection (Masud, 2019). The diversity of marine resources has helped Malaysia preserve its reputation as a popular tourist destination among foreign visitors, as well as improved the level of living of the local coastal communities (Masud, 2019; Musa et al., 2020a).

Therefore, the objective of this research study is related to the population, socio-economic activities, and economic valuation of coastal and island communities. It discusses the people living in coastal and island communities; highlights the socio-economic activities of the coastal and island communities, which are wholly dependent on marine activities as the source of their monthly income; and explains how changes in coastal and marine ecosystem services translate into societal benefits and costs.

2.0 OBJECTIVES

Malaysia lies in Southeast Asia near the equator, and its important ports are on international marine and commerce routes (Chen et al., 2016; Rashidi et al., 2021). The exploitation of coastal resources and habitats is determined by the size of the human population and its level of socio-economic development. Thus, marine resources have become a place that provides various services and essentials to human well-being, such as health, livelihood, and survival. Therefore, the objective of the study:

I. To study the demographics of coastal and island populations in Malaysia

II. To identify the socio-economic activities in the Coastal and Island of Malaysia.

III.To examine the economic valuation of marine biodiversity resources in Malaysia.

3.0 MATERIALS AND METHODS

This part discusses the critical sub-sections used in the current study: resources, systematic review procedure, and data abstraction and analysis.

3.1 RESOURCES

The current study's review procedures were conducted using two significant databases, Scopus and Web of Science, because both databases are reliable and cover over 256 fields of study, including environmental research and marine research. Specifically, Scopus indexes a total of 252 journals related to the keywords of the study for all the research questions, while Web of Science (Social Science Citation Indexed) indexes 174

journals related to the research questions. Scopus and WoS were consistent with (Gusenbauer & Haddaway 2020), suggesting that these two search sources had comparable searching abilities. The chosen databases have many advantages, including advanced searching functions; being extensive (indexing over 5000 publishers), controlling article quality; and having a multidisciplinary focus, including studies related to our studies (Gusenbauer & Haddaway, 2020; Martín-martín et al., 2019).

Further, it should be remembered that no database, including Scopus and Web of Science, is flawless or complete (Mohamed Shaffril et al., 2019). Therefore, Paula (2010) recommended that researchers need to run their searches across additional databases or need to have a supporting database to maximize the chances of finding relevant publications (Mohamed Shaffril et al., 2019). According to Xiao & Watson (2019), supporting databases are needed, while Bates et al. (2019) found that the database's sensitivity to the keywords generated for searching relevant papers isn't 100%. Therefore, the current study conducted manual searching on several established sources, such as Google Scholar and My Cite - Malaysian Citation Index, because they are reliable databases containing journals related to the population, socioeconomic activities, and economic valuation of marine biodiversity resources coastal and island communities. These databases are significant for obtaining additional sources, such as non-indexing journals and any publications absent from the major databases. The chosen supporting database has its benefits. Gusenbauer & Haddaway (2020) verified this in their report, estimating that 389 million documents are available in the Google Scholar database. Martín-martín et al. (2019) found that Google Scholar finds more citations in all subject areas than the WoS Core Collection and Scopus. Besides, the university/agency library was also visited to look for any relevant written journals/documents.

3.2 THE SYSTEMATIC REVIEW PROCESS FOR SELECTING THE ARTICLES

Systematic searching strategies were run according to the multiple keywords chosen from the research question, which are population, socioeconomic activities, and economic valuation of marine biodiversity resources of coastal and island communities. Three sub-processes of systematic searching strategies, namely identification, screening, and eligibility, were used to assure rigorous and systematic searching.

3.2.1 IDENTIFICATION

Identification is the method of looking for synonyms, similar terms, and variations of the study's main keywords: population, socioeconomic activities, and economic valuation. It aims to give the selected database more options for searching for more related articles for the study. The selection of appropriate keywords is based on an online thesaurus, keywords used in previous research, keywords suggested in all the databases, and keywords recommended by experts (refer to table 1). The quest was conducted on selected leading and supporting databases using advanced searching techniques such as the Boolean operator, phrase searching, truncation, wild card, and field code function separately or by combining these searching techniques into a complete searching string

based on the main and enriched keywords (shown in table 2). While handpicking, snowballing, and emailing the relevant author were some of the manual searching strategies also used in the study.

Thus, a total of 1654 papers were found after searching the leading and supporting databases from Scopus, WoS, Google Scholar, and My Cite - Malaysian Citation Index.

Table 1 Results of Identification Process

SECTION	MAIN KEYWORDS	ENRICHED KEYWORDS
RQ1: Demographics of coastal and island populations in Malaysia	Demographics Coastal and Island Population	**Demographics**- Geographical **Coastal**- Marshy, inshore **Island**- Isle, atoll, archipelago **Population**- residents, natives, community, society, citizens
RQ2: Socioeconomic activities in the Coastal and Island of Malaysia.	Socioeconomics Activities Coastal and Island	**Socioeconomic activities**- social activities, economic activities, recreational activities, tourism activities **Coastal**- Marshy, inshore **Island**- Isle, atoll, archipelago **Coastal Development**-Marshy growth, inshore growth, inshore development, marshy development **Fishing Activities**-catching activities
RQ3: The economic valuation of Marine Biodiversity Resources in Malaysia.	Economic Valuation Marine Biodiversity Resources	**Economic Valuation**- Economic Value, Economic evaluation **Marine Biodiversity**- Aquatic Biodiversity, Marine species, Aquatic species

3.2.2 SCREENING

The first step in the screening process was to eliminate papers that had met exclusion criteria. Fifty-six articles were screened in the first stage. This research screened all 56 papers by selecting criteria for article selection, which was done automatically based on the sorting functions available in the databases used. The exact requirements were applied to all databases, and articles were manually omitted when sorting functions were unavailable. Here the researchers' inclusion and exclusion criteria can be used (Mohamed Shaffril et al., 2019). In this instance, as stated in table 3, the researcher applied their inclusion and exclusion criteria.

The initial round of screening was to filter the results based on the year. Because it is nearly impossible for researchers to study all the current published articles, experts advise determining a time range or set a time frame for their review (Okoli, 2015). As per Higgins & Green (2005), timeline publishing limits should be enabled only when it is clear that related research has only been published within a specific time frame. Based on the results of the search on the chosen database, it was discovered that the number of studies on population, socioeconomic activities, and economic valuation of marine biodiversity resources of coastal and island communities had increased dramatically since 1887. Meanwhile, there is no restricting the search this year. As a result, the period between 1887 and 2021 was chosen as one of the inclusion criteria. Therefore, based on this, the timeline between 1887 and 2021 was selected as one of the inclusion criteria.

The second step was refined according to the document type. Several authors advise literature review writers to look through all available sources of information, including books, conference papers, and grey literature (Briner & Denyer, 2012; Kraus, Breier, & Dasí-Rodríguez, 2020). However, the researcher only looked for journal papers (articles), book chapters, and conference proceedings when selecting the document type for the literature reviews in this study. The use of grey literature (such as working papers, conference proceedings, etc.) in systematic literature reviews is currently being debated, but we would advise against it (Kraus et al., 2020). Thus, publications published in a journal, conference papers, and books were included to assure the review's quality. The third phase involves selecting a research subject or area for this study. This paper chose all fields to increase the possibility of retrieving related articles. While for some keywords, the researcher decides on articles published in the field of economics only. Lastly, only papers written in English and Malay are included in the study to prevent misunderstandings.
As a conclusion of this screening process, we excluded 56 articles as they did not fit the inclusion criteria, and the remaining 1598 articles were used for the eligibility process.

3.2.3 ELIGIBILITY

The third stage in the screening process is to determine eligibility. Its purpose is to ensure that all articles discovered throughout the screening process fulfill the predefined criteria (Liberati et al., 2009; Shaffril et al., 2021). To do this, the researchers do not need to read the entire paper. Instead, they may skim the title and abstract to determine whether or not the article is eligible for inclusion in the review (Bilotta et al., 2014; Shaffril

et al., 2021). If this phase does not provide the researchers with a clear image of the articles' eligibility, the substance of the papers must be thoroughly examined (Shaffril et al., 2021).

A total of 1598 articles were prepared for the third stage, known as eligibility, in this study. First, 65 duplicate papers from all four databases were screened at this stage. After removing identical papers, the remaining articles' titles, abstracts, and primary contents were carefully scrutinized to see whether they met the inclusion requirements and could be used in the current study to address the research questions. As a result, a total of 1405 articles were excluded because the majority of the publications were discovered to be complex science studies that did not focus on the economic area and were not based in Malaysia; more emphasis on marine population species rather than community population, and pure scientific articles such as fishing species experiments, chemical oceanography, aquatic diseases and immunity, and so on. Papers that met these criteria were extensively evaluated, and essential material was filtered further for this evaluation. Finally, a total of 193 articles remains to be analyzed.

3.3 DATA ABSTRACTION AND ANALYSIS

The data extraction and synthesis approach for thematic synthesis use thematic analysis; themes are drawn from the literature, clustered, and then combined to form analytical themes (Thomas & Harden, 2008; Xiao & Watson, 2019). Then, these analytic themes—whose structure is comparable to third-order constructs—are applied to respond to the research question. Thomas and Harden (2008) explain, "*It may be, therefore, that analytical themes are more appropriate when a specific review question is being addressed (as often occurs when informing policy and practice), and third order constructs should be used when a body of literature is being explored in and of itself, with broader, or emergent, review questions*." Therefore, this study conducted a theme and sub-theme approach, which is a type of review that examines and synthesizes several research designs (qualitative, quantitative, and mixed methods) to answer the research question, and this can be resolved by qualifying quantitative data or quantifying qualitative data (Mohamed Shaffril et al., 2019; Whittemore & Knafl, 2005).
Based on thematic analysis, the procedures for creating relevant themes and sub-themes were carried out. The data collection phase was the initial step in the theme development process. In this phase, we carefully need to analyze a total of 193 selected articles to extract statements or data that answer the research questions. In the second step, the authors used the coding approach to construct meaningful groupings based on the nature of the data. In other words, the second phase transforms raw data into usable data by identifying themes, concepts, or ideas that may be used to create more connected and related data (Sandelowski, 1995; Patton, 2002; Mohamed Shaffril et al., 2019). Subsequently, in the second phase, the authors created influential groups via a coding method according to the nature of the data. In other words, the second phase converts raw data into usable data via identifying themes, concepts, or ideas for more connected and related data (Mohamed Shaffril et al., 2019; Patton, 2002; Sandelowski, 1995).

Therefore, the process yielded three significant themes: impacts, awareness, and social problems among coastal communities. Further, a total of 6 sub-themes emerged through this approach. The findings were themed, and a record was kept throughout the data analysis process to capture the results of the analysis, thoughts, riddles, or any other concept that may be linked to the data interpretation. Finally, the established themes and sub-themes were tweaked to ensure they were consistent. Expert evaluations were conducted to confirm the authenticity of the themes and sub-themes. The expert review process established domain validity and ensured that each sub-theme within its respective themes was clear, relevant, and suitable. Adjustments were made based on the researchers' judgment, depending on the feedback and suggestions of the experts (Mohamed Shaffril et al., 2019).

4. RESULTS/DATA ANALYSIS

4.1 SECONDARY DATA ANALYSIS

The population of Malaysia in 2010 was 28.6 million people, and 22 percent of the population lived in coastal and island areas. Hence, this section will explain the demographics of coastal and island communities in Malaysia as well as their socio-economic activities.

4.1.1 COASTAL AND ISLAND POPULATION DEMOGRAPHICS

The coastal and island population in Malaysia in 2010 was 6.3 million people. Demographic information of coastal and island communities, such as citizenship status, ethnic group, gender, age, and education background, as follows:

i. Nationality and Ethnicity

89.8 percent of the population on the coast and islands are Malaysian citizens, while non-citizens are 10.2 percent. Based on Figure 2, most coastal and island areas only record a low percentage of non-citizens, below 20 percent, except in Perhentian Island, which is 26.9 percent. In addition, the coast and some islands in Sabah also recorded a high percentage of non-citizens, 24.7 percent in coastal areas, Pulau Bangkawan at 91.3 percent, Pulau Bum Bum at 38.6 percent, Pulau Mabul at 72.1 percent, and Pulau Sebatik at 45.7 percent.

The largest ethnic groups are Malays and Bumiputera at 70.6 percent, followed by Chinese at 24.6, Indians at 4 percent, and others at 0.8 percent. Malays and Bumiputera occupy most of the coastal and island areas except for Penang Island (39.5%), Pulau Pangkor (47%), and Pulau Ketam (2.6%). Chinese occupy at least 10 percent in all coastal and island areas except in Kelantan (1.2%), Terengganu (3.7%), Pulau Langkawi (5.1%), islands in Johor (0 to 7.2%), Pulau Besar (Melaka) (0%), Pulau Tioman (2.3%), Pulau Redang (4.6%), Pulau Kapas (0.1%) and islands in Sabah (0 to 0.8%). Unlike the third largest ethnic group, which is India, there are only three main areas that are occupied which are Negeri Sembilan (17.7%), Selangor (12.6%), and Penang (10.2%).

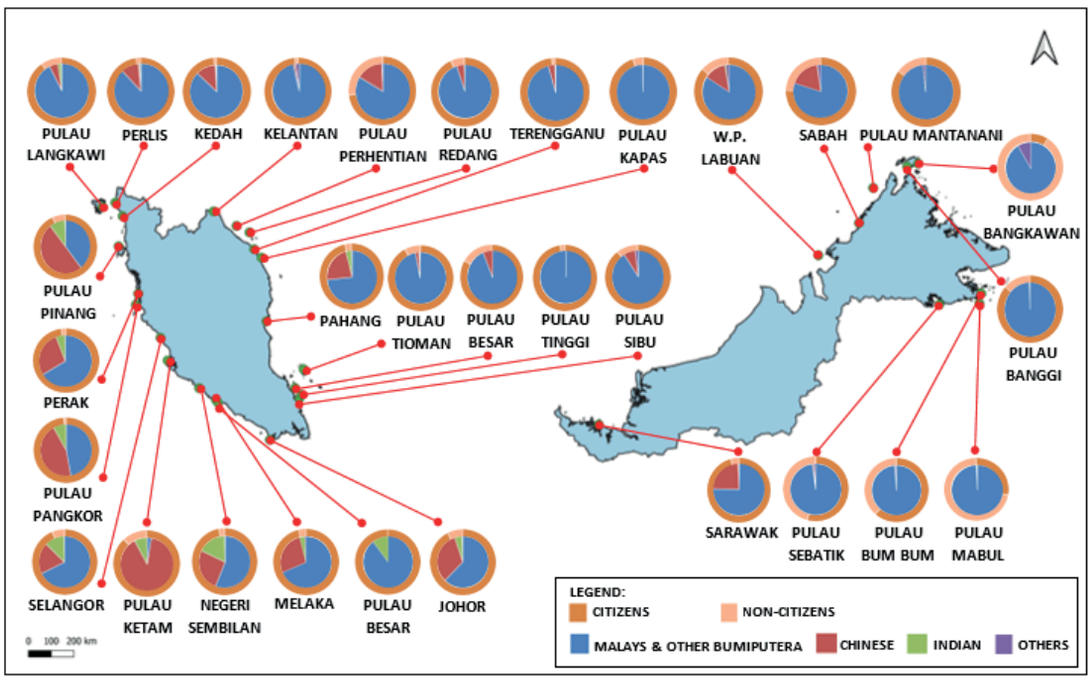


Figure 3 Total Population by Nationality and Ethnicity

ii. Gender and Age Group

The gender ratio of the population in coastal and island areas in Malaysia is balanced, with 51 percent male and 49 percent female. Figure 3 shows the total population by gender and age group. There are four areas where the difference in the percentage of men is high, namely Pulau Sibu (61.3%), Pulau Besar (Johor) (83.1%), Pulau Besar (Melaka) (61.4%) and Pulau Perhentian (62.1%). The coastal and island population by age group is led by the adult age group of 15 to 64 years old (67%), followed by children from 0 to 14 years old (28%) and the elderly who are 65 years old and above (5%).

Pulau Besar (Melaka) recorded the highest adult population of 95 percent and senior citizens of 5 percent, making this island uninhabited by children. However, the situation is different in Pulau Bangkawan, where children are the majority group which is 69 percent, followed by adults, 30 percent, and 1 percent elderly. In addition, Pulau Besar (Johor) also recorded a high adult population of 73 percent and a balanced proportion of children and elderly at 13 and 14 percent, respectively. Adults on this island are also the most compared to other coastal and island areas in Malaysia.

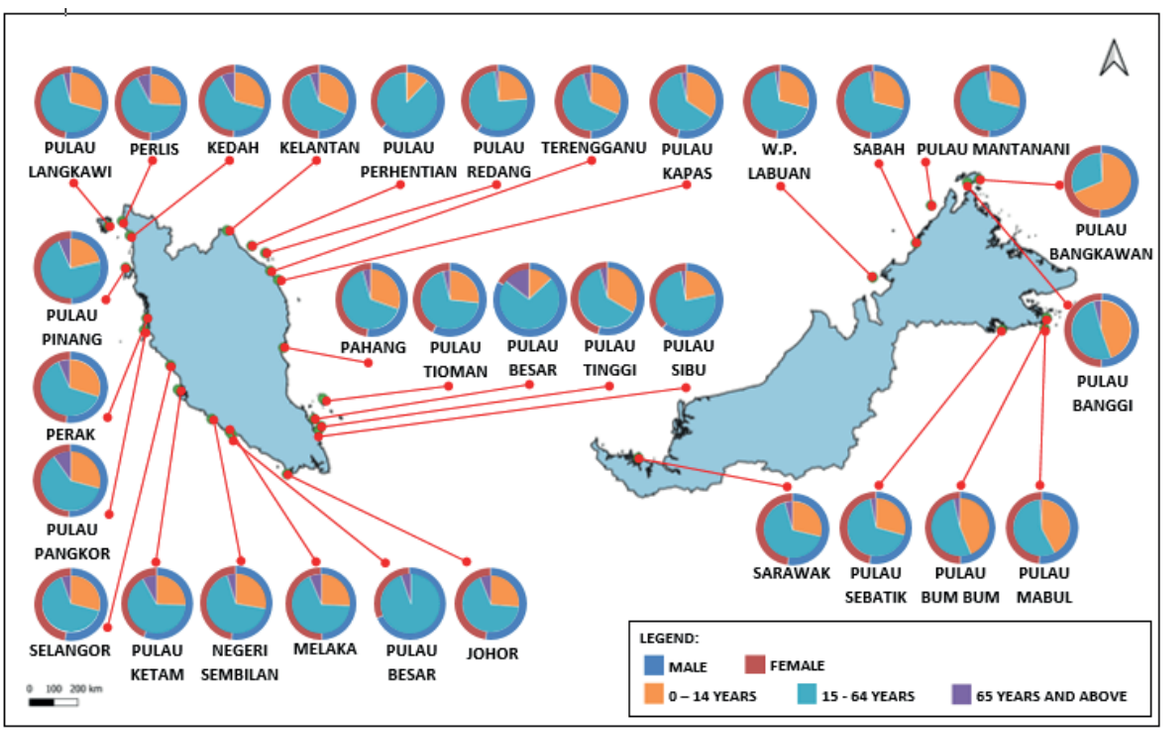


Figure 4 Total Population by Gender and Age Group

iii. Education Background

In 2010, 91 percent of Malaysian coastal and island communities were recorded as having a formal education background, which is at least at the primary school level (28%), secondary school (48%), and tertiary education (15%), while the remaining 9 percent were no formal education. Based on Figure 4, Pulau Besar (Melaka) records 100 percent of its population having a formal education, where 90 percent is in secondary school, 5 percent in primary school, and 5 percent in tertiary education. Residents of Pulau Mabul and Pulau Bum Bum recorded a high percentage of no formal education, 61 and 52 percent, respectively.

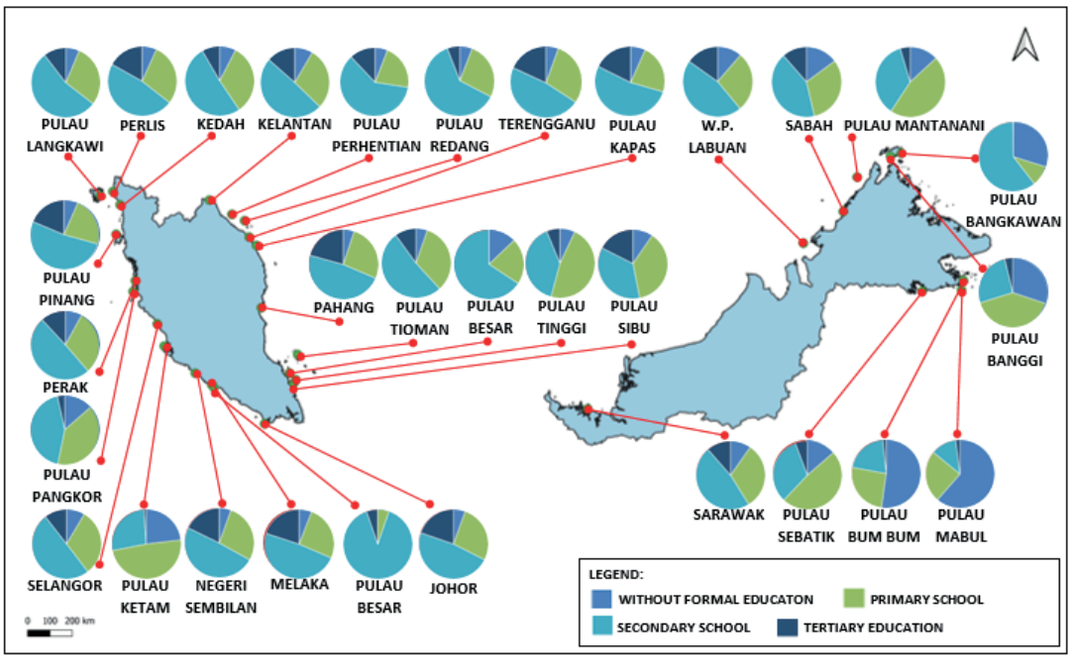


Figure 5 Level of Education of Coastal and Island Communities

4.1.2 SOCIO-ECONOMIC ACTIVITIES OF COASTAL AND ISLAND COMMUNITY

In 2010 a total of 2.5 million people from all coastal and island communities worked in various job categories and industries. In addition, transactions in Agro-tourism activities amounting to RM134 million have been made from 2000 to 2019. The details of the socio-economic activities of coastal and island communities are as follows:

i. Employment

The highest percentage of coastal and island communities involved in employment in 2010 was from Service Workers and Sales, which was 22 percent, as shown in Figure 5. The second highest group is Craft and Related Trades Workers, 12 percent, followed by Elementary Occupation by 11 percent and Plant and Machine-operators and Assemblers by 11 percent. However, 7 percent are from Unknown jobs that are not listed in any other job category.

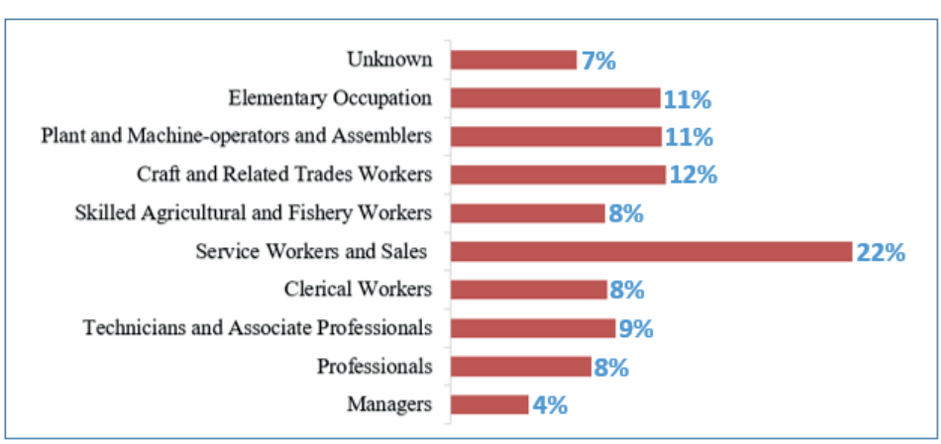
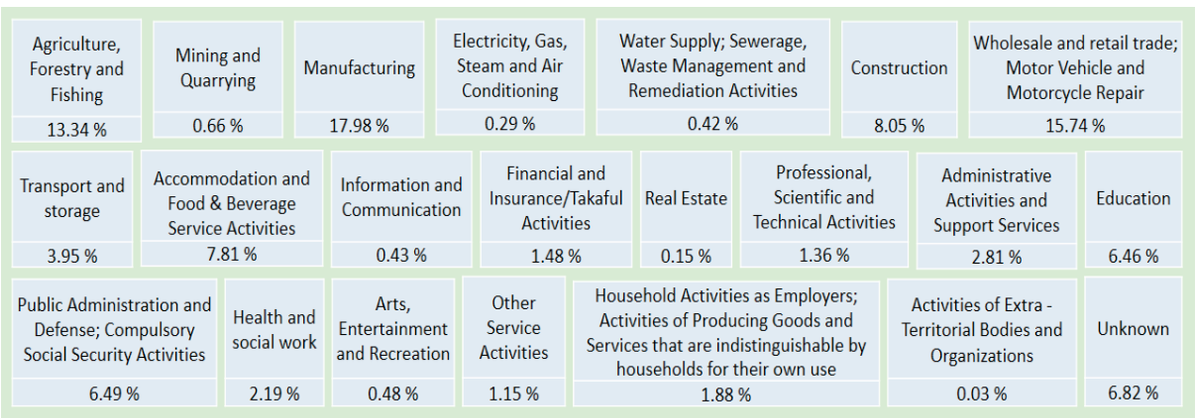


Figure 6 Occupation Category of Coastal and Island Residents, 2010

ii. Industry

As for the industry category, the Manufacturing category recorded the highest percentage for the involvement of coastal and island communities, 17.98 percent. The second highest industry is Wholesale and Retail Trade (Motor Vehicle and Motorcycles Repair) which is 15.74 percent. The following industry category is Agriculture, Forestry, and Fishing which is 13.34 percent. Figure 6 shows the 21 industry categories involved, and as many as 6.82 percent are Unknown jobs not from the listed industry categories.



There are three main agro-tourism activities undertaken by fishermen individually or through fishermen's associations: restaurants (Medan Ikan Bakar), accommodation (chalets), and Sportfishing. The activity with the most significant amount of transactions is restaurants, with a total of RM93 million from 2000 to 2019. Throughout the 20 years recorded, restaurants showed a decrease in transactions in 2003, 2011, 2012, 2014, and 2018 compared to other years that showed an increase. The second highest activity was accommodation which recorded a transaction amount of RM36 million, followed by Sportfishing with a transaction amount of RM2.1 million during the same period. Other agro-tourism activities recorded transactions amounting to RM2.7 million.

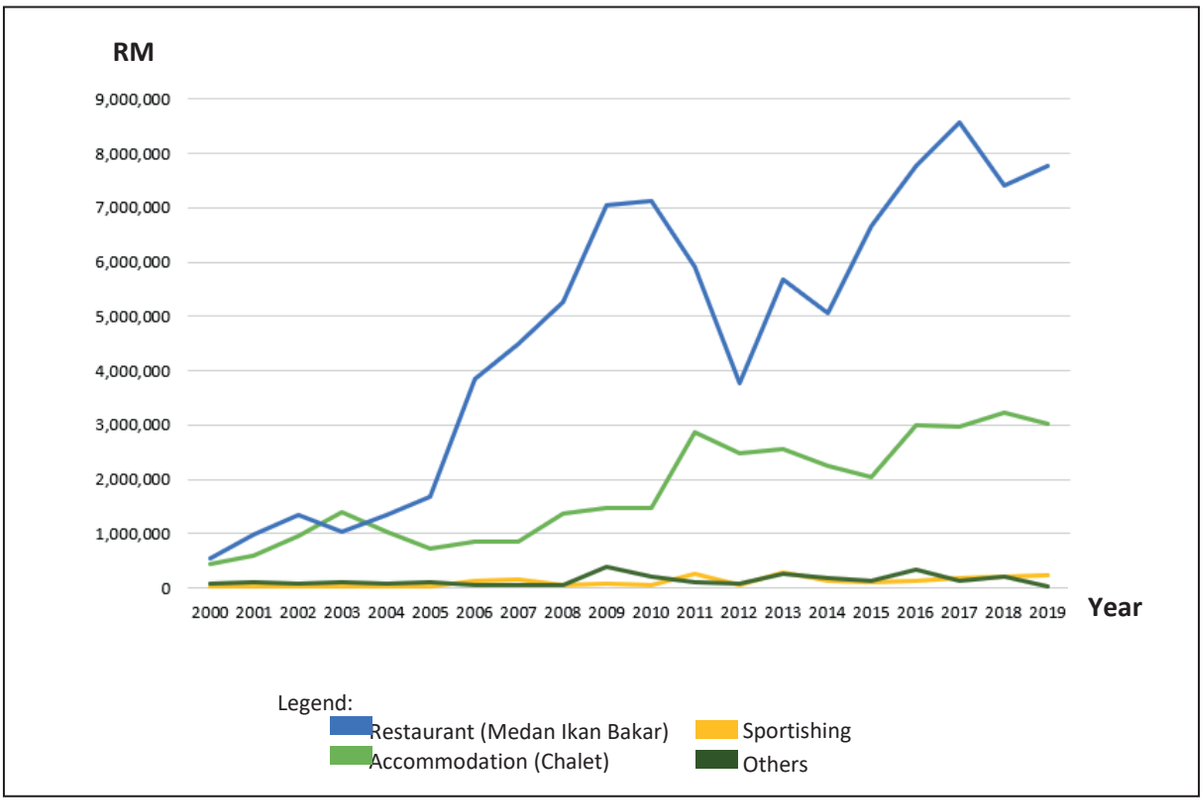


Figure 8 Agro-Tourism Activity Transactions, 2000-2019

Figure 7 compares transactions for Agro-Tourism activities from 2000 to 2019. The highest transaction for restaurants was in 2017, amounting to RM8.6 million. Accommodation recorded the highest transaction in 2018, RM3.2 million, and Sportfishing in 2013, RM286 thousand. Other Agro-Tourism activities recorded the highest transaction in 2009, amounting to RM386 thousand.

4.2 GENERAL FINDINGS

The top 193 publications were not selected by the authors of this paper based on their personal preferences. Instead, they were chosen based on the weights the entire academic community gave each. The authors of this study are putting much effort into thoroughly reviewing all 1654 papers. Before getting to the primary outcomes, researchers must first discuss the general findings. This is done to highlight significant contributions made in earlier research. In this evaluation, we focus on the paper's publication year, focused country, studies by state, type of document, preferred language, and coastal and island communities' livelihoods.

4.2.1 GEOGRAPHICAL LOCATION OF STUDIES

Only 193 papers have been published on the selected keywords, so it is essential to look at the central regions where this study has been conducted. Although marine biodiversity resources, the population of coastal and island communities, and socioeconomic activities of coastal and island communities are global issues, these 193 papers covered areas of Peninsular Malaysia's north, central, southern, and east coasts, as well as the East Malaysia Region (Borneo Malaysia).

The Peninsular Malaysian Federal Department of Town and Country Planning (JPBD) provides the guidelines through the conservation and development of Environmental Sensitive Regions (ESA), which establish that those coastal areas are comprised of 5 KM of land along the coastal shoreline. This study aims to measure the present and projected number of inhabitants living within 5 kilometers of the coastline. Malaysia's coastal zone is often described as where terrestrial and marine procedures interact, such as coastal plains, deltas, coastal humidity, estuaries, and lagoons. Malaysia covers approximately 4.4 million hectares, accounting for 13% of the total land area within five kilometers, and the Malaysian Peninsular's coastline covers an area of about 1.2 million hectares (Ehsan et al., 2019). Moreover, their study shows that, in the coastal areas, around 70% of the population lives.

4.2.2 STUDIES IN EACH STATE

The 193 documents are now organized according to the state, and the review of the 193 articles revealed that most papers were carried on or researched in Terengganu. Terengganu is a state in Malaysia's federal government (Peninsular Malaysia). Kuala Terengganu, located at the entrance of the Terengganu River, is the state's biggest town, covering an area of about 605 km2. Most of the population lives in coastal cities and villages (Bagheri et al., 2019). Its coastline stretches for 200 miles (320 kilometers) along the South China Sea (Bagheri et al., 2012, 2013; Bagheri and Azmin, 2010). It is located between 5°27'58.31''N and 5°11'42.36''N, as well as 102°57'06.10''E and 103°13'18.69''E. It can be contended that this is the primary reason why most studies are conducted in Terengganu. Even though the Perak state has many fishing villages, few researchers chose Perak as their study location. The distribution of articles per state is shown in Figure 8.

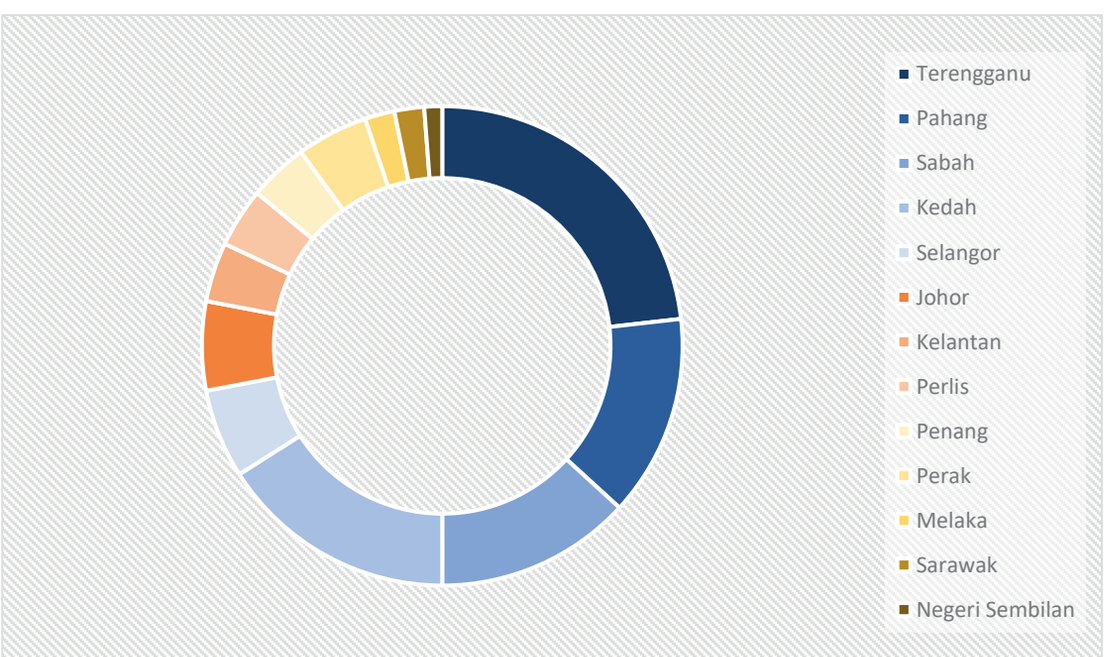


Figure 9 The Number of Studies Per State

4.2.3 DOCUMENT TYPE

These 193 relevant documents focus on four types of documents: research articles, conference papers, book chapters, reports, and theses and dissertations from all four databases. Furthermore, the review of the 193 documents revealed that most of the pieces were published as research articles. In other words, these marines ecologically related topics are primarily published as research articles compared to those discussed in conference papers or book chapters. Based on the 193 documents, 163 documents are research article-based, 19 documents are conference paper-based, eight documents are book chapters, two theses, and dissertations, and one document is a scientific report.

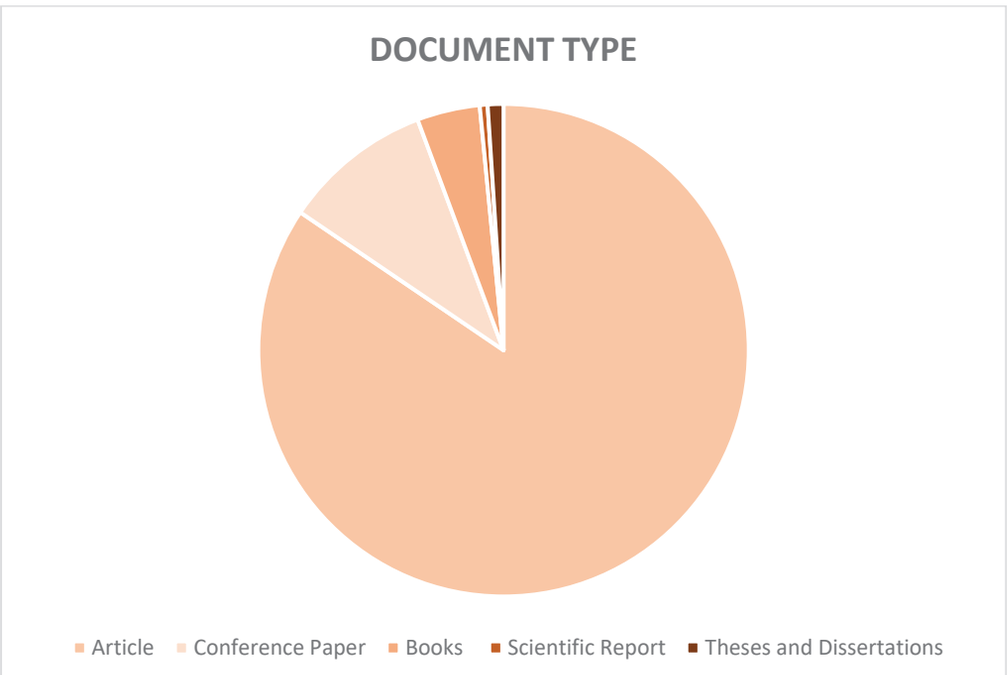


Figure 10 Document Types

4.2.4 LANGUAGE

The four significant databases all use an enormous variety of languages. For these 193 publications, we chose two different languages, English and Bahasa Malaysia, each of which has a specific purpose based on the language the researcher selects. English was chosen for this study since it is often used in academic journals across the globe. Additionally, this study added Bahasa Malaysia as a second language to access more knowledge and perspectives on the Malaysian-based marine ecological topic (which uses Bahasa Malaysia as the national language). Figure 10 shows that most of the papers here used English as a first language, while the least of these studies used Bahasa Malaysia as their intermediate language for their analysis.

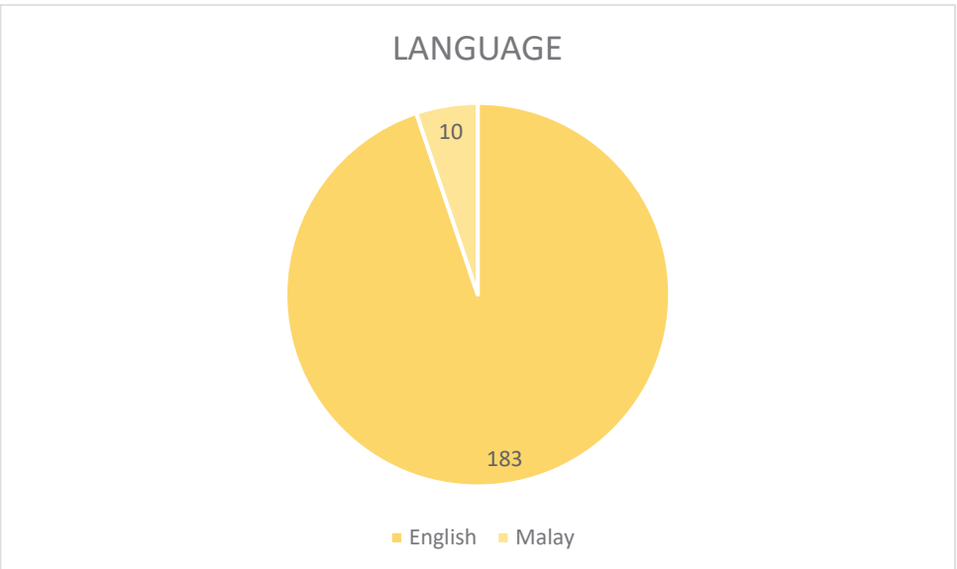


Figure 11 Language used in the study

4.3 RESEARCH QUESTION-BASED FINDINGS

In this section, the discussion revolves around the research questions-based findings. Although the topics overlap significantly, each shows a different feature of interpersonal relationships and supports its subject.

4.3.1 DEMOGRAPHICS OF COASTAL AND ISLAND POPULATIONS IN MALAYSIA

This part focuses on the demographics of coastal and island populations in Malaysia. A total of 61 articles were discussed under this research question. First, these 61 articles will be separated according to the region where the study was conducted, and then the researcher will discuss the majority method used in these relevant 61 articles. The researcher will discuss how the demographic data recorded in the articles and the demographics of coastal and island populations stated in these 61 articles relate. Most articles here measure the population's demographics through respondents' knowledge, awareness, responses, perceptions, and analysis of concerns closely related to issues that coastal and island people are going through via survey, questionnaire, interview, focus group discussion, etc.

In Malaysia, the coastal zone is roughly described as regions where terrestrial and marine processes interact, such as coastal plains, deltaic zones, coastal wetlands, estuaries, and lagoons (Ehsan et al., 2019). This study specifies that those coastal regions comprise 5 kilometers of land along the coastline, as mentioned above. The latest data from DOSM stated that of the country's population of 32.7 million, 70% of the population lives along or near the coastline. From the above statement, the researcher believes that the population is quickly expanding, and the future growth will be focused on the coastline zone. Therefore, this study focuses on the demographics of Malaysia's coastal and island populations.

Demographic information offers data concerning research participants and is used to determine if the individuals in a specific study are representative samples for generalization purposes for the target population. The various demographic features or factors of the respondents are discussed in this section. Demographic features include age, race, sex, ethnicity, religion, income, schooling, household ownership, marriage status, familial size, state of health and disability, and mental diagnosis. Most of the papers here include demographic information in their studies. Buttressing this, Dahlui et al. (2020a) surveyed health status, healthcare utilization, and quality of life among the coastal communities in Sabah. Their study includes the socio-demographic portion of their questionnaire. Their study captured sociodemographic information such as date of birth, ethnicity, academic background, employment status, relationship status, and other relevant information.

Moreover, all household members, including the head of household, are also included in their socio-demographic part. Another study by Musa et al. (2020a) included socio-economic and demographic information in their questionnaire. Their reflections on socio-economic and demographic factors include religion, age, education, marital status, number of households, and monthly income.

The research “Non-communicable diseases among low-income adults in rural coastal communities in Eastern Sabah, Malaysia" includes similar types of information” by Harris et al. (2019). But they add additional features to their socio-demographic data. They recorded gender, age, ethnic group, religious affiliation, educational level, marital status, occupation, household income, household size, and cigarette/tobacco smoking status. Apart from this research, another study conducted by Mohamed Shaffril, D’Silva, et al. (2015), entitled "The Coastal Community Awareness towards Climate Change in Malaysia," reveals that the state and duration of living in the area (years) can also be included in the demographic data characteristics. Even though their studies comprise all the features the above authors (mentioned earlier), they just add two features discussed above. The researchers conclude that most papers used similar demographic characteristics in their studies.

The diagram below shows the population's demographics by age and stage of humans from the 61 selected papers. Most of the documents here chose communities between 15 and 70 years old as their respondents for their surveys, focus group discussions, or interviews. At the very least, papers chose children as their respondents. This is because they researched children around coastal areas or island areas; otherwise, the choice of the researchers would have been adults. Most of the people polled are between the ages of 15 and 50. As a result, the information collected in their research may be regarded as accurate and acceptable because the degree of dependability is relatively high. Further, the table below shows the topic discuss in each paper.

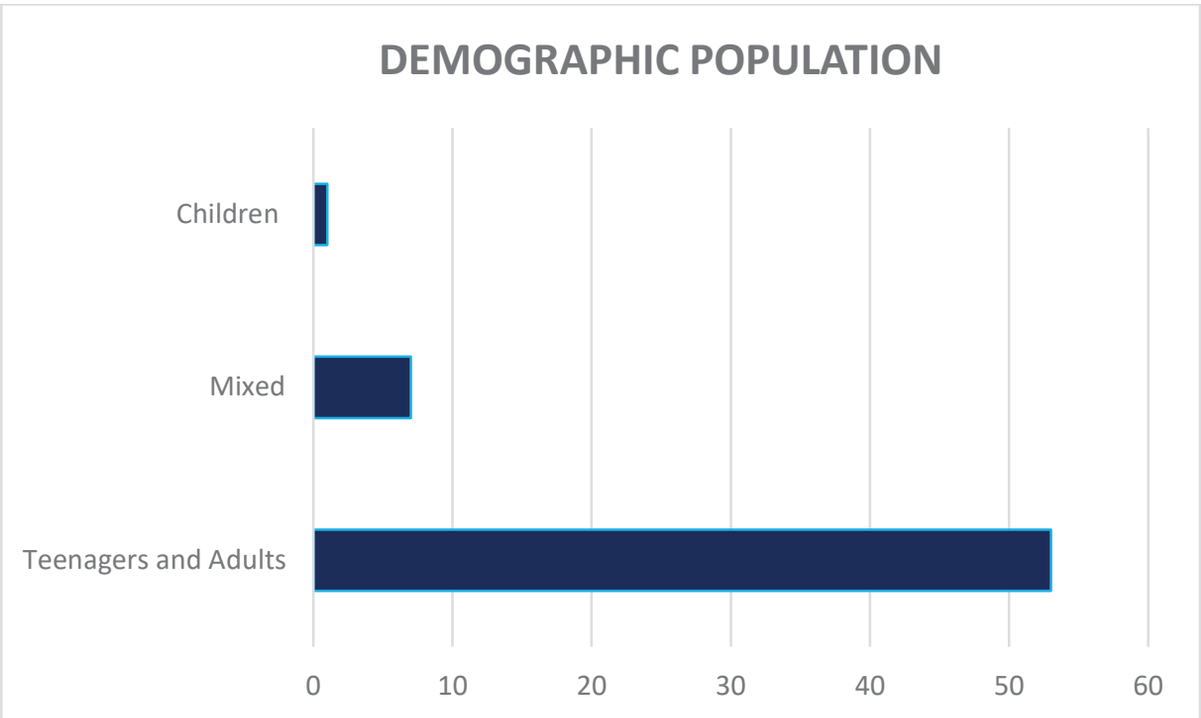


Figure 12 Demographic Population of Coastal Communities

Table 2 Specific Research Areas Covered by the Selected Papers

Specific Scope	Reference
Coastal Hazard	(Islam et al., 2021), (Masud et al., 2018), (Jaafar et al., 2016), (Said et al., 2011), (Omar et al., 2013), (Md Hashim et al., 2019), (Mohd et al., 2018), (Abas et al., 2017), (Saufi & Salleh, 2018), (Kamarulzamana et al., 2016), (A. M. Abdullah et al., 2013), (Ahmad Saufi Fauzilah Salleh, 2018), (Kamarulzamana et al., 2016)
Health	(Dahlui et al., 2020), (Harris et al., 2019), (Shafie et al., 2016), (Shahar et al., 2015), (Ahmad et al., 2014), (Hajeb et al., 2008), (Hajeb and Jinap, 2011), (Ngui et al., 2016), (Ahmad et al., 2014), (Shahar et al., 2020), (Praveena & Lin, 2015), (Narayan & Khan, 2007), (Husna Maizura et al., 2012),
Social and Economic	(Halim et al., 2021), (Halim et al., 2015), (Mohamed Shaffril et al., 2015), (Salleh et al., 2014), (Ghani et al., 2014), (Hanafiah et al., 2013), (Mohammed et al., 2014), (Aisyah et al., 2014), (Ghani et al., 2010), (Mahazan Muhammad et al., 2011), (Mohd Salleh et al., 2011), (Masud & Kari, 2015), (Masud et al., 2014), (Yusof et al., 2021), (Al Mamun et al., 2018), (Zubir Ibrahim et al., 2018),(Kamarulzamana et al., 2016), (M. Abdullah et al., 2013), (Said & Pegah, 2011), (Ali & Mohd Arif, 2007), (Syarifuddin et al., 2018), (Mustapha et al., 2013), (Chia, Ramachandran, Ho, & Ng, 2018), (Mohd. Shariff & Tahir, 2003), (Kamarulzamana et al., 2016), (Mohd Shariff Shaharuddin Tahir, 2003),
Solid Waste	(Azizan et al., 2020),
Marine Coastal Plants and Animals	(Musa et al., 2020), (Hussin & Khoso, 2017), (Shah et al., 2016), (Yeo et al., 2017), (Abdullah et al., 2013), (Praveena & Lin, 2015), (Husna Maizura et al., 2012)
Telecommunication	(Meng et al., 2014), (Yusof et al., 2014)
Security	(Rahim et al., 2014)
Language	(Mansor et al., 2013)

The demographic data of Malaysia's coastal and island populations is presented in various ways in these 61 studies. Here, these 61 papers indirectly reveal the total population of the coastal and islands of Malaysia and speak through population surveys, focus group discussions, and interviews with the selected coastal and island communities. Some of the studies like the ones described above are discussed here.
Islam et al. (2021) recently tested community awareness of Pahang's coastal hazards and adaptation strategies. They chose 11 study areas to conduct this study. 498 household (in the age category between 18 to 65 and above) respondents from 11 sites were selected for the community-wide survey of coastal hazard impacts and to identify the adaptation methods needed for enhanced resilience in Pahang. A household survey was carried out using a standardized questionnaire in response to face-to-face interviews with 498 household respondents. Furthermore, Dahlui et al. (2020a) revealed that their study involved a collection of 600 adults from the total populations of these three districts in Sabah (Kudat, Kota Marudu, and Pitas), respectively. They estimate that of 600 adults, there will be about 300 households to be interviewed based on the assumption that each family has two adults.

Next, Hajeb et al. (2008) investigated the hair mercury levels of coastal communities linked to fish consumption in Malaysia. The survey was carried out on fish consumption in four distinct coastal Malaysian states: Johor, Terengganu, Selangor, and Kedah. In the questionnaire on fish consumption, a total of 800 adults aged 18 to 80 were interviewed. But just 380 participants agreed to donate their hair samples. The questions were pilot-tested and confirmed as culturally acceptable by community representatives. Aside from this, a conference proceeding paper titled "A Comparison of Local Community Sustainability of Livelihood: A Case Study in the Redang and Tioman Islands, Malaysia" by Mohd Salleh et al. (2011) shows that the information was gathered primarily through a survey of 226 adults ranging in age from 20 to 80 years old in both island parks, supplemented by a questionnaire in Pulau Tioman and a questionnaire in Pulau Redang. Further, M. H. Hanafiah et al. (2013a) researched the local community's attitude and support towards tourism development on Tioman Island. As everyone knows, Tioman Island is located in the state of Pahang. Their study specifically revealed the total population of five specific villages on this island: Kampung Salang, Kampung Tekek, Kampung Air Batang, Kampung Paya Genting, Kampung Mukat, and Kampung Juara. As per their study, in 2012, Tioman Island had a total number of 3,314 inhabitants. The population list of the five settlements from their studies was acquired from the Development Authority of Pulau Tioman. For their study, there were 248 questionnaires distributed, with 185 valid replies. One hundred eighty-five surveys were completed from 384 adult respondents solicited, yielding a 48.18 percent response rate for their study. K. Mohammed et al. (2014) investigated urbanization in the perception of the local communities of Balik Pulau. Their study area was located on Penang Island, Malaysia. Their article is based on a fieldwork survey where 320 respondents were selected using a stratified random sample approach among the adult population aged 21 to 70 living in Balik Pulau.

A study was conducted on Langkawi Island by Salleh et al. (2014) to observe the development of the tourism industry and its impact on the Langkawi Island community. Their study data was collected from a face-to-face interview. The interviews took place

at pre-determined sampling sites near tourist destinations. A total of 439 people, from the teenage to the adult category, were interviewed successfully. The demographic population of their study was chosen as residents from the local community. The research of Masud et al. (2018) was conducted in five Marine Protected Areas (MPAs), which are Perhentian Kecil, Perhentian Besar, Tioman Island, Redang Island, and Tinggi Island. Their study analysis is about community responses to flooding risk management. Their survey questionnaire was undertaken on a sample of 320 households aged 18 to 60 and targeted the entire population of the MPAs residing nearby.

Moreover, Al Mamun et al. (2018) studied intentions and behaviors toward green consumption among low-income households. Their study area focuses on Johor, Pahang, Kedah, Perlis, Terengganu, Selangor, Perak, and Melaka. The residents of the local community are the population of this study. This cross-sectional research relied on 380 low-income household respondents from Peninsular Malaysia's coastal regions. A recent study by Harris et al. (2019) was conducted in Sabah about non-communicable diseases among low-income adults in rural coastal communities. This cross-sectional research was conducted in seven coastal communities on Sabah's Semporna mainland. Socio-demographic information was gathered using interviewer-administered questionnaires, and 330 adult respondents completed the study.

Furthermore, a study by Jaafar et al. (2016) chose Kampung Kemeruk, Kota Bharu, and Kelantan as their study areas. The purpose of their research is to observe coastal erosion threats and the adaptation of coastal communities. Their primary data came from a field survey of 83 households vulnerable to the adverse effects of coastal erosion. Most of the respondents they surveyed are in the productive age range between 31 and 50 years old. Therefore, the information in their studies can be said to be accurate and acceptable information because the level of reliability is relatively high. Rather than that, a survey conducted by Yusof et al. (2021) exploring the affordances of the outdoor environment in a coastal community affected young children’s play behavior. Their study included an ethnographic method, direct participant observations, auto photos, go-along interviews, and focus group interviews on extracting the number of affordances encountered by 45 respondents aged 3–13 on Bum Bum Island, Sabah, Malaysia.

4.3.2 SOCIOECONOMIC ACTIVITIES IN COASTAL AND ISLAND OF MALAYSIA

This section will discuss the social and economic activities of coastal and island communities in Malaysia. A total of 108 articles were discussed under this research question. First, these 108 articles will be separated according to socioeconomic activities, and then we will thoroughly discuss all these relevant articles.
Human survival is dependent on a steady and long-term supply of natural resources. Natural resources are essential materials in ecosystems that aid in the provision of services such as climate management, flood control, natural habitats, amenities, and cultural services, all of which are necessary for technical and economic progress, human wellbeing, and everyday existence (Chow et al., 2003; Yang et al., 2020; Yu et al., 2016). According to the United Nations (2019), marine and coastal resources each year provide around 5% of global GDP.

In the coastal region of Peninsular Malaysia, there are 22 municipalities and 12,400 rural communities, 28 industrial properties, and 54 ports. In addition to this, there has been extensive coastal growth and development in neighboring areas such as agriculture (especially rubber, coconut, paddy, and oil palm), fisheries and aquaculture, production industries, transport and communication, reserves of oil and gas, mineral resources (tin, gold, platinum, chromite, etc.), and natural and tourist habitats (Shahruzaila,1993; Ehsan et al., 2019). At the same time, if we do not reserve carefully, marine resources will be jeopardized.

Most coastal places worldwide provide various goods and services that satisfy human needs. It supplies food for consumption, as well as employment and leisure activities. Because coastal regions can provide the necessities to maintain and improve life, demand for coastal and marine resources is increasing. Thus, they become more developed, and the population in these places also grows (Bañas et al., 2020).

For a long time, coastal areas have been the attention of scholars all over the globe, who have been investigating the legal framework, the historical-geographical elements, the socioeconomic benefits of the region, and the necessity to develop an integrated monitoring and protection system. As a result, various analyses, research, initiatives, plans, scientific publications, and books have led to a better understanding of complicated coastal activities (Kovačić et al., 2020). Thus, in this section, researchers will separate 108 papers according to the socioeconomic activities in their respective coastal and inland areas.

The diagram below shows that most papers focus on tourism as the significant socio-economic activity in most coastal areas in Malaysia. Tourism is Malaysia's most important economic industry, contributing significantly to the country's growth (UNWTO, 2018). Beaches and islands are among the key attractions for Malaysia's coastal recreation tourism due to the abundance of marine resources (Alam & Paramati, 2016; M. H. Hanafiah et al., 2021; Yusoff et al., 2006). The sale of "sun, sand, and surf experiences," the development of tourism infrastructure (e.g., hotels, resorts, marinas, and transportation infrastructure), and the growing popularity of marine tourism (e.g., fishing, scuba diving, windsurfing, and yachting) have all added to the coastal area's stress (Comerio & Strozzi, 2019). The cash provided by coastal tourism benefits the local economy by producing jobs, allowing coastal tourism to catapult residents into better financial conditions and, in some cases, out of poverty (Archer & Fletcher, 1996; Hanafiah et al., 2021; Selamat et al., 2016; Sulaiman et al., 2018).

Moreover, here are some papers focusing on fishing activities and agricultural activities too. Fishing and farming activities are equally important to the people leaving coastal and island areas. There is a paper researched by Rashidi et al. (2021) that states that the agricultural sector and fishing industry each contribute to our country’s economy. According to the figure below, most populations in coastal and island areas rely entirely on marine sectors, including tourism, fishing, agriculture, and manufacturing, for their monthly incomes. The distribution of articles based on socioeconomic activities and according to socioeconomic activities is depicted in the diagram below.

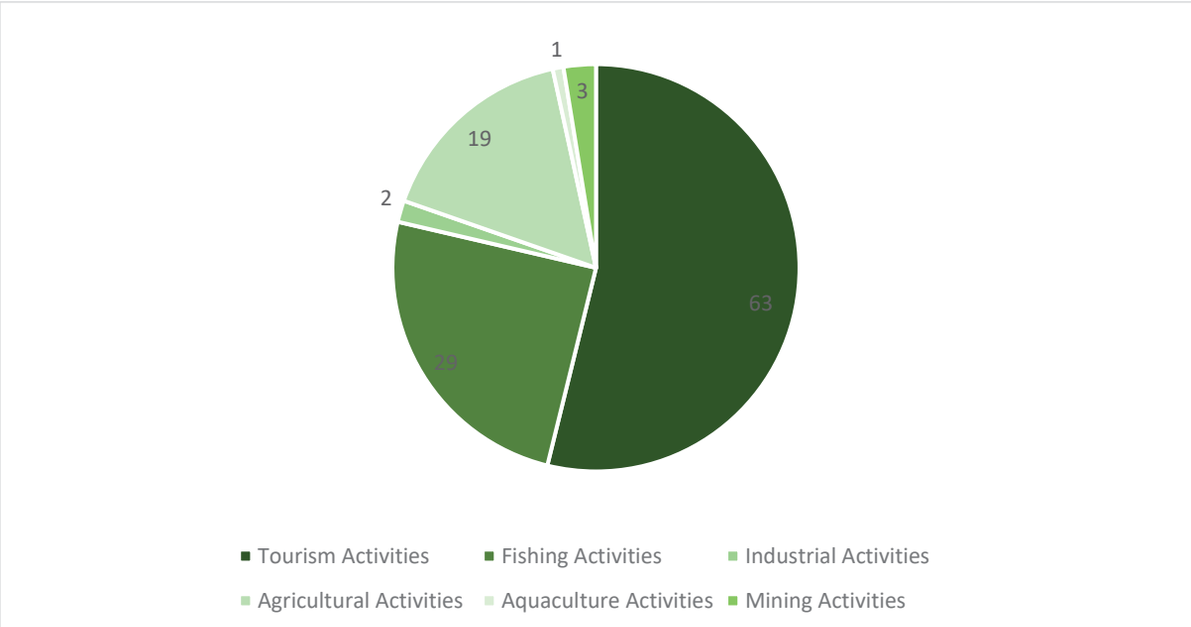


Figure 13 Distribution of Socioeconomic Activities

4.3.3 THE ECONOMIC VALUATION OF MARINE BIODIVERSITY RESOURCES IN MALAYSIA

This research question adds to existing studies to value and conserve coastal and marine ecosystem services and gives policymakers and resource managers helpful information regarding the economic relevance of coastal resources for planning, restoration, and damage assessment. A total of 26 articles were discussed under this research question. These 26 will be divided into categories of marine biodiversity, after which we shall extensively explore all pertinent publications.

Coastal areas worldwide are dynamic habitats at the intersection of terrestrial, marine, and freshwater systems. Nearly 2.4 billion people, or 40% of the world's population, now reside in these places (United Nations, 2017). Additionally, coastal zones are becoming more appealing for development and tourism. However, the coastal ecosystems inside these zones are subject to several anthropogenic influences, including excess nutrients, invasive species, harsh weather, sea level rise, and oil spills, among other issues (Milon & Alvarez, 2019).

Thus, this special issue focuses on the economic valuation of coastal and marine resource ecosystem services. Economic valuation is significant because it provides methods and techniques for determining how coastal and marine ecosystem services change into societal benefits and costs. Economic values are substantial daily because they give valuable human satisfaction and welfare information. Valuation provides a consistent framework for understanding human–nature interactions across a wide range of coastal and marine resources and assessing the sustainability of these relationships (Milon & Alvarez, 2019). It is becoming increasingly clear that including an economical approach to ecosystem management is critical for preserving the flow of essential commodities from marine ecosystems (Farber et al., 2006; Teh et al., 2018). Quantifying the economic value of ecosystems to social and economic wellbeing allows for informed

trade-offs in conservation planning, possibly improving stakeholder buy-in and leading to more effective marine management.

Marine biodiversity, one of the most established research disciplines in environmental science in general and ocean science in particular, embraces a wide variety of regional and temporal dimensions for examining global patterns of change in marine biodiversity (Tolochko & Vadrot, 2021). Marine biodiversity is vital for the structure and functioning of ocean ecosystems and for delivering the complete spectrum of ecosystem services that benefit people on local, regional, and global scales (Lotze, 2021). Thus, to analyze the economic value of marine biodiversity resources, we separated marine biodiversity into two categories: marine resources and mainland socio-economic resources. This is since these 26 articles are only concerned with the two abovementioned topics.

Protecting marine megafauna from human impact is a global conservation priority. Marine turtles in Sabah still face substantial threats from illegal hunting and human activities, including mass killings for unknown reasons and smuggling. Therefore, Teh et al. (2018) paper made an economical approach to marine megafauna conservation in the coral triangle. Acceptance, involvement, and buy-in from resource stakeholders are required for successful protection, which is frequently challenging. Therefore, their research determines the total economic value sea turtles have on Semporna, Sabah's fishing villages.

Another marine resource focused on in this study is coral reefs. Malaysia has around 4,006 km2 of coral reefs, with over 550 species contributing to the nation's economy, while coral reefs in Malaysia are under threat. Peninsular Malaysia's poor to the fair state of coral reefs is due to increased sedimentation and tourism impacts. Overfishing and fish blasting were Sabah's two most serious threats to coral reefs. Coral reefs in Sarawak are endangered by heavy sedimentation and sand mining. Therefore, Praveena et al. (2012) review studies on coral reefs, dangers, and the aquatic environment in Malaysia. Furthermore, Akhter's (2014) study also chose coral reefs as the focus of their marine resources study. They researched the Pulau Perhentian Marine Park (PPMP), one of Malaysia's most stunning coral reef islands. However, because of the rapid growth of tourism, pollution, and resource exploitation have escalated. Marine Park was established to protect coral reefs and the flora and wildlife that go along with them, but because of lax enforcement, resources are being damaged. As a result, the primary objectives of this research are to evaluate the activities that negatively impact the environment and resources at PPMP and to propose corrective measures to stop further degradation.

An estimated 500,000 people worldwide participate in the rapidly expanding tourism sector of shark diving each year, and the research study of Vianna et al.(2018) chose shark populations as their focus on marine resources. Therefore, a poll of consumers' willingness to pay was conducted to determine the industry's viability as a source of funding for the administration and enforcement of a fictitious Marine Protected Area (MPA) intended to protect shark populations. Faizan's (2014) study also focuses on the impact of anthropogenic pressure on coral reefs around Cape Rachado, Malacca. Coral reef management practices are essentially nonexistent in these regions, leaving the reefs

vulnerable to several stresses brought on by the fast growth of the nearby coastal areas. The most significant barrier to managing and conserving this weak yet considerable resource is the lack of adequate funding due to a lack of knowledge about the actual economic value of coral reef ecosystems. Therefore, focusing on coral reefs, they researched and studied to determine the economic benefits of better coral reef management in Fisheries Prohibited Areas (FPAs).

Arabamiry et al. (2013) analyzed the Marine Park Visitors' Trade-off among Marine Ecological Attributes in Terengganu, Malaysia. Perhentian Island Marine Park was the study site for this research. Human activities on the islands, such as sewage and mechanical damage (e.g., freshwater submarine pipelines), have also affected coral life and water quality. Moreover, the felling of trees causes a reduction in coral growth due to rainwater that carries fine soil into the coastal zone, whereby sediment prevents light from reaching the benthos, resulting in a high concentration of sedimentation that can kill corals. Therefore, their study focuses on the economic valuation of ecological function values using ecological features and biophysical indicators.

Zaiton et al. (2019) focused on mangroves as another mainland socioeconomic resource. A mangrove ecosystem provides a variety of services to people, society, and the economy as a whole. Local communities rely heavily on mangrove ecosystems for food, firewood, charcoal, timber, and other resources. However, mangrove deterioration is becoming a significant problem due to land conversion for aquaculture and coastal development. As a result, their study employed the contingent valuation method (CVM) to estimate the economic value of an ecosystem by polling people on their willingness to pay for the conservation of mangroves. In addition to serving as fishing grounds, the protected coral reefs off the coast of Malaysia are also a reason for being visited by many tourists. The necessity for more costly conservation measures becomes more pressing due to these combined environmental constraints. It seems only reasonable to consider the possibility of expanding the "user pays" idea, which is already in place in the form of different user fees. Therefore, the Emang et al. (2016) study investigated the possibility of price discrimination among scuba divers at Sipadan in Malaysia.

The distribution of articles about the socioeconomic resources of land and marine resources is shown in the table below.

Table 3 Economic Valuation of Marine Biodiversity Resources in Malaysia

Authors	
Mainland Socio-Economics Resources	(Arabamiry et al., 2013), (Zaiton et al., 2019), (Yacob et al., 2009), (Akhter, 2014), (Arabamiry, 2018), (Latiff, 2016), (Pascoe et al., 2014), (Osman et al., 2017), (R. Ismail et al., 2020), (Mokhtar et al., 2020), (S. Hassan et al., 2019),(R. Ismail et al., 2021) , (Emang et al., 2016), (N. Ab Razak, 2017), (Rawi, 2012), (Latiff et al., 2015), (Musa et al., 2020), (Arabamiry, 2014)
Marine Resources	(Teh et al., 2018), (Praveena et al., 2012), (Teh et al., 2011), (Kamaludin et al., 2021), (Faizan, 2014), (Yeo, 2004), (Akhter, 2014), (Vianna et al., 2018)

The public's enjoyment and appreciation of natural resources tend to benefit naturally from establishing marine parks. Marine parks support the growth of both ecotourism and tourism. Nevertheless, overuse and environmental degradation have happened due to unfettered access to marine park resources and the market system's failure to impose restrictions on their use. The viability of ecotourism may be impacted in the future by the degradation of marine parks. Additionally, consumers don't cover the total costs of using the natural resources in the marine parks, contributing to market failure. Therefore, Yacob et al. (2009) study's objective is to determine the value of ecotourism resources using environmental and economic tools, with a particular emphasis on the WTP contingent valuation method.

Table 4 shows the method of economic evaluation that the authors used in their study to analyze the marine biodiversity of marine resources.

Table 4 Method of Economic Evaluation

Evaluate The Economic Evaluation By	Ref Number
Total Economic Value (TEV)	**2**
Choice Modelling Method (CM)	**4**
Contingent Valuation Method (CVM)	**9**
Choice Experiment (CE)	**4**
Cost Benefit Analysis (CBA)	**1**
Travel Cost Analysis	**1**
Chi-Square Automatic Interaction Detection (CHAID)	**2**
Input-output analysis	**1**

5. GAP ANALYSIS

Gaps of study can be found in the literature by listing all the arguments. The figure below explains the gap in the literature specifically. As a result, these gaps have been found and divided into three categories: humankind, the economy, and the environment. All these sections will be explained accordingly to the subtopic that has been categorized. Besides, the figure above shows that every subtopic classified according to the main topic of the literature here and under humankind has three specific categories: lifestyle, skill and knowledge, and health or disease. Then there are subtopics such as socioeconomics, tourism, fisheries, and telecommunications under economics. In the area of the environment, there are four main subtopics: ecosystem, climate change, coastal hazard, waste, water, and sewage. Following the chart below, we will briefly explain each area of the gap we identified.

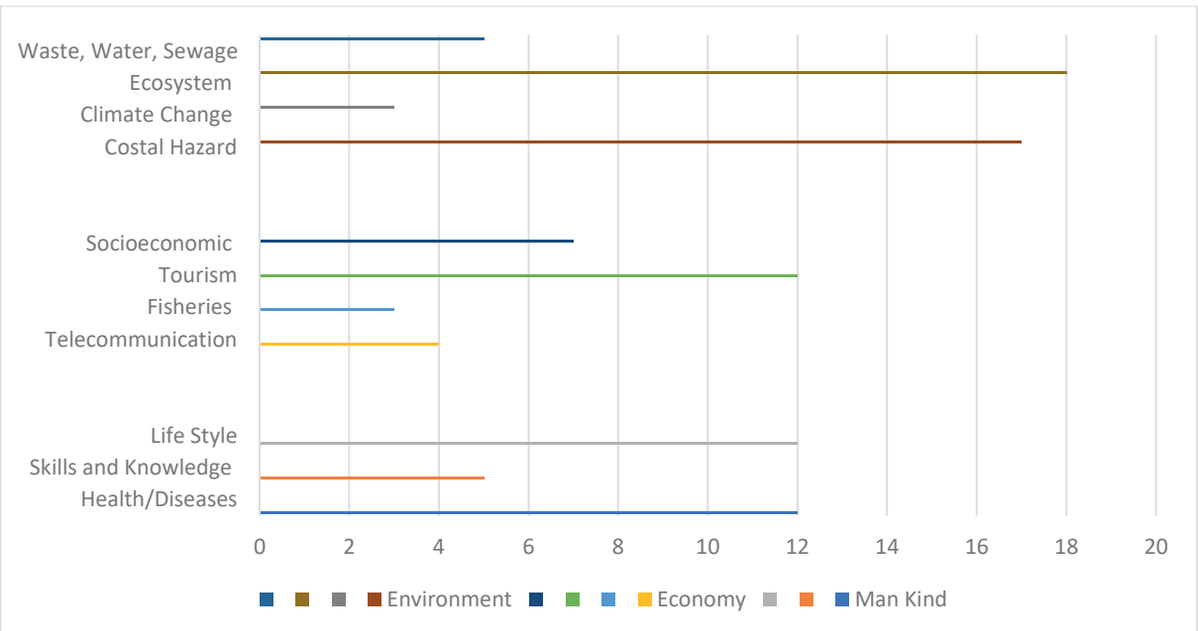


Figure 14 The Most Common Gaps Discovered

5.1 ENVIRONMENT

5.1.1 COASTAL HAZARD

Several extreme weather events have hit Malaysia, wreaking havoc on the country's resources, food supply, coastal zone, public health, and human settlements (Tang, 2019). Malaysia also experiences high temperatures, relative humidity, variable wind conditions, and heavy rainfall almost yearly (Mayowa et al., 2015). Extreme precipitation events like the enormous floods have wreaked havoc on Peninsular Malaysia's hydrology (Shahid et al., 2017). According to (F. A. Mohd et al., 2019), approximately 22% of the Cherating–Pekan coastline is at risk of flooding by 2100. Cherok Paloh, Beserah, Batu Hitam, Cherating, Sg. Ular, Sg. Kuantan, Tanjung Tembeling, and Kuala Pahang are the most vulnerable coastal areas, with sea levels expected to rise the most between 2020 and 2100. As a result, Islam et al. (2021) found a global lack of awareness about coastal hazards. The study proves that coastal hazard is an essential factor for environmental conservation.

Further, in the study of Hashim et al. (2019), we found that a lack of awareness among coastal communities on sea level rise is a gap. According to Nicholls et al. (2009), sea level rise caused by global warming has also affected marine life cycle systems and coastal ecosystems. Thus, this author argued that the phenomenon indirectly affects human life, especially those who depend on marine and coastal ecosystem life. Bird (1985) argued that erosion, land depletion, and saltwater intrusion further increased human vulnerability in coastal areas. According to Bindoff et al. (2007), there are three trigger factors for sea level rise global: first, an increase in the temperature (and energy) of the oceans; second, the melting of glaciers in Greenland and Antarctica and third, changes in the storage of terrestrial water resources. Thus, climate change, such as changes in ambient temperature, abnormal rainfall distribution, and extreme events, coupled with sea level rise, reflects an increasing scale of dangers and disasters in the future. Therefore, this paper aims to identify the level of knowledge and awareness among coastal communities on climate change and sea level rise.

Besides, the study of Mohd et al. (2018) discovered that rising sea levels were a gap in their research. According to the Ministry of Science, Technology, and Innovation (2012), climate change brings various catastrophes such as major floods, prolonged droughts, as well as solid hurricanes, as well as can change the characteristics of current climate patterns and patterns to be different in the future (Shaffril et al., 2011). Abdul Rahman (2009) argued that rapid development in agriculture, aquaculture, industry, and urbanization not only disrupts the ecosystem of the coastal zone but also destroys it. According to S. N. Jaafar et al. (2016), coastal areas are sensitive and prone to various threats such as coastal erosion, sea level rise, and so on that can affect the well-being of human life, the environment, and ecosystems. It will also make areas vulnerable to strong winds and large wave impacts, making the problem of erosion more difficult to deal with. In terms of the physical effects of sea level rise, Faour et al. (2013) explain that sea level rise will cause flood risk and lowland and wetland displacement movements. Therefore, to identify the impact of sea level rise that occurs in coastal areas is the main objective of this study.

Furthermore, Rashidi et al. (2021) identified the rise in beach erosion and sea level rise as a gap in their research. Malaysia's shoreline is constantly exposed to ocean dangers, resulting in coastal decline and sea-level rise. Ariffin (2017) argued that the East Asian monsoon system significantly impacts coastal processes in Malaysia, bringing a high intensity of relevant physical phenomena such as waves, current velocities, winds, and a high rainfall frequency, ultimately altering the cycle of beach erosion and accretion. Hosen et al. (2020) and Mohamad Hamzah et al. (2017) argued that due to land encroachment and inundation from economic activities (comprising aquaculture, agriculture, industries, and oil and gas exploitation), these threats have a significant impact on coastal areas, particularly in terms of the aging of coastal structures as a result of chronic and acute weather exposure, accelerating infrastructure degradation and the projected increase in population living in coastal urban areas. Therefore, the primary objectives of this article are to examine the country's current condition of coastal erosion and sea-level rise possibilities.

5.1.2 CLIMATE CHANGE

In the study of Abas et al. (2017), we found that the rise and less awareness of climate change were the gaps. Climate change is, without a doubt, the most pressing issue confronting our society. Climate change research, particularly in Malaysia, demonstrate temperature increases and rainfall patterns changes. Razali (2014) argued that agricultural activity would be halted in deteriorated or swamped regions. Approximately 29,000 sq km of land in Peninsular Malaysia is at risk of flooding, affecting 4.82 million people. Lee and Teh (2001) argued that sea level increase would instigate tidal inundation, coastline erosion, increased wave action, and salt intrusion, would result in coral submergence, the loss of fishery resources, plantation lands, and mangrove forests, and the relocation of coastal infrastructure. The worldwide community has made numerous efforts to raise public awareness about climate change and discover solutions to mitigate its effects. Therefore, their study's objective is to determine the respondents' socioeconomic characteristics and their level of climate change awareness in the selected study area.

5.1.3 ECOSYSTEM

The deterioration of mangrove forests was discovered as a research gap that we found in Shah et al. (2016) study. Mangroves are one of the world's most prolific ecosystems, with many roles and services, particularly for the livelihoods of coastal communities (Kathiresan & Bingham, 2001). Macintosh et al. (2011) argued that human impacts on mangroves had risen recently, with several countries losing 50–80 percent of their forest cover in the last 50 years. Meanwhile, raising community awareness can aid in the preservation of mangrove ecosystems. As evident in the FOA (2007) report, the rate of mangrove degradation has decreased due to increased community understanding of the mangrove ecosystem. According to Faridah-Hanum et al. (2012), the Malaysian Forestry Department recognizes the importance of community knowledge of mangrove resources; however, this aspect is rarely explored, and very few data are available in this context, particularly in Sarawak. Therefore, this study was carried out in Sibuti, Sarawak, Malaysia, to measure the level of awareness of coastal people regarding the tangible and intangible advantages of mangroves and their local usage.

In the study of Bee et al. (2011), the extinction of sea turtles was categorized as the gap. Fisheries provide vital food supplies for many people worldwide and play a significant role in coastal communities' livelihoods. Cantor (1847) argued that in the earliest, dated 1847, green turtles were abundantly caught in fishing stakes in the Straits of Malacca at all seasons. Siow & Moll (1982) attributed fishing as the cause of the annual increase in the number of deceased turtles on beaches. Further, data gathered from interviews with fishermen revealed that inadvertent captures of sea turtles in fishing gear contribute significantly to the mortality of these creatures in Terengganu, according to E. H. Chan et al. (1988). Aside from that, from the personal communication with K. A. Musa, he points out that, on the east coast, artificial reefs have been created to stop trawling in shallow regions. This minimizes the potential for sea turtle–fishery interaction by indirectly discouraging the unlawful practice of trawling near coastal areas. Therefore, this research examines coastal fisheries, including sea turtle–fishery relationships, as well as the socioeconomic profile and perceptions of local fishermen about sea turtle issues along Peninsular Malaysia's east coast.

Moreover, wetland threats are categorized as that research gap. Wetlands are essential for mitigating climate change and protecting populations from the effects of shifting weather patterns (Moomaw et al., 2018). Unfortunately, Azlisham et al. (2009) argued that Setiu Wetland, like other wetlands, is severely threatened by nearby projects that have harmed its ecosystems. Because bivalve species, such as oysters, are sessile, they are among the most severely damaged organisms. Bivalves filter suspended particles in water due to their feeding mechanism. Affizah et al. (2009) and Najiah et al. (2008) added that bivalves filter suspended particles in water, including toxic particles such as arsenic, mercury, zinc, and copper. Haron et al. (2020) argued that wetlands are devalued and not prioritized in coastal management decisions even though they are rich in biodiversity and provide habitat for many organisms, including endangered species. Moomaw et al. (2018) argued that many scientists and policymakers are unaware of the critical function of wetlands' carbon storage in wetlands management and policy. Therefore, the focus of this research was to look at the ecosystems of Setiu Wetland and the socio-economic activities surrounding the oyster habitats to see if marine spatial planning (MSP) may be used to lessen conflicting uses of the wetland in the future.

Besides, in the study of Aziz et al. (2021a), threatened reef ecosystems are categorized as one of the research gaps. The coral reef ecosystem is one of the world's most biologically diversified ecosystems, and it has shaped the balance of environmental processes during the last 200 million years. But according to Shanbudin et al. (2017) arguments, they stated that coral reef ecosystems are imperiled or extinct worldwide due to climate change and human involvement. Furthermore, Anthony et al. (2015) also point out that, on a larger scale, climate change has harmed tropical reefs' natural resilience by raising sea temperatures and acidifying the ocean. At the same time, Anthony et al. (2015), Bruno & Selig (2007), and Cowburn et al. (2018) contended that local human stressors such as coastal expansion and pollution, reef predatory behaviors, and diseases impede reefs' ability to recover from the severe consequences of climate change. As a result, knowing the health state of individual reefs in the area is critical for ensuring that the coral reef survives and recovers from large mortality events. Therefore, this research focuses on determining the health of the coral reefs surrounding Pulau Tioman.

5.1.4 WASTE, WATER, AND SEWAGE

The Wang et al. (2021) study discovered solid waste management as a research gap. Solid waste management will remain a significant environmental issue on small islands where tourism is the primary economic driver. (Mohd Salleh et al., 2014) argued that tourism negatively influences the environment by consuming resources and contributing to public health issues. Deshmukh (2004) acknowledges that tourism development directly impacts a tourist destination's ecology, just like hotels discharging sewage and waste into the sea, polluting and unsanitary coastal areas. One of the significant difficulties confronting small islands is rising waste generation, which is exacerbated by land scarcity, a lack of economic prospects, and insufficient waste management capabilities. Dong et al. (2019) argued that the production of solid trash has increased in tandem with the growth of tourism. For instance, around 350,000 visitors visit Green Island, Taiwan, each year, generating an average of 3.91 kg of solid garbage per person. Mohee et al. (2015) argued that governance issues impede solid waste management

from progressing. Research on Gili Trawangan by Willmott & Graci (2016) points out that the effectiveness of solid waste management on small islands is highly dependent on strong leadership and governance. Therefore, this study investigates the rigidity in the administration of solid waste management, particularly on small islands, and how related problems are addressed via the lens of Evolutionary Governance Theory.

Besides, in the study of Baharuddin et al. (2018), we found a salinity problem as the gap. To provide a holistic management strategy for the groundwater aquifer, it is necessary to know the groundwater requirements for domestic water supply and agricultural activity. The situation is more complicated at the coast due to saltwater contamination, which has limited groundwater use for water supply and farming purposes. Because of its proximity to the sea, problems of saltwater contamination are constantly linked to the seawater intrusion phenomenon. Furthermore, IPCC (2001) points out that groundwater use for water supply and agriculture in coastal areas may be impacted by sea level rise in the twenty-first century due to climatic change. According to the IPCC (2007) and Været et al. (2009), sea-level hills near coastal aquifers may cause the current hydrogeological boundary to shift in the future. The saline groundwater is thicker than previously, and it will continue to transfer to landward coastal locations in the future. Therefore, this research focused on how seawater intrusion affected the groundwater's suitability for water supply and oil palm agriculture on Malaysia's Carey Island.

5.2 ECONOMY

5.2.1 TELECOMMUNICATION

In the study, Meng et al. (2014a), were found preferred media tools as a gap in the study. Omar et al. (2011), Jensen (2007), and Evoh (2009) argued that a massive percentage of fishermen use mobile phones because it allows them to share and disseminate information (market prices, current weather, and fishing locations), improve their safety, and improve the quality of their interactions with family members and other fishermen. While M. S. Hassan et al. (2011) stated that most rural populations prefer to rely on television for information because their favored programs (e.g., prime news) are usually aired in the evening when most of them spend their free time in front of the television. Shaffril et al. (2012) added that television is favored by rural populations, particularly the senior community, because it is more user-friendly than modern instruments like computers and the Internet. Therefore, their study determined the preferred media tool and its use among Malaysian coastal communities.

Furthermore, gratification for weather information was identified as a gap in Mohamed Yusof et al. (2014) research. Azarian et al. (2012) and Shaffril et al. (2012) argued that television is seen as a traditional means of transmitting information; it has proven to be beneficial in rural communities' efforts to find agricultural-related information (including weather information). M. S. Hassan et al. (2010) discovered that the rural communities in their study thought of television as a credible and trustworthy instrument because they had grown up with it. Shaffril et al. (2012) argued that agricultural people prefer to get weather information via television because they believe it is more relevant to their daily activities. Azarian et al. (201 2) agreed, stating that television can meet the cognitive needs of agricultural people in terms of information seeking. Therefore, this study

measures the satisfaction of Malaysian coastal populations with weather information obtained via television.

Further, in the study of Omar et al. (2013), we found that a lack of understanding of patterns of weather forecasting is a gap. Local studies on social sensitivity to changing weather by Shaffril et al. (2011) and Abu Samah et al. (2011) have found and argued that coastal communities have observed these changes and that the changes have negatively impacted their socio-economic activities. Besides, Shaffril et al. (2013) and Fulsås (2007) have argued the importance of access to weather information in response to changing weather. The weather data is essential for coastal communities because it helps them manage their reactions to changing climate, which can save lives and property. Fulsas, 2007; Lincoln & Lucas (2010) claimed that many scholars around the world have focused their attention on weather forecasting studies, particularly its effects on the community. However, just a few researchers have looked at the Malaysian context. Therefore, the purpose of this study is to look into the trends of weather forecasting usage in Malaysian coastal areas.

5.2.2 TOURISM

The impact of tourism development became the gap that we found in the study of Salleh et al. (2014). According to Garegnani (1970), tourism development affects local communities, bringing beneficial socioeconomic changes and transforming economic activity. Andereck et al. (2005); Sirakaya et al. (2001); Jurowski et al. (1997); and Pearce (1991) argued that residents evaluate the impact of tourist development in terms of quality of life, or the three forms of sustainability: economic, socio-cultural (culture and social), and environmental sustainability (physical environment). According to Kang et al. (2008), tourism development not only modifies the physical landscape of a tourist destination but also causes social changes within the community, particularly in the attitude and behavior of the locals. Sahdan et al. (2009) argued that tourism growth also injects good morals into their traditional way of life, family relationships, individual behavior, and community. On the contrary, Jahi et al. (2009) argued that a tourist influx that exceeds a destination's carrying capacity will cause the destination's ecosystem to deteriorate. Therefore, this article aims to investigate the personal benefits the local community derives from tourism growth and how they perceive the development's impact and support for future development.

Besides, in the study of M. H. Hanafiah et al. (2013a), we found the personal benefit gained from tourism development as a gap. M. H. M. Hanafiah et al. (2011) stated that the tourism industry's ability to produce revenue, facilitate currency transactions, and give employment opportunities. Angelkova et al. (2012) argued that only a little study had been done on personal gain's effects on people's support for future tourism development. Jafari (2001) claimed that tourist development research should consider the impact of perceived benefits on tourism planning and development. Therefore, the current study examines the influence of tourism development on Langkawi Island's native communities.

5.2.3 SOCIOECONOMIC

Lack of involvement in business is the gap that we found in the study of Halim et al. (2015). Zakaria (2011) argued that the lack of coastal residents' involvement in entrepreneurship in fisheries, aquaculture, fish processing plants, and coastal tourism would be substantially impacted by their transfer from rural to urban industrial zones. Ariff et al. (2012) argued that the growth of advanced industries in coastal areas such as Dungun, Paka, Kerteh, Kemasek, Kijal, Chukai, Gebeng, Semambu, and Pekan had formed business opportunities; it has also resulted in a significant decrease in the number of coastal residents who are involved in entrepreneurship. Idris (2001) also exposed that, compared to labor in a range of sectors in urban areas, most young people in coastal communities are uninterested in fishing or other marine industries. Some are uninterested in pursuing a commercial career in coastal entrepreneurship (Wan Nawang et al., 2009). Therefore, their study is to determine the elements that influence social entrepreneurship in developing Terengganu's socio-economic and social life.

In addition, in the study of Saufi & Salleh (2018), we found communities' welfare as the gap. Lodhia (2011) argued that coastal ecosystems would be adversely affected by these activities, which include urbanization, agriculture, industrialization, fishing and aquaculture, salt production, tourism, mining and quarrying, and other natural disasters, resulting in coastal erosion due to rising sea levels, drought, tropical cyclones, floods, and other natural disasters. Based on past studies, numerous solutions for reducing and adapting to coastal erosion could be implemented. This is because, even if the adaptation method were implemented, the community's financial burden would not be alleviated. Therefore, it is proposed that authorities give another option not mentioned in the earlier study: takaful. Takaful is a financial protection scheme for the coastal people affected by the calamity. To summarize, this Takaful product is critical for coastal communities affected by coastal erosion. The project's point is to experiment on the Takaful plan's role in assisting the coastal population in the event of coastal erosion.

5.2.4 FISHERIES

A decline in fishery production and income became a gap in the study of Zainudin et al. (2019). On climate change uncertainty, N. M. G. Islam et al. (2016) pointed out that fishing operations in Terengganu are minimal due to strong winds during the monsoon season. Asli (2012) argued that the monsoon season, which happens every year between December and February and creates stormy weather with large waves and strong winds, may lead fishermen to lose their primary source of income if they do not have an alternative source of income. Rhoumah (2016), on the other hand, argued that the fishermen in Malaysia still face a high incidence of poverty, which includes both extreme and typical poverty. Similarly, Yahaya and Wells (1982) and N. M. G. Islam et al. (2016) also stated that poverty is widespread in Terengganu, particularly among artisanal fishermen's households. Poor fishermen are still relevant today, as most earn less than MYR 1,500 per month and fall into the bottom 40% of the income distribution (B40) (Khatijah et al., 2017). Therefore, the research examines the fishing community's socioeconomic characteristics in the Terengganu towns of Kuala Marang and Seberang Takir.

5.3 MANKIND

5.3.1 HEALTH/DISEASES

The Dahlui et al. (2020a) study discovered a gap in coastal communities' awareness of their health status, healthcare utilization, and quality of life. Initiatives to develop and improve the landscape and ecosystem have been planned extensively in many local coastal areas, particularly in Peninsular Malaysia(Mohd Salim et al., 2020) (Abdullah, 2005; Abdullah, 1993; Salim et al., 2018). In contrast, Sabah's socioeconomic advancement has been somewhat gradual, owing to the state's isolated and inaccessible coastline zones, as well as its linguistic diversity and cultural distinctions (Tha et al., 2018). Despite the fact that public health facilities exist, they are restricted and may not reach individuals who need them owing to a lack of infrastructure (Haris et al.,2019). Furthermore, Sabah's coastal districts are seeing a high prevalence of poverty and an influx of stateless and illegal persons (Allerton, 2017). Because of these factors the coastal communities of Sabah are suffering a variety of health and healthcare difficulties. To date, this research focusing on the health issues, healthcare gaps, and medical requirements of individuals living along Sabah's coast is lacking. Therefore, this paper proposes a study protocol to investigate the health status, healthcare utilization, and quality of life of Sabah's coastal populations.

Furthermore, in the study of Shafie et al. (2016), a lack of awareness of mosquito-borne diseases was categorized as the research gap. Dengue fever, malaria, chikungunya, Japanese encephalitis, yellow fever, and filariasis have all been recorded in Malaysia over the last few decades. Skae (1902) argued that dengue fever was first documented in Penang in 1902, followed by a significant outbreak in 1970. According to Sam et al. (2009), the country also had the first chikungunya virus infection in 1998 in Selangor, with the largest outbreak covering the entire country for three years, from 2008 to 2010. Because there is presently no vaccine available, primary prevention is the most efficient method of preventing and controlling dengue fever. The community's health knowledge, awareness, and practices (KAP) research on vector-borne diseases has been carried out, particularly in urban and rural communities like Peninsular Malaysia, such as the Federal Territory of Kuala Lumpur (Ayyamani et al. 1986), Perak (Hairi et al. 2003), and Negeri Sembilan (Leong 2014). However, there is a scarcity of such information among the islanders. Therefore, this research was conducted to determine the depth of knowledge, awareness, and habits among the island community regarding mosquito-borne diseases.

In addition, the high level of mercury exposure through the hair of the adult population was found as a gap in the study by Hajeb et al. (2008). Humans have used mercury for over 3,500 years for a variety of purposes. Herrstrom et al. (2003) argued that Calomel, Hg_2Cl_2, was one of the constituents in "teething powder," which was used to avoid soreness in the mouth of infants who were getting their first teeth before 1960. Metallic mercury has been utilized in thermometers, barometers, and diffusion pumps, among other laboratory instruments. At the same time, Chatterjee et al. (2002) argued that Alkyl mercury compounds were first used as agricultural fungicides in the early twentieth century. While Aschner (2001), Axtell et al. (2001), Castoldi et al. (2001), Frankish (2001), and Mendola et al. (2001) argued that humans are mostly exposed to mercury by fish consumption. Microorganisms in water or soil can convert inorganic mercury to

methylmercury, a more deadly organic form. Methylmercury can accumulate in animal tissues and induce biomagnifications in the aquatic food chain. As a result, people who consume fish are at a higher risk of methylmercury poisoning. Therefore, this paper investigates mercury exposure by measuring mercury levels in adults' hair in four coastal districts.

5.3.2 SKILLS AND KNOWLEDGE

Moreover, we found a lack of knowledge on green consumption among coastal communities as a gap in the study of Al Mamun et al. (2018). Based on Rezai et al. (2013) arguments, many environmental initiatives have been established, yet many residents are unfamiliar with the concept of being green, and their view of eco-friendly items is low. Furthermore, Ginsberg and Bloom (2004) argued that businesses had undervalued environmentally friendly items. After all, they believe they will not increase customer demand because they are not a requirement. Nagaraju and Thejaswini (2016) stated that most consumers are unaware of the advantages of green products, which influences their purchase decisions. Therefore, this study aimed to examine the elements influencing intention and behavior when using green products among low-income households in Peninsular Malaysia's coastal region.

Furthermore, in the article by M. Abdullah et al. (2013), we discovered a gap in the participants' knowledge and skills. Mangrove forests can be found across Malaysia, particularly around the coast. Mangrove forests supply local communities with timber and marine resources and other benefits. Branton (1999) has argued that establishing ecotourism development in local regions necessitates careful planning and management in close partnership with local groups. Locals will see a significant increase in their incomes compared to their traditional work as ecotourism becomes more visible and beneficial to community development. At the same time, the residents can conserve natural resources that are potentially decreasing. Therefore, the study's purpose was to analyze local community participation in mangrove ecotourism and the intervention procedures required for such a project's effectiveness.

5.3.3 LIFESTYLE

Changes in quality of life are the gap found in the study of Abdul Ghani et al. (2013). Yahaya Ibrahim (2007) study, based on the Redang Island, Perhentian Island, and Tioman Island areas, argued that members of a community living on a small island that is a latecomer to development would frequently have difficulty adapting to the process when it comes to tourism growth. Besides, Badaruddin Mohamed et al. (2008) argued, based on their study carried out in Langkawi, Pangkor, Tioman, and Redang, that while the islands welcome more tourists and tourism development, they are concerned about rising general prices, the loss of greenery, greater urbanization, and a variety of other difficulties. Joshua B. Fisher et al. (2008) argued that tourism development creates jobs and exposes natives to western culture and visitor behavior, which may conflict with deeply held community values. Therefore, this study aims to look into the impact of the tourism industry on the well-being of islanders on Langkawi and Redang Island using different measures of well-being such as employment, spending, and ownership.

Further, the social mobility gap changes were found in Sa'at (2011) study. Social mobility is a transformation or migration involving an individual or a group of individuals from one position to another, either between generations or within generations. Lipset and Bendix (1964) argued that there are two reasons why social mobility exists in every society. First, changes in demands for achievement or improvement. Second, changes in the supply of talents or abilities. Therefore, this article examines coastal communities, particularly patterns of change and social mobility among fishermen in Kuala Terengganu.

6. DISCUSSION

In this section, the discussion revolves around the theme and subtheme-based discussion. The analysis produced three themes and six sub-themes for this theme and subtheme-based debate. The subjects are not in any particular order, and their arrangement has nothing to do with their frequency or importance. The findings contain conceptual definitions, descriptive statistics, and supportive quotations from the literature analyzed.

The discussion revolves around the analysis, which produced three themes and six sub-themes. The three themes are impacts, awareness/ knowledge/ experience/ conservation/ enforcement/ programme/approach and social problems, along with the emerging six sub-themes. Although there is considerable overlap between the themes, each depicts a distinct element of interpersonal interaction, supporting its theme. The themes are not in any particular order, and their arrangement has nothing to do with their frequency of occurrence or relevance. The findings include conceptual definitions, data from descriptive themes, and supporting verbatim quotes from the evaluated publications.

6.1 IMPACT

The first theme, which is impact, was described in generic terms. This influence might be positive or detrimental, and the researcher explored the effect on the economic, community, environmental, and health aspects in coastal and island areas.

6.1.1 HEALTH

The coastal environment significantly impacts the quality of life and the health of the population in coastal areas (in both positive and negative ways) (Dahlui et al., 2020). So, a few academics looked into the health of coastal communities.
There is a shortage of data on the frequency of parasitic diseases among Malaysia's island people, with most studies performed between the 1960s and the 1980s. An Ahmad et al. (2014) study was conducted to ascertain the present prevalence status of parasitic illnesses among communities residing in Pangkor Island, Peninsular Malaysia. A total of 298 serum samples and 131 stool samples were taken, and they were each subjected to microscopic inspection for the presence of *Toxoplasma gondii* antibodies and intestinal protozoa and helminths using commercial ELISA kits. According to the findings of their investigation, the prevalence of intestinal parasite illnesses among the Pangkor Island

people has decreased significantly since it was first documented 35 years ago. Massive advancements in socioeconomic level, personal cleanliness, water facilities, and sanitation may have contributed to this community's low occurrence of parasitic illnesses.

Further, Sabah's poor economic condition is still disproportionately prevalent in rural coastal communities. And in Sabah's coastal districts, non-communicable diseases are generally undetected, according to verbal communication among medical experts, but no published data supports this. Therefore, Harris et al. (2019) researched non-communicable diseases among low-income adults in rural coastal communities in Eastern Sabah. Their study shows 40.6% of newly diagnosed hypercholesterolemia, 5.8% of diabetic mellitus, and 24.5% of cases of hypertension. Adults from extremely low socioeconomic positions accounted for the most significant percentage of those identified with undetected hypertension and uncontrolled blood pressure. This is because many residents in this rural coastal community were utterly ignorant that they had excessive cholesterol and high blood pressure.

Besides, strongyloidiasis in humans has not yet been the subject of epidemiological research in Malaysia. To ascertain the prevalence of Strongyloides stercoralis infection among the residents of long-house indigenous villages in Sarawak, a cross-sectional study was conducted by Ngui et al. (2016). Each participant provided a single feces and blood sample, which were then analyzed using molecular, serological, and microscopy approaches. Stool microscopy was used to identify five different types of intestinal parasites. For S. stercoralis, none of the stool samples tested positive. However, strongyloidiasis was detected in 11% of 236 serum samples. Additional verification using a molecular approach on stool samples from seropositive participants effectively amplified five samples, indicating ongoing infections. Adult males had a much higher incidence than females, which tended to rise with age.

6.1.2 ECONOMY AND COMMUNITIES

Coastal resources are considered necessary in promoting national coastal development since they provide many advantages to human well-being. The coastal environment is a crucial source of livelihood for coastal populations, providing a variety of appealing locations and biological diversity that is seen as a critical aspect in achieving the aim of ending global poverty in all of its manifestations by 2030 (He & Mai, 2021).
One of the most significant economic sectors is tourism, which has expanded not just in Malaysia but also globally. Over 23.6 million visitors visited Malaysia in 2009, and their presence helped the country's economy. Othman et al. (2012) investigated tourism activities and their impact on environmental sustainability in coastal areas. Everyone knows that tourism is an important sector of the economy and has a lot of sound effects on local communities. According to their analysis, Cahaya Bulan Beach's (PCB) tourism sector has experienced tremendous expansion, which has boosted the local economy by creating jobs and providing income to the local populace. Residents of coastal areas might diversify their sources of income by engaging in entrepreneurship. In light of this,

their research emphasizes the importance of tourism for boosting local social and economic conditions and generating revenue for the neighbourhoods.

Furthermore, one of Malaysia's top tourist spots for domestic and foreign visitors is Langkawi Island. The island's tourism sector's growth has directly and indirectly affected the community. Thus Salleh et al. (2014) study analyzed the development of the tourism industry and its impact on the Langkawi Island community. The mean analyses showed that the two factors with the highest mean scores enhance good employment opportunities (4.15) and give local citizens access to employment (4.09). This indicates that the coastal communities have more suitable employment opportunities, stronger family economies, and the ability to handle daily spending. So, in general, the community believes that tourist growth has a beneficial impact.

Besides, the development of the Langkawi and Redang islands' tourism industries has significantly enhanced the quality of life for the local population. Therefore, Ghani et al. (2014) conducted research in Langkawi and Redang Island about the impact of the tourism industry on the community's well-being. This study seeks to understand how tourism affects islanders' well-being through several well-being measures, including employment, expenditure, and ownership. Their findings demonstrated a noticeable improvement in people's well-being on both islands, particularly regarding work, income, and expenses. All respondents agreed that receiving numerous work opportunities on the islands has changed their sense of well-being. The majority of the 30 responders in Langkawi acknowledged having higher incomes. All respondents spent enough to support their families and themselves financially.

Meanwhile, Jaya-Ram et al. (2018) researched muscle fatty acid content in selected freshwater fish. Their research was conducted at Bukit Merah Reservoir, a popular fishing spot for locals. Individuals, society, and the environment all benefit from inland fisheries, which provide a source of income and food security.

Due to its capacity to create income, employment opportunities, and a higher standard of living, the tourism industry has become a symbol of how it can support the local community, particularly in transforming the economy and environment. Local opinions can directly impact the growth of the tourism sector. So, Abas & Mohd Hanafiah (2014) studied local community attitudes toward tourism development on Tioman Island. Their result shows that local communities benefit financially from the influx of tourists, particularly those who run chalets, resorts, or rooms, sea taxi services, shops, and handicraft stores. More visitors will boost the economy, and the locals tend to see tourism as a way to earn cash and job prospects. However, the findings also found that the local community, which experienced a negative impact from tourist activities, also supports tourism development in the future owing to their reliance on this sector as their primary source of income.

6.1.3 ENVIRONMENT

Coastal areas make desirable locations for living, employment, or other pursuits. The main threats to coastal ecosystems include habitat loss or conversion brought on by coastal development, agriculture, or aquaculture; habitat degradation brought on by eutrophication, pollution, and contamination; and resulting changes in sediment and water supply brought on by human activities along the coasts and in upstream watersheds (Neumann et al., 2017).

One of the leading causes contributing to the decline of the quality of the natural environment is the ineffective and inadequate management of solid waste. Therefore, Shamshiry et al. (2012) research study examines the impact of landfill leachate on water quality in Langkawi Island using environmental system management. Urban areas frequently experience ecological contamination, caused mainly by irregular garbage collection and unplanned, indiscriminate waste disposal that frequently goes untreated. These conditions contribute to severe environmental pollution, especially as individuals often open-burn waste when it accumulates due to sporadic waste collection, a practice that significantly increases air pollution. According to their findings, groundwater from the Langkawi landfill boreholes is thought to be polluted with cadmium and hence has to be treated before being used as a potable water supply source.

Furthermore, off the coast of Peninsular Malaysia, Pulau Tioman is a well-known tourist destination with stunning coral reefs. A'ziz et al. (2021) researched Pulau Tioman, which is about the health of the coral reefs surrounding Pulau Tioman. Many tourism activities have a negative impact on marine resources. According to their findings, most sample locations favor coral reef growth and have strong recoverability from future environmental stress; however, certain regions with increased coastal development and tourists have poorer water and sediment quality. Due to climate change and human interference, coral reef ecosystems are endangered or have disappeared.

Coral populations in the Caribbean and Indo-Pacific reefs are declining due to coral disease outbreaks. Despite being exposed to numerous natural and artificial dangers, there is limited information on coral diseases in Malaysian reefs. Fortunately, a study about the assessment of coral health and disease was conducted by Akmal & Shahbudin (2020) in Tioman Island Marine Park, Malaysia. This is due to increased human disturbances, particularly sedimentation and nutrient pollution, and rising sea surface temperatures, which are the primary drivers of coral disease's spatial and temporal dynamics. Overall, as per their findings, coastal development and tourism activities may impact the severity of coral conditions and symptoms of impaired health.

Furthermore, Ahmad et al. (2019) examined the impact of coastal development on mangrove distribution in the Cherating Estuary, Pahang. Over the previous 20 years, the mangrove cover along the Cherating estuary's 131.642 ha total area has declined by over 19.99% (26.275 ha). The removal of mangroves to make way for commercial or residential areas and aquaculture activities were among the factors they identified as contributing to mangrove deterioration. They also stated that Cherating is one of the main tourist attractions in Pahang and that coastal development could contribute to the

decline of mangrove ecosystems. Mangroves have been destroyed to make room for these developments, and growth has been expanding yearly.

Concerns about the cumulative effects of scuba divers on the marine ecosystem beneath the ocean surface have arisen due to the growing demand for dive tourism activities. Fortunately, Ong & Musa (2011) researched recreational divers' underwater behavior by attitude-behavior theories. Their study also revealed that significant positive relationships are observed between all the domains with responsible underwater behavior and adversely affect the undersea marine environment. Othman et al. (2012) researched tourism activities and their impact on environmental sustainability in coastal areas. Their results revealed that tourism activities, such as the beach's cleanliness, affect ecological sustainability.

6.2 AWARENESS, KNOWLEDGE, EXPERIENCE, CONSERVATION, ENFORCEMENT, PROGRAMME, AND APPROACH

6.2.1 HEALTH

Health is an essential element that the local coastal communities need to be aware of. A few articles specifically show expertise focusing on the health needs in coastal communities.

Over the past few decades, mosquito-borne diseases have been rising at an alarming rate. Shafie et al. (2016) researched mosquito biology and mosquito-borne disease awareness among island communities in Malaysia. The most excellent way to detect and eradicate mosquito-borne diseases is through mosquito surveillance and control programs; however, these initiatives are ineffective without a knowledgeable and engaged population. According to their findings, respondents were aware of the basics of mosquito biology and used personal protection against mosquito bites, but most had limited knowledge of the diseases spread by mosquitoes. Therefore their study recommends strengthening and expanding public health education outreach initiatives to island people and increasing community engagement in vector surveillance and control.

Besides, thyroid antibodies and autoimmune thyroid conditions are closely connected. There is currently no information on the prevalence of these antibodies among Malaysians. Shahar et al. (2020) stated that their study aimed to ascertain the prevalence of thyroid antibodies and the risk factors for thyroid antibodies in the adult population of Malaysia. The author said that Anti-TPO and anti-TG thyroid antibodies are employed in diagnosing autoimmune thyroid diseases (AITD). They stated that the low prevalence of thyroid antibodies and thyroid diseases in coastal communities might be related to the region's iodine sufficiency.

Further, Malaysia's coastlines can significantly impact the well-being of locals and their means of subsistence. The Malaysian government has planned to improve the environment and landscape, but the process has been slow due to some coastal regions' remoteness and accessibility issues. Research by Dahlui et al. (2020) investigates the

health status, use of healthcare, and standard of living in coastal communities and the interaction between the community and its coastal environment. This study has the potential to raise public awareness of health disparities among the coastal communities and to build a tailored intervention for the community's context-specific health and quality of life intervention program.

6.2.2 ECONOMY AND COMMUNITY

The economic factors that support local coastal communities are greatly influenced by awareness. To stabilize living expenses in a coastal area, knowledge about the socioeconomic status of the surrounding areas is required.

One industry that has helped the growth of island communities in the modern era is ecotourism. Therefore, Halim et al. (2021) paper examine the relationship between entrepreneurship development programs and business performance among entrepreneurs in Tioman Island, Malaysia. The outcomes showed that market access and technology application considerably positively impact business performance. The authors of this study recommended that local ecotourism business owners network with outside parties to help them further establish micro and small ecotourism businesses. The individual entrepreneurs and the community in the village itself will benefit economically from the social business strategy when industry, government, and non-governmental organizations work together. Additionally, they advised that to succeed in their firm's ecotourism sector, it would be wise for them to build their business network.

Further, Bhuiyan et al. (2014) research title is *"Tourists' perception of the local economy of Terengganu state in Malaysia."* The current research aimed to determine whether visitors' perceptions of Lake Kenyir and the Sekayu Recreational Forest indicated that they intended to boost the local economy. Their finding revealed that most responders from both domestic and international tourists agreed to support the local economy. Further, the authors recommend that the provincial government encourage visitors to consume local food and products, shop at local businesses, stay in local lodging, and take advantage of regional tourism offerings. This means the quality of local goods and services has risen in response to tourist demand. They further stated that the destination authorities might encourage visitors to purchase local foods and products, shop at local stores, stay in local accommodations, and enjoy the benefits of regional tourism offerings.

Besides that, Mohd Salleh et al. (2011) compare local community sustainability of livelihood. The purpose of this paper is to examine how the Pulau Tioman (TIMP) and Pulau Redang Marine Parks (PRMP) have affected the livelihood of these island communities. The findings demonstrate that, generally, both communities' needs for human, physical, and social assets are met. On the financial and environmental fronts, they are unsatisfied, nevertheless. Since there are still some school dropouts among the children of these island settlements, the education component must also be addressed.

Despite this, the residents are still protected from socioeconomic challenges, uncertainty, illness outbreaks, and natural calamities.

Regarding the framework for sustainable living, their report recommends that the public and private sectors work together to ensure the islands' viability as marine parks. Processes or activities that can be used, such as enforcing laws, regulations, norms, and institutions, assist the efforts. Once the procedures are followed, it is envisaged that they will assist in managing the consumption of sustainable resources. The residents' income will ultimately rise, and their standard of living.

The local government must emphasize improving its people's quality of Life (QoL). Ghani et al. (2010) studied the quality of life, settlements, and housing in Pulau Perhentian. This study tries to evaluate the island under the study's objective quality of life level. The area of an objectively high-quality existence covers everything from food and drink to shelter, clothes, health services, public transportation, education, personal safety, and guaranteed income for all. Their survey results show that the population under study has a medium degree of objective quality of life. According to one part of the survey, the local population lives in highly populated villages. Compared to the community on the mainland, the houses in this neighborhood were terrible. So the study's author suggested that homes in the front sections should be moved to another portion of the island due to the recurring flooding issue on Pulau Perhentian Kecil. Additionally, the government should devise a better plan to relocate the communities to a better place or provide them with better alternative areas to construct their homes to address the overpopulation issue.

6.2.3 ENVIRONMENTS

Environmental awareness is one of the most critical factors that must be prioritized. Here, we discussed the environmental protection that the authors recommend in their research papers.

According to the National Hydraulic Research Institute of Malaysia, by 2050, the nation's east coast will experience an increase in significant rainfall, a rise in sea level, and frequent flooding. It is now more critical than ever for coastal communities to consider the effects of coastal hazards, vulnerabilities, and adaptation measures. Therefore, Islam et al. (2021) research paper intends to evaluate the level of community awareness of and response to coastal hazards and to study variations in understanding based on socioeconomic characteristics. Under their research results, more than half of household heads are highly aware of the effects of coastal hazards, including human casualties, losses of mangroves, coastal forests, aquatic, wildlife, and livestock resources, as well as harm to residential properties, coastal infrastructures, agriculture, and economic activities. Their research recommends implementing a sustainable awareness program using modern adaptive measures and tactics. Developing knowledge, awareness, and education are crucial components of adaptation strategies for dealing with the consequences of natural hazards.

Further, in Malaysia, the group most at risk from sea level rise is the coastal community. Md Hashim et al. (2019) studied the seaside community's awareness and concern about rising sea levels. This article analyzes the coastal community's knowledge and understanding of climate change and sea level rise. According to their findings, approximately 70% of respondents are aware of climate change-related difficulties, with coastal residents having the most influence due to their effects on human health. However, the respondents' awareness of the risks associated with climate change and sea level rise showed an average result of 43%. The results indicate that Malay respondents scored highest regarding knowledge structures, awareness, and perceptions of climate change. It is anticipated that the findings of this study will be helpful to authorities in the administration and planning of adaptation programs and disaster preparedness in the event of a sea-level rise disaster.

Al Mamun et al. (2018) research paper title is intention and behavior toward green consumption among low-income households. This research observes the purpose and behavior toward green consumption among low-income families to address climate change concerns through prudent resource management and environmental protection. Their research states that responsible organizations need to develop programs and policies that reduce the negative consequences of climate change through resource management and ecological conservation, like encouraging Malaysians to purchase green goods.

The surrounding communities benefit significantly from the mangrove forest's high productivity and both concrete and intangible benefits. Mangroves are a source of income for millions worldwide, including in Malaysia. Hence, the focus of Shah et al. (2016) study is on raising public knowledge of the advantages of the Sibuti mangrove forest to the local population in Sarawak. Their findings revealed that community knowledge, willingness, and incentive to participate were extraordinarily high and positive, according to the awareness dimensions of the UNDP human development report. This is because the community believed that mangrove forests protected them from cyclones, storms, tsunamis, and other natural disasters and helped to form new land.

Moreover, the flood risk will also be part of the communities' environmental awareness that needs to be dealt with continuously. Floods are becoming more frequent, which puts coastal communities and the many natural areas in the nearby MPAs in grave environmental and social danger. Hence, Masud et al. (2018) focus on the coastal populations' perceptions of flood risk occurrence and their consequences on MPAs, which are critical for flood risk management (FRM) exercises. Coastal communities' opinions on the development of flood risk analysis strengthen the FRM cycle by increasing preparedness, management, and recovery levels. The findings explain that the perception of risk, perceived severity, advantages, and past flood risk experience positively and substantially affect the desire to engage in flood prevention initiatives. This study recommends that a flood defense system (FDS) be included as a fundamental part of all flood mitigation efforts. For example, culverts must be built along the route to guarantee that excessive water can precisely flow through them without posing a risk of over-flooding.

6.3. SOCIAL PROBLEMS AMONG COASTAL COMMUNITIES

Dahlui et al. (2020) studied health status, healthcare utilization, and quality of life among the coastal communities in Sabah. In their study, in one section, they stated that coastal communities have a high rate of cigarette, alcohol, and illegal drug usage.

Mohd et al. (2014) study about the influence of tourism development on Langkawi's local population. One of the variables in their research is the criminal case. Their study result shows that this "does not increase the number of criminal cases" variable records the lowest mean scores, which is mean = 2.80. The typical mean (2.80) ratings imply that tourism development on Langkawi Island does not have a significant social impact on the local people. This problem exists but occurs at a declining rate.

Mohamed Shaffril et al. (2015) study the socio-economic effects of agro-tourism activities in Malaysia's coastal communities known as Desa Wawasan Nelayan (DWN). The perceptions of locals on the social impacts of Agro-Tourism activities significantly contribute to drug and alcohol problems, showing a mean of 1.97. Because the mean is likewise at a lower level, this implies that drug and alcohol problem activities are still present in the community but at a lower level

REFERENCES

A'ziz, A. N. A., Minhat, F. I., Pan, H. J., Shaari, H., Saelan, W. N. W., Azmi, N., Manaf, O. A. R. A., & Ismail, M. N. (2021). Reef foraminifera as bioindicators of coral reef health in the southern South China Sea. *Scientific Reports*, *11*(1), 8890. https://doi.org/10.1038/s41598-021-88404-3

Ab Razak, M. S., Jamaludin, N., & Mohd Nor, N. A. Z. (2018). The Platform Stability of Embayed Beaches On The West Coast Of Peninsular Malaysia. *Jurnal Teknologi*, *80*(4), 33–42. https://doi.org/10.11113/jt.v80.11526

Ab Razak, N. (2017). *Eco visitors Economic Value In Matang Mangrove Forest Reserve, Perak, Malaysia*.

Abas, N., Daud, Z. M., Mohamed, N., Halim, S. A., Malaysia, T., Sultan, J., Petra, Y., & Lumpur, K. (2017). Climate change impact on coastal communities in Malaysia. *Journal of Advanced Research Design Journal Homepage*, *33*(1), 1–7. www.akademiabaru.com/ard.html

Abas, S. A., & Mohd Hanafiah, M. H. (2014). Local Community Attitudes Towards Tourism Development in Tioman Island. *Tourism, Leisure and Global Change*, *1*, 22–24. http://geog.nau.edu/igust/Sabah2013/

Abd Rahman, R., Zaini, A. R., & Lyndon, N. A. (2018). Kearifan Lokal Masyarakat Melayu Muslim Langkawi dalam Pelancongan Membantu Pelestarian Pembangunan Masyarakat Local Wisdom of the Langkawi Muslim Community in Tourism Helps the Preservation of Community Development. *ISLÓMIYYÓT*, *40*(2), 115–122. https://doi.org/10.17576/islamiyyat-2018-4002-03

Abdul Ghani, N., Azmi, N. H., & Ali Puteh, D. A. (2013). The Impact of the Tourism Industry on the Community's Well-being on Langkawi and Redang Islands, Malaysia. *Advances in Natural and Applied Sciences*, *7*(3), 276–283. http://www.pdllangkawi.blogspot.com

Abdul Munir Najmuddin, Mohammad Firas Azmi, Ahmad Sanusi Hassan, Muhammad Hafeez Abdul Nasir, & Witchayangkoon, B. (2019). A Quality of Urban Design Elements in Fishing Village At Teluk Kumbar, Penang. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies*, *10*(11), 1–12.

Abdul Rahman, H. (2009). Global climate change and its effects on human habitat and environment in Malaysia. *Journal of Environmental Management*, *10*(2), 17–32.

Abdullah, A., Hamzah, Z., Saat, A., Wood, A. K., & Alias, M. (2015). Accumulation of Mercury (Hg) and Methyl Mercury (MeHg) concentrations in selected marine biota from Manjung Coastal Area. *Malaysian Journal of Analytical Sciences*, *19*(4), 669–678.

Abdullah, A. M., Ismail, M. M., Khai, N. X., & Durham, S. (2013). Mangrove Conservation Awareness Amongst Shrimp Culturist in Malaysia. *Pertanika Journal of Social Sciences and Humanities*, *21*, 47–62.

Abdullah, M., Noor, A., Faridah-Hanum, I., Zakaria, M. H., & Yip, H. W. (2013). Local Community Participatory Process and Intervention Procedure in Mangroves Ecotourism of Marudu Bay, Sabah. *Pertanika J. Trop. Agric. Sci*, *36*(S), 173–180. http://www.pertanika.upm.edu.my/

Abu Hena, M. K., Kumar, U., Idris, M. H., Karim, N. U., Ismail, J., & Jaafar, N. M. S. N. (2021). Temporal variation in community structure of Dragnet (Pukat Tarik) fishery in relation to ecological variables in an inshore area of Sarawak, Malaysia. *Songklanakarin Journal of Science and Technology*, *43*(3), 871–880. https://doi.org/10.14456/sjst-psu.2021.115

Abu Samah, B., Shaffril, H. A. M., D'Silva, J. L., & Uli, J. (2011). The Negative Environmental Changes on the Sea and its Impact on the Aspects of Economic, Social and Health of the Fishermen Living in the East Coast Zone of Peninsular Malaysia. *American Journal of Environmental Sciences*, *7*(6), 534–541. https://doi.org/10.3844/ajessp.2011.534.541

Adeel, Z., & Pomeroy, R. (2002). Assessment and management of mangrove ecosystems in developing countries. *Trees - Structure and Function*, *16*(2–3), 235–238. https://doi.org/10.1007/s00468-002-0168-4

Affizah, N., Vedamanikam, V. J., & Shazilli, N. A. M. (2009). Concentration of arsenic and mercury in the oyster (Crassostrea iredalei) from Setiu lagoon, Terengganu. *Toxicological & Environmental Chemistry*, *91*(2), 259–265. https://doi.org/10.1080/02772240802166573

Ahmad, A. F., Ngui, R., Muhammad Aidil, R., Lim, Y. A. L., & Rohela, M. (2014). Current status of parasitic infections among Pangkor Island community in Peninsular Malaysia. *Tropical Biomedicine*, *31*(4), 836–843.

Ahmad Saufi Fauzilah Salleh, N. (2018). Does Coastal Community Need Takaful Protection from Coastal Erosion? *International Journal of Tourism, Hospitality, and Environment Management*, *3*(7), 43–56. www.jthem.com

Ahmad, Z., Mohamad Suharni, M. L., Taib, S. N. A., & Shammodin, M. S. (2019). Impact of coastal development on mangrove distribution in Cherating Estuary, Pahang, Malaysia. *Malaysian Journal of Fundamental and Applied Sciences*, *15*(3), 456–461. https://doi.org/10.11113/mjfas.v15n3.1091

Aisyah, D., Omar, K., & Mokhtar, N. F. (2014). Social welfare development program among coastal community (SPKMP) in Kuala Terengganu : a preliminary assessment on the performance of the program. *Social Studies*, *74*, 27065–27071.

Akhter, S. (2014). *Economic Valuation Of Eco-Tourism Resources In Pulau Perhentian Marine Park, Malaysia*.

Akmal, K. F., & Shahbudin, S. (2020). Baseline assessment of coral health and disease in Tioman Island Marine Park, Malaysia. *Community Ecology*, *21*(3), 285–301. https://doi.org/10.1007/s42974-020-00030-7

Akmal, K. F., Shahbudin, S., Faiz, M. H. M., & Hamizan, Y. M. (2019). Diversity and Abundance of Scleractinian Corals in the East Coast of Peninsular Malaysia: A Case Study of Redang and Tioman Islands. *Ocean Science Journal*, *54*(3), 435–456. https://doi.org/10.1007/s12601-019-0018-6

Al Mamun, A., Mohamad, M. R., Yaacob, M. R. Bin, & Mohiuddin, M. (2018). Intention and behavior towards green consumption among low-income households. *Journal of Environmental Management*, *227*, 73–86. https://doi.org/10.1016/j.jenvman.2018.08.061

Alam, M. S., & Paramati, S. R. (2016). The impact of tourism on income inequality in developing economies: Does Kuznets curve hypothesis exist? *Annals of Tourism Research*, *61*, 111–126. https://doi.org/10.1016/j.annals.2016.09.008

Ali, I., & Mohd Arif, M. R. (2007). Hubungan Ekosistem Marin Pinggir Pantai Dan Muara Sungai Dengan Sosio-Ekonomi Komuniti Nelayan Di Teluk Brunei Dan Teluk Padas, Sabah: Satu Tinjauan. *Jurnal JATI*, *12*, 229–245. https://s3.amazonaws.com/academia.edu.documents/45238137/Ismail_Ali__Mohd_Raduan-The_Relationship_of_Marine_Coastal_Ecosysmtem_and_River_Estuaries.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1522045000&Signature=HtCZliWG%2BB1rrhKCFmzM%2FRrPNlc%3D&resp

Ali, M. F., Rahman, N. F. A., Khalid, K., & Liem, N. D. (2014). Langat river basin hydrologic model using integrated GIS and ArcSWAT interface. *Applied Mechanics and Materials*, *567*, 86–91. https://doi.org/10.4028/www.scientific.net/AMM.567.86

Amirah Mohd Rozadi, F., Mukrim Baharuddin, Z., & Haryati Ibrahim, P. (2021). Terengganu Identity: Proposed Harbourscape Tourism At Kampung Seberang Takir, Terengganu. *Design Ideals Journal (DIJ)*, *3*(2), 7–18.

Amri Mohd, F., Nizam Abdul Maulud, K., Ara Begum, R., Karim, O. A., Firoz Khan, M., Norsakinah Selamat, S., Aziz Ab Rahman, A., Aizat Saiful Bahri, M., Mastura Syed Abdullah, S., Khairul Amri Kamarudin, M., Barzani Gasim, M., & Juahir, H. (2018). Variation of Beach Profile Along Pahang Coast in Malaysia. In *International Journal of Engineering & Technology* (Vol. 7, Issue 3). www.sciencepubco.com/index.php/IJET

Andereck, K. L., Valentine, K. M., Knopf, R. C., & Vogt, C. A. (2005). Residents' perceptions of

community tourism impacts. *Annals of Tourism Research*, *32*(4), 1056–1076. https://doi.org/10.1016/j.annals.2005.03.001

Angelkova, T., Koteski, C., Jakovlev, Z., & Mitrevska, E. (2012). Sustainability and Competitiveness of Tourism. *Procedia - Social and Behavioral Sciences*, *44*, 221–227. https://doi.org/10.1016/j.sbspro.2012.05.023

Anthony, K. R. N., Marshall, P. A., Abdulla, A., Beeden, R., Bergh, C., Black, R., Eakin, C. M., Game, E. T., Gooch, M., Graham, N. A. J., Green, A., Heron, S. F., Hooidonk, R., Knowland, C., Mangubhai, S., Marshall, N., Maynard, J. A., McGinnity, P., McLeod, E., ... Wear, S. (2015). Operationalizing resilience for adaptive coral reef management under global environmental change. *Global Change Biology*, *21*(1), 48–61. https://doi.org/10.1111/gcb.12700

Anuar, A. R., & Harun, A. (2019). Malaysia-Indonesia Cross-Border Governance: Is There a Trade-off between Security and Economic Development? *Journal International Studies*, *15*, 21–34. https://doi.org/10.32890/jis2019.15.2

Apuke, O. D. (2017). Quantitative Research Methods : A Synopsis Approach. *Kuwait Chapter of Arabian Journal of Business and Management Review*, *6*(11), 40–47. https://doi.org/10.12816/0040336

Arabamiry, S. (2014). *Visitors' Economic Valuation of The Attributes of Marine Resource Conservation And Management In The Perhentian Marine Park, Malaysia*.

Arabamiry, S. (2018). How international visitors do contribute to management processes of Perhentian Island Marine Park Malaysia? In *Arabamiry / Environmental Resources Research* (Vol. 6, Issue 1). www.SID.ir

Arabamiry, S., Rahim, K. A., Radam, A., Khademfar, M., & Yacob, M. R. (2013). Marine Park Visitors ' Trade-off among Marine Ecological Attributes in Malaysia. *International Journal of Business and Social Science*, *4*(17), 218–228.

Archer, B., & Fletcher, J. (1996). The economic impact of tourism in the Seychelles. *Annals of Tourism Research*, *23*(1), 32–47. https://doi.org/10.1016/0160-7383(95)00041-0

Ariff, M. R., Sharir, M., Ali, I., Majid, M., & Hussin, H. (2012). Perkembangan perusahaan perikanan di Semenanjung Malaysia: Isu dan persoalan (The development of fishing industry in Peninsula Malaysia: Issues and questions). *Journal of Southeast Asian Studies*, *16*, 265–299.

Ariffin, E. H. (2017). *Effect of Monsoons on Beach Morphodynamics in the East Coast of Peninsular Malaysia: Examples from Kuala Terengganu Coast* [Universite Bretagne Loire, France.]. https://www.researchgate.net/publication/320563984_Effect_of_Monsoons_on_Beach_Morphodynamics_ in_the_East_Coast_of_Peninsular_Malaysia_Examples_from_Kuala_Terengganu_coast

Ariffin, E. H., Sedrati, M., Daud, N. R., Mathew, M. J., Akhir, M. F., Awang, N. A., Yaacob, R., Siddiqui, N. A., & Husain, M. L. (2018). Shoreline Evolution Under the Influence of Oceanographic and Monsoon Dynamics: The Case of Terengganu, Malaysia. In *Coastal Zone Management: Global Perspectives, Regional Processes, Local Issues*. Elsevier Inc. https://doi.org/10.1016/B978-0-12-814350-6.00005-7

Arof, Z. M., Masron, T., Aniza, N., & Ail, M. (2014). *Homestay Re-visit Implementation Model Based on Spatial Perspective in Langkawi Island* (Vol. 9, Issue 1).

Asli, Y. (2012). Nelayan hilang punca pendapatan. *Utusan Online: Timur*.

Asmawi, M. Z., Din, A. M., Sshamsuddin, N. F., & Paiman, T. (2012). Financing Coastal Land Use Planning: A Case Study of LUAS, Malaysia. *APCBEE Procedia*, *1*, 325–330. https://doi.org/10.1016/j.apcbee.2012.03.053

Azarian, Z., Hassan, M., & Samah, B. (2012). Gratification Obtained from Agricultural Information Disseminated through Radio among Malaysian Farmers. *Journal of Basic and Applied*, *2*(11), 11711–11716. http://www.textroad.com/pdf/JBASR/J. Basic. Appl. Sci. Res., 2(11)11711-11716, 2012.pdf

Azhar, M. M., Maulud, K. N. A., Selamat, S. N., Khan, M. F., Jaafar, O., Jaafar, W. S. W. M., Abdullah, S. M. S., Toriman, M. E., Kamarudin, M. K. A., Gasim, M. B., & Juahir, H. (2018). Impact of shoreline changes to the coastal development. *International Journal of Engineering and Technology(UAE)*, *7*(3.14), 191–195. https://doi.org/10.14419/ijet.v7i3.14.16883

Aziz, N., Yien Lua, W., Ghazali, F., Abd. Rasid, N. H., Idris, I., & Wan Talaat, W. I. A. (2021). Marine Spatial Planning and the Local Community'S Awareness of Ecosystems in Setiu Wetland. *Journal of Southeast Asian Studies*, *26*(1), 97–123. https://doi.org/10.22452/jati.vol26no1.5

Azizan, M., Zulkeflli, A. E., & Azizan, K. (2020). Residents Perception of And Participation In Solid Waste Recycling In Langkawi. *ESTEEM Journal of Social Sciences and Humanities*, *4*, 57–65.

Azlisham, M., Vedamanikam, V. J., & Shazilli, N. A. M. (2009). Concentrations of cadmium, manganese, copper, zinc, and lead in the tissues of the oyster (Crassostrea iredalei) obtained from Setiu Lagoon, Terengganu, Malaysia. *Toxicological & Environmental Chemistry*, *91*(2), 251–258. https://doi.org/10.1080/02772240802138127

Bagheri, M., Zaiton Ibrahim, Z., Bin Mansor, S., Abd Manaf, L., Badarulzaman, N., & Vaghefi, N. (2019). Shoreline change analysis and erosion prediction using historical data of Kuala Terengganu, Malaysia. *Environmental Earth Sciences*, *78*(15), 1–21. https://doi.org/10.1007/s12665-019-8459-x

Baharuddin, M. F. T., Masirin, M. I. M., Hazreek, Z. A. M., Azman, M. A. A., & Madun, A. (2018). Resistivity-Chemistry Integrated Approaches for Investigating Groundwater Salinity of Water Supply and Agricultural Activity at Island Coastal Area. *Journal of Physics: Conference Series*, *995*(1), 012093. https://doi.org/10.1088/1742-6596/995/1/012093

Bañas, J. C. C., Subade, R. F., Salaum, D. N., & Posa, C. T. (2020). Valuing vanishing coasts: The case of Miagao coastline in Southern Iloilo, Philippines. In *Ocean and Coastal Management* (Vol. 184). https://doi.org/10.1016/j.ocecoaman.2019.105008

Bee, H. Y., Squires, D., Ibrahim, K., Gjertsen, H., Syed Mohd Kamil, S. K., Zulkifli, R., Groves, T., Peter H, D., Hong, C. M., & Tan, C. H. (2011). Sea Turtle-Fisheries Interactions in Coastal Fisheries: A Case Study of the East Coast of Peninsular Malaysia. In *Conservation of Pacific Sea Turtles* (pp. 290–318).

Bhuiyan, M. A. H., Siwar, C., Ismail, S. M., & Aman, A. (2014). Tourists' perception on local economy of Terengganu state in Malaysia. *Journal of Food, Agriculture and Environment*, *12*(3–4), 345–348.

Bilotta, G. S., Milner, A. M., & Boyd, I. (2014). On the use of systematic reviews to inform environmental policies. *Environmental Science and Policy*, *42*, 67–77. https://doi.org/10.1016/j.envsci.2014.05.010

Bin, L. C., Salleh, N. H. M., & Bin, L. K. (2020). The evaluation model for coral reef restoration from management perspective for ensuring marine tourism sustainability. *Journal of Sustainability Science and Management*, *15*(1), 93–104.

Bindoff, N. L., Willebrand, J., Artale, V., Cazenave, A., Gregory, J., Gulev, S., Hanawa, K., Le Quéré, C., Levitus, S., Nojiri, Y., Shum, C. K., & Talley, L.D., Unnikrishnan, A. (2007). *Observations: Oceanic climate change and sea level.*

Bird, E. C. F. (1985). *Coastline changes. A global review*. Chichester, John Wiley & Sons.

Bruno, J. F., & Selig, E. R. (2007). Regional Decline of Coral Cover in the Indo-Pacific: Timing, Extent, and Subregional Comparisons. *PLoS ONE*, *2*(8), e711. https://doi.org/10.1371/journal.pone.0000711

Cantor, T. (1847). Catalogue of Reptiles Inhabiting the Malayan Peninsula and Islands. *Journal of the Asiatic Society of Bengal*.

Chan, E. H., Liew, H. C., & Mazlan, A. G. (1988). The incidental capture of sea turtles in fishing gear in Terengganu, Malaysia. *Biological Conservation*, *43*(1), 1–7. https://doi.org/10.1016/0006-3207(88)90074-2

Chan, G. K. L., Selvadurai, S., & Abdul Aziz, R. (2020). The Culture Of Heritage Conservation In

Malaysia: A Study Of Eco-Tourism In Langkawi. *Journal of Social Sciences and Humanities*, *17*(1), 165–174.

Chan, G. K. L., Selvadurai, S., & Aziz, R. A. (2020). The Culture of Heritage Conservation in Malaysia: a Study of Eco-Tourism in Langkawi. *E-BANGI: Jurnal Sains Sosial Dan Kemanusiaan*, *17*(1), 165–174.

Chee, S. Y., Othman, A. G., Sim, Y. K., Mat Adam, A. N., & Firth, L. B. (2017). Land reclamation and artificial islands: Walking the tightrope between development and conservation. *Global Ecology and Conservation*, *12*, 80–95. https://doi.org/10.1016/j.gecco.2017.08.005

Chen, S.-L., Jeevan, J., & Cahoon, S. (2016). Malaysian Container Seaport-Hinterland Connectivity: Status, Challenges and Strategies. *The Asian Journal of Shipping and Logistics*, *32*(3), 127–138. https://doi.org/10.1016/j.ajsl.2016.09.001

Chia, K.-W., Ramachandran, S., Ho, J.-A., & Ng, S. S.-I. (2018). Conflicts To Consensus : Stakeholder Perspectives of Tioman Island Tourism Sustainability. *International Journal of Business and Society*, *19*, 159–174.

Chia, K.-W., Ramachandran, S., Ho, J.-A., Siew, S., & Ng, I. (2018). Conflicts To Consensus: Stakeholder. *International Journal of Business and Society*, *19*(1), 159–174.

Chong, V. C. (2007). Mangroves-fisheries linkages - The Malaysian perspective. *Bulletin of Marine Science*, *80*(3), 755–772.

Chow, J., Kopp, R. J., & Portney, P. R. (2003). Energy Resources and Global Development. *Science*, *302*(5650), 1528–1531. https://doi.org/10.1126/science.1091939

Comerio, N., & Strozzi, F. (2019). Tourism and its economic impact: A literature review using bibliometric tools. *Tourism Economics*, *25*(1), 109–131. https://doi.org/10.1177/1354816618793762

Cooke, F. M. (2004). Symbolic and social dimensions in the economic production of seaweed. *Asia Pacific Viewpoint*, *45*(3), 387–400. https://doi.org/10.1111/j.1467-8373.2004.00246.x

Cowburn, B., Samoilys, M. A., & Obura, D. (2018). The current status of coral reefs and their vulnerability to climate change and multiple human stresses in the Comoros Archipelago, Western Indian Ocean. *Marine Pollution Bulletin*, *133*, 956–969. https://doi.org/10.1016/j.marpolbul.2018.04.065

Dahlui, M., Azzeri, A., Zain, M. A., Mohd Noor, M. I., Jaafar, H., Then, A. Y. H., Suhaimi, J., Kari, F., Creencia, L. A., Madarcos, J. R., Jose, E., Fleming, L. E., White, M. P., Morrissey, K., Fadzil, K. S., & Goh, H. C. (2020). Health status, healthcare utilisation, and quality of life among the coastal communities in Sabah: Protocol of a population-based survey. *Medicine*, *99*(37), e22067. https://doi.org/10.1097/MD.0000000000022067

Deshmukh, D. . (2004). *Developing A Framework of Best Practices for Sustainable Solid Waste Management in Small Tourist Islands*. Master's Thesis University of Cincinnati, Cincinnati, OH, USA.

Dong, R., Chen, X., Ding, Z., Guo, H., Li, X., Lian, X., & Zhao, X. (2019). Study on the Solid Waste Properties and Disposal Methods of Island at Home and Abroad. *IOP Conference Series: Earth and Environmental Science*, *252*, 042028. https://doi.org/10.1088/1755-1315/252/4/042028

DOSM. (2021). *Population Size and Growth*. https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=430&bul_id=aFYzVjJ3anNyQytHZGxzcUZxTG9Ydz09&menu_id=L0pheU43NWJwRWVSZklWdzQ4TlhUUT09

Ehsan, S., Ara Begum, R., Ghani Md Nor, N., & Nizam Abdul Maulud, K. (2019). Current and potential impacts of sea level rise in the coastal areas of Malaysia. *IOP Conference Series: Earth and Environmental Science*, *228*(1). https://doi.org/10.1088/1755-1315/228/1/012023

Emang, D., Lundhede, T. H., & Thorsen, B. J. (2016). Funding conservation through use and potentials for price discrimination among scuba divers at Sipadan, Malaysia. *Journal of Environmental Management*, *182*, 436–445.

https://doi.org/10.1016/j.jenvman.2016.07.033
Esa, M. B., & Rahman, S. N. S. A. (1992). Technological development in Malaysian rural environment. *[Proceedings] WESCANEX '91*, 252–259. https://doi.org/10.1109/WESCAN.1991.160557
Evoh, C. (2009). The role of Social Entrepreneurs in Deploying ICTs for Youth and Community Development in South Africa. *The Journal of Community Informatics*, *1*(5), 1–16.
Faizan, M. (2014). *Study On The Impact Of Anthropogenic Pressure On Coral Reefs Around Cape Rachado , Malacca And Recommendations To Improve Its Management*.
Faour, G., Fayad, A., & Mhawej, M. (2013). GIS-Based Approach to the Assessment of Coastal Vulnerability to Sea Level Rise: Case Study on the Eastern Mediterranean. *Journal of Surveying and Mapping Engineering*, *1*(3), 41–48.
Faridah-Hanum, I., Kudus, K. A., & Saari, N. S. (2012). Plant diversity and biomass of marudu bay mangroves in Malaysia. *Pakistan Journal of Botany*, *44*, 151–156.
FOA. (2007). The world's mangroves 1980-2005. A thematic study prepared in the framework of the global forest resources assessment 2005. *Rome (Italy)*, *153*, 1–74.
Fulsås, N. (2007). What did the Weather Forecast do to Fishermen, and what did Fishermen do to the Weather Forecast? *Acta Borealia*, *24*(1), 59–83. https://doi.org/10.1080/08003830701352304
Ghani, N. A., Azmi, N. H., & H.M Ali Puteh, D. A. (2014). The impact of the tourism industry on the community's well-being on Langkawi and Redang Islands, Malaysia. *American-Eurasian Journal of Sustainable Agriculture*, *7*(4), 389–396.
Ghani, N. A., Yassin, S. M., Wan Ahmad, W. I., & Wong Abdullah, W. S. (2010). Island communities: Level of quality of life, settlements and housing in Pulau Perhentian, Terengganu, Malaysia. *Social Sciences*, *5*(5), 433–439. https://doi.org/10.3923/sscience.2010.433.439
Ghazali, N. H. M., Awang, N. A., Mahmud, M., & Mokhtar, A. (2018). Impact of Sea Level Rise and Tsunami on Coastal Areas of North-West Peninsular Malaysia. *Irrigation and Drainage*, *67*, 119–129. https://doi.org/10.1002/ird.2244
Gusenbauer, M., & Haddaway, N. R. (2020). Which academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google Scholar, PubMed, and 26 other resources. *Research Synthesis Methods*, *11*(2), 181–217. https://doi.org/10.1002/jrsm.1378
Hajeb, P., & Jinap, S. (2011). Mercury Exporture Through Fish and Seafood Consumption in the Rural and Urban Coastal Communities of Peninsular Malaysia. *World J Fish Marine Sci*, *3*(3), 217–226.
Hajeb, P., Selamat, J., Ismail, A., Bakar, F. A., Bakar, J., & Lioe, H. N. (2008). Hair mercury level of coastal communities in Malaysia: A linkage with fish consumption. *European Food Research and Technology*, *227*(5), 1349–1355. https://doi.org/10.1007/s00217-008-0851-9
Halim, M. A. S. A., Muda, M. S., Amin, W. A. A. W. M., & Salleh, A. M. M. (2015). The perception of coastal communities toward the relationship of social-entrepreneurship, socio-economic and quality of life. *Mediterranean Journal of Social Sciences*, *6*(4S2), 667–677. https://doi.org/10.5901/mjss.2015.v6n4s2p667
Halim, M. A. S. A., Omar, K., Saputra, J., Kamaruddin, S. N. A. A., & Razali, M. K. A. M. (2021). Examining the relationship between entrepreneurship development programs and business performance among entrepreneurs in Tioman island, Malaysia. *Journal of Environmental Management and Tourism*, *12*(3), 846–854. https://doi.org/10.14505/jemt.v12.3(51).24
Hamid, A. A. I., Din, A. H., & Omar, K. M. (2019). Interpretation Of Sea Level Variability over Malaysian Seas using Multi-mission Satellite Altimete. *ASM Science Journal*, *12*(2), 90–99. https://fig.net/resources/proceedings/fig_proceedings/fig2018/index.htm
Hamsan, M. A. S., Mustapa, M. Z., & Ramli, M. Z. (2019). Morphology and sand characteristics at five recreational beaches in pahang. *Journal of Sustainability Science and Management*,

14(6), 22–38.
Hamzah, J., Buang, A., Habibah, A., & Sharifah Mastura, S. A. (2011). Sustainability of shoreline tourism in regional development setting: The challenge of product integration. In *World Applied Sciences Journal* (Vol. 13, Issue 13, pp. 87–92).
Hamzah, J., Habibah, A., Buang, A., Er, A. C., & Mastura, S. A. S. (2014). Investigating the Shoreline Touristic Resources for Sustainable Tourism Development Options. *International Conference on Education and Social Sciences (Intcess14), Vols I and Ii*, 739–754.
Hanafiah, M. H., Jamaluddin, M. R., & Kunjuraman, V. (2021). Qualitative assessment of stakeholders and visitors perceptions towards coastal tourism development at Teluk kemang, port dickson, Malaysia. *Journal of Outdoor Recreation and Tourism*, *35*(June), 100389. https://doi.org/10.1016/j.jort.2021.100389
Hanafiah, M. H., Jamaluddin, M. R., & Zulkifly, M. I. (2013). Local Community Attitude and Support towards Tourism Development in Tioman Island, Malaysia. *Procedia - Social and Behavioral Sciences*, *105*, 792–800. https://doi.org/10.1016/j.sbspro.2013.11.082
Hanafiah, M. H. M., Harun, M. F., & Jamaluddin, M. R. (2011). Trade and Tourism Demand : A Case of Malaysia. *International Conference on Business and Economics Research*, *1*(February 2015), 1–4.
Haqimin, N., Salleh, M., Azlan, M., & Halim, A. (2018). Enhancing environmental sustainability over fisheries industry through proactive risk evaluation: A case of Tok Bali fishing port Maritime Operations View project Maritime Tourism View project The Role of Transparency and Management Integrity in Organisat. *Journal of Sustainability Science and Management Special Issue*, *4*, 51–65. https://www.researchgate.net/publication/326016609
Haron, N. F., Aziz, I., Ab Ghani, H., & Amirah, N. A. (2020). Environmental Awareness: Do People Really Concern about the Setiu Wetlands in Terengganu, Malaysia? *International Journal of Academic Research in Business and Social Sciences*, *10*(10). https://doi.org/10.6007/IJARBSS/v10-i10/8268
Harris, H., Ooi, Y. B. H., Lee, J. S., & Matanjun, P. (2019). Non-communicable diseases among low income adults in rural coastal communities in Eastern Sabah, Malaysia. *BMC Public Health*, *19*(4), 1–13. https://doi.org/10.1186/s12889-019-6854-6
Hashim, N. M., Sakawi, Z., Choy, L. K., Jaafar, M., Rose, R. A. C., & Ahmad, N. H. (2019). Tahap kesedaran komuniti pinggir pantai terhadap kenaikan aras laut. *Malaysian Journal of Society and Space*, *15*(2), 69–83. https://doi.org/10.17576/geo-2019-1502-06
Hassan, M. S., Shaffril, H. A. M., Ali, M. S. S., & Ramli, N. S. (2010). Agriculture agency, mass media and farmers: A combination for creating knowledgeable agriculture community. *African Journal of Agricultural Research*, *5*(24), 3500–3513.
Hassan, M. S., Yassin, S. M., Shaffril, H. A. M., Othman, M. S., Abu Samah, B., Samah, A. A., & Ramli, S. A. (2011). Receiving the Agriculture Information through Mass Media and Interpersonal Sources among the Rural Community. *American Journal of Agricultural and Biological Sciences*, *6*(3), 451–461. https://doi.org/10.3844/ajabssp.2011.451.461
Hassan, S., Olsen, S. B., & Thorsen, B. J. (2019). Urban-rural divides in preferences for wetland conservation in Malaysia. *Land Use Policy*, *84*, 226–237. https://doi.org/10.1016/j.landusepol.2019.03.015
He, J., & Mai, T. H. T. (2021). The circular economy: A study on the use of airbnb for sustainable coastal development in the Vietnam mekong delta. *Sustainability (Switzerland)*, *13*(13), 1–18. https://doi.org/10.3390/su13137493
Higgins, J., & Green, S. J. (2005). *Cochrane handbook for systematic reviews of interventions*. Glossary.
Hosen, N., Nakamura, H., & Hamzah, A. (2020). Adaptation to Climate Change: Does Traditional Ecological Knowledge Hold the Key? *Sustainability*, *12*(2), 676. https://doi.org/10.3390/su12020676
Huda Zulkifli, N., Haryati Ibrahim, P., & Zakariya, K. (2020). Integration Of Rural Landscape

Characters of The Pahang- Terengganu Coastal Route For Tourism Route Planning. *Alam Cipta*, *13*(1), 6–13.

Husna Maizura, A. M., Khebir, V., Chong, C. K., Azman Shah, A. M., Azri, A., & Lokman Hakim, S. (2012). Surveillance for sarcocystosis in Tioman Island, Malaysia. *Malaysian Journal of Public Health Medicine*, *12*(2), 39–44.

Hussin, H., & Khoso, A. (2017). Seaweed cultivation and coastal communities in Malaysia: An overview. *Asian Fisheries Science*, *30*(2), 87–100. https://doi.org/10.33997/j.afs.2017.30.2.003

Idris, R, A. (2001). *Sosio ekonomi dan pembangunan dalam komuniti nelayan: Satu kajian kes di Kampung Air Tawar, Besut Terengganu.* Bachelor dissertation, Universiti Malaya.

Idris, H., & Hussin, H. (2018). Improving Intra-Asean Connectivity and Inland Waterways Network for Further Integration of the Coastal Shipping and Tourism Sector Developments. *Journal of Southeast Asian Studies*, *23*(1), 75–101. https://doi.org/10.22452/jati.vol23no1.5

Intergovernmental Panel on Climate Change (IPCC). (2001). *Climate Change 2001: Impacts, Adaptations, and Vulnerability: contribution of working group II to the third assessment report of the Intergovernmental Panel on Climate Change.* https://www.ipcc.ch/site/assets/uploads/2018/04/pin-19february2001.pdf

Intergovernmental Panel on Climate Change (IPCC). (2007). *Climate Change 2007: Impacts, Adaptations, and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,*. https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg2_full_report.pdf

Islam, M. M., Amir, A. A., & Begum, R. A. (2021a). Community awareness towards coastal hazard and adaptation strategies in Pahang coast of Malaysia. *Natural Hazards*, *107*(2), 1593–1620. https://doi.org/10.1007/s11069-021-04648-2

Islam, M. M., Amir, A. A., & Begum, R. A. (2021b). Community awareness towards coastal hazard and adaptation strategies in Pahang coast of Malaysia. *Natural Hazards*, *107*(2), 1593–1620. https://doi.org/10.1007/s11069-021-04648-2

Islam, N. M. G., Ali, J., Zamhuri, S., Viswanathan, K. K., & Abdullah, H. (2016). Impact of Subsidies on the Economic and Environmental Conditions of Small Scale Fisheries in Malaysia. *The European Proceedings of Social & Behavioral Science*, *6*(7), 12–15.

Islam, S., Goerlandt, F., Feng, X., Uddin, M. J., Shi, Y., & Hilliard, C. (2020). Improving disasters preparedness and response for coastal communities using AIS ship tracking data. *International Journal of Disaster Risk Reduction*, *51*(June), 101863. https://doi.org/10.1016/j.ijdrr.2020.101863

Ismail, F., Mansor, N., Hafiz, W., & Syukri, W. Z. (2018). A cross-cultural study of destination attributes: Impact on sustainability of Island Tourism. *Journal of Sustainability Science and Management Special Issue Number*, *5*, 1–14. https://www.researchgate.net/publication/326391764

Ismail, R., Jaafar, H., & Khalid, K. (2016). Estimating Perhentian Island's Environmentally Sustainable Tourism Yield for the Recreational Segment. *Asia-Pacific Journal of Innovation in Hospitality and Tourism APJIHT*, *5*(3), 51–70.

Ismail, R., Khalid, K., Jaafar, H., & Ismail, R. (2020). Perhentian Islands' Cost of Environment: Estimating the Loss of Revenue from Tourism Impact. *International Journal of Academic Research in Business and Social Sciences*, *10*(8), 826–842. https://doi.org/10.6007/ijarbss/v10-i8/7639

Ismail, R., Khalid, K., Jaafar, H., & Ismail, R. (2021). Accounting for Environmental Sustainability of the Tourism Industry: The Case of Perhentian Island. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, *12*(3), 613–625. https://doi.org/10.17762/turcomat.v12i3.766

Jaafar, M., & Maideen, S. A. (2012). Ecotourism-Related Products and Activities, and The Economic Sustainability of Small and Medium Island Chalets. *Tourism Management*, *33*(3),

683–691. https://doi.org/10.1016/j.tourman.2011.07.011
Jaafar, S. N., Yusoff, M. M., & Ghaffar, F. A. (2016). Ancaman hakisan pantai dan adaptasi komuniti pesisir pantai di Malaysia: kajian kes Kampung Kemeruk, Kota Bharu, Kelantan. *Geografia : Malaysian Journal of Society and Space*, *12*(10), 145–158.
Jafari, J. (2001). The socio-economic costs of tourism to developing countries. *Annals of Tourism Research*, *1*(7), 227–262. https://doi.org/10.1016/0160-7383(74)90018-8
Jahi, J. ., Aiyub, K., Arifin, K., & Awang, A. (2009). Development, Environmental Degradation and Environmental Management in Malaysia. *European Journal of Social Sciences*, *9*(2), 257–264.
James Lunkapis, G., & Wilkerson Danny, H. (2016). Preliminary Impact Assessment of Seaweed Cultivation by the Coastal Communities in Sabah, Malaysia. *Transactions on Science and Technology*, *3*(2), 413–420. http://transectscience.org/
Jaya-Ram, A., Fuad, F., Zakeyuddin, M. S., & Amir Shah, A. S. R. (2018). Muscle Fatty Acid Content In Selected Freshwater Fish From Bukit Merah Reservoir, Perak, Malaysia. *Tropical Life Sciences Research*, *29*(2), 103–117. https://doi.org/10.21315/tlsr2018.29.2.8
Jaya-Ram, A., Fuad, F., Zakeyuddin, M. S., & Md. Sah, A. S. R. (2018). Muscle Fatty Acid Content in Selected Freshwater Fish from Bukit Merah Reservoir, Perak, Malaysia. *Tropical Life Sciences Research*, *29*(2), 103–117. https://doi.org/10.21315/tlsr2018.29.2.8
Jayaraman, T. K., & Choong, C.-K. (2009). Growth and oil price: A study of causal relationships in small Pacific Island countries. *Energy Policy*, *37*(6), 2182–2189. https://doi.org/10.1016/j.enpol.2009.01.025
Jensen, R. (2007). The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector. *The Quarterly Journal of Economics*, *122*(3), 879–924. https://doi.org/10.1162/qjec.122.3.879
Jurowski, C., Uysal, M., & Williams, D. R. (1997). A Theoretical Analysis of Host Community Resident Reactions to Tourism. *Journal of Travel Research*, *36*(2), 3–11. https://doi.org/10.1177/004728759703600202
Kamaludin, M., Haron, N. F., Ridzuan, A. R., & Azlina, A. . (2021). Assessing Visitors' Willingness To Pay (WTP) For Coral Reef Conservation Program In Perhentian Island, Terengganu, Malaysia. *Journal of Business And Social Development*, *9*(2), 79–92. https://doi.org/10.46754/jbsd.2021.09.006
Kamaludin, M., Ridzuan, A. R., & Azlina, A. A. (2021). Assessing Visitors' Willingness To Pay (WTP) for Coral Reef Conservation Program in Perhentian Island, Terengganu, Malaysia. *Journal of Business and Social Development*, *9*(2), 79–92. https://doi.org/10.46754/jbsd.2021.09.006
Kamaruddin, S. A., Abd. Aziz, K. N., Roslani, M. A., & Zainol, Z. E. (2021). Sustainable Management of the Coastal Water pH of Pulau Tuba Using the Inverse Distance Weighted (IDW) Method. *Jurnal Intelek*, *16*(2), 162–174. https://doi.org/10.24191/ji.v16i2.428
Kamarulzamana, N. H., Selvakkumar, V., Nor Atiah, I., & Md Azree Othuman, M. (2016). Local Knowledge of Flood Preparedness: Current Phenomena To Future Action. *Jurnal Teknologi*, *78*(5), 85–89.
Kamaruzaman, N. F. S., Kassim, Z., Jasmani, S., & Mohtar, N. F. (2018). Seasonal variations of harpacticoid copepod and size-fractionated abundances in relation to environmental changes in Setiu Wetland. *Journal of Environmental Biology*, *39*(5), 883–887. https://doi.org/10.22438/jeb/39/5(SI)/5
Karim, M. F. (2015). Local-Central Dynamics and Limitations of Micro-Regionalism: Understanding West Kalimantan and Sarawak Cross-Border Cooperation. In *Balanced Growth for an Inclusive and Equitable ASEAN Community* (pp. 86–124). https://www.rsis.edu.sg/wp-content/uploads/2015/09/ASEAN-Canada_Balanced-Growth-for-Inclusive-and-Equitable-ASEAN-Community.pdf
Kathijotes, N. (2013). Keynote: Blue Economy - Environmental and Behavioural Aspects Towards Sustainable Coastal Development. *Procedia - Social and Behavioral Sciences*, *101*, 7–13.

https://doi.org/10.1016/j.sbspro.2013.07.173
Kathiresan, K., & Bingham, B. L. (2001). *Biology of mangroves and mangrove Ecosystems* (pp. 81–251). Advances in Marine Biology. https://doi.org/10.1016/S0065-2881(01)40003-4
Khairil, M., Ain, N., M., S., Faranazuha, A., Khandaker, M., Yusoff, N., Azalina, A., Azimah, I., Noor-Amalina, R., & Salam, M. (2019). Tree Species Composition, Diversity And Aboveground Biomass Of Two Forest Types At Perhentian Island, Peninsular Malaysia. *Bioscience Research*, *16*(4), 3834–3845. https://www.researchgate.net/publication/338252720
Khairunnisa, A. K., Fauziah, S. H., & Agamuthu, P. (2012). Marine debris composition and abundance: A case study of selected beaches in Port Dickson, Malaysia. *Aquatic Ecosystem Health and Management*, *15*(3), 279–286. https://doi.org/10.1080/14634988.2012.703096
Khuzaimah, Z., Mansor, S., & Ismail, H. (2015). Land use change analysis with relation to the ecosystem service value in Singai Merbok Fprest reserve. *ACRS 2015 - 36th Asian Conference on Remote Sensing: Fostering Resilient Growth in Asia, Proceedings*.
Kovačić, M., Mrvica, A., & Hlača, M. Š. (2020). Analytical research on the methodological suitability of multi-criteria analysis for the scientific evaluation of the coastal area. *Transactions on Maritime Science*, *9*(2), 316–323. https://doi.org/10.7225/toms.v09.n02.013
Kraus, S., Breier, M., & Dasí-Rodríguez, S. (2020). The art of crafting a systematic literature review in entrepreneurship research. *International Entrepreneurship and Management Journal*, *16*(3), 1023–1042. https://doi.org/10.1007/s11365-020-00635-4
Kunjuraman, V., Hussin, R., & Yasir, S. (2015). Challenges of seaweed community-based homestay programme in Sabah, Malaysian Borneo. In *Hospitality and Tourism 2015* (pp. 123–126). CRC Press. https://doi.org/10.1201/b19162-28
Latiff, N. (2016). *Willingness To Pay For Marine Conservation Of Tun Sakaran Marine Park, Semporna, Sabah, Malaysia*.
Latiff, N., Herman, S., Afandi, M., Shuib, A., & Samdin, Z. (2015). Application of Choice Experiment in Assessing Willingness to Pay of Tourist for Marine Conservation Area in Tun Sakaran Marine, Malaysia Park. *J. Agric. & Environ. Sci*, *15*, 18–23. https://doi.org/10.5829/idosi.aejaes.2015.15.s.203
Leman, N., Ramli, M. F., & Khirotdin, R. P. K. (2016). GIS-based integrated evaluation of environmentally sensitive areas (ESAs) for land use planning in Langkawi, Malaysia. *Ecological Indicators*, *61*, 293–308. https://doi.org/10.1016/j.ecolind.2015.09.029
Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *BMJ (Clinical Research Ed.)*, *339*. https://doi.org/10.1136/bmj.b2700
Lim, A. C. O., Chong, V. C., Wong, C. S., & Choo, C. K. (2011). Diversity, habitats and conservation threats of syngnathid (Syngnathidae) fishes in Malaysia. *Tropical Zoology*, *24*(2), 193–222.
Lincoln, J. M., & Lucas, D. L. (2010). Occupational Fatalities in the United States Commercial Fishing Industry, 2000–2009. *Journal of Agromedicine*, *15*(4), 343–350. https://doi.org/10.1080/1059924X.2010.509700
Lindberg, K. (1991). Policies for Maximizing Nature Tourism's Ecological and Economic Benefts. *International Conservation Financing Project*.
Lodhia, S. V. (2011). Risk and management of climate induced disasters in coastal Gujarat in India. *Management of Environmental Quality: An International Journal*, *23*(1), 82–100. https://doi.org/10.1108/14777831211191610
Logam, P., Bagi, B., Masin, I. A., Ditangkap, Y., Perairan, D., & Dickson, P. (2015). Assessment of Heavy Metal in Self-caught Saltwater Fish from Port Dickson Coastal Water, Malaysia. In *Sains Malaysiana* (Vol. 44, Issue 1).

Longhorn, R. A. (2004). *Coastal spatial data infrastructure GIS Coast.* Zo. Manag.

M., Abdullah, A. G., Awang Noor, I., Faridah Hanum, Z., Harah, M., & Yip, H. W. (2013). Local Community Participatory Process and Intervention Procedure in Mangroves Ecotourism of Marudu Bay , Sabah. *Journal of Tropical Agricultural Science*, *36*, 173–180.

M., M. F., Ang, S. Y., H., S. B., & S., M. K. H. (2013). Colonization of Marine Epibiota around WABCORE Artificial Reef at Panuba Bay, Tioman Island, Malaysia. *APCBEE Procedia*, *5*, 416–422. https://doi.org/10.1016/j.apcbee.2013.05.072

Macintosh, D. J., Epps, M. M., & Abrenilla, O. (2011). Ecosystem approaches to coastal resources management: the case for investing in mangrove ecosystems. *Food for All Investing in Food Security in Asia and the Pacific*, 140–155.

Mahazan Muhammad, Azimi Hamzah, Sulaiman Md. Yassin, Bahaman Abu Samah, Neda Tiraieyari, J. L. D. and H. A. M. S. (2016). Environmental Issues of Agro-Tourism: The Views of Coastal Community in Malaysia. *The Social Sciences*, *11*(3), 192–195. https://doi.org/http://dx.doi.org/10.36478/sscience.2016.192.195

Mansor, N., Rohanamansor, N., & Rahim, N. (2013). Sustaining Coastal Terengganu Malay Dialect: An Analysis on The Linguistic Features. *Journal of Sustainability Science and Management*, *8*(1), 68–72.

Martín-martín, A., Orduna-malea, E., López-cózar, E. D., & Martín-martín, A. (2019). Google Scholar, Web of Science, and Scopus: a systematic comparison of citations in 252 subject categories. *Journal of Informetrics*, *12*(4), 1160–1177. http://arxiv.org/abs/1808.05053

Marzuki, A., & Khoo, J. (2016). Community Development Strategies for Tourism Development in Langkawi Islands, Malaysia. In *Tourism - From Empirical Research Towards Practical Application*. https://doi.org/10.5772/62575

Marzuki, A., Mohamad, D., & Jaafar, M. (2015). International Visitors' Perspectives on Geopark Sustainability in Langkawi Island, Malaysia. *Tourism Planning and Development*, *12*(2), 190–207. https://doi.org/10.1080/21568316.2014.913677

Masud, M. M. (2019). Major Challenges to Conservation of Marine Resources and Sustainable Coastal Community Development in Malaysia. In *Conservation of Marine Resources and Sustainable Coastal Community Development in Malaysia* (pp. 79–100). Springer Singapore. https://doi.org/10.1007/978-981-13-9730-1_6

Masud, M. M., & Kari, F. B. (2015). Community attitudes towards environmental conservation behaviour: An empirical investigation within MPAs, Malaysia. In *Marine Policy* (Vol. 52, pp. 138–144). https://doi.org/10.1016/j.marpol.2014.10.015

Masud, M. M., Kari, F. B., Binti Yahaya, S. R., & Al-Amin, A. Q. (2014). Impact of residents' livelihoods on attitudes towards environmental conservation behaviour: An empirical investigation of Tioman Island Marine Park area, Malaysia. *Ocean and Coastal Management*, *93*, 7–14. https://doi.org/10.1016/j.ocecoaman.2014.03.008

Masud, M. M., Sackor, A. S., Ferdous Alam, A. S. A., Al-Amin, A. Q., & Abdul Ghani, A. B. (2018). Community responses to flood risk management – An empirical Investigation of the Marine Protected Areas (MPAs) in Malaysia. *Marine Policy*, *97*, 119–126. https://doi.org/10.1016/j.marpol.2018.08.027

Mayowa, O. O., Pour, S. H., Shahid, S., Mohsenipour, M., Harun, S. Bin, Heryansyah, A., & Ismail, T. (2015). Trends in rainfall and rainfall-related extremes in the east coast of peninsular Malaysia. *Journal of Earth System Science*, *124*(8), 1609–1622. https://doi.org/10.1007/s12040-015-0639-9

Md Hashim, N., Sakawi, Z., Choy, L. K., Jaafar, M., Che Rose, R. A., & Ahmad, N. H. (2019). Tahap kesedaran komuniti pinggir pantai terhadap kenaikan aras laut. *Malaysian Journal of Society and Space*, *15*(2), 69–83. https://doi.org/10.17576/geo-2019-1502-06

Meng, C. C., Omar, S. Z., Kamaruddin, N., Bolong, J., D'Silva, J. L., & Mohamed Shaffril, H. A. (2014). Media usage among the coastal communities in Malaysia. *Asian Social Science*, *10*(8), 30–34. https://doi.org/10.5539/ass.v10n8p30

Meyer-Arendt, K. J., & Lew, A. A. (2013). New Perspectives on Tropical Coastal and Island Tourism Development. *Tourism Geographies*, *15*(1), 1–2. https://doi.org/10.1080/14616688.2012.727100

Milon, J. W., & Alvarez, S. (2019). Coastal resources economics and ecosystem valuation. *Water (Switzerland)*, *11*(11), 1–5. https://doi.org/10.3390/w11112206

Mohamad, D., & Mohamed, B. (2018). Acceptance towards tourism development: The case of Perhentian Island. *Planning Malaysia*, *16*(4), 117–129. https://doi.org/10.21837/pmjournal.v16.i8.543

Mohamad Hamzah, F., Mohd Saimi, F., & Jaafar, O. (2017). Identifying the Monotonic Trend in Climate Change Parameter in Kluang and Senai, Johor, Malaysia. *Sains Malaysiana*, *46*(10), 1735–1741. https://doi.org/10.17576/jsm-2017-4610-09

Mohamed, B. (2012). Effects of tourism activities and development on the physical environment of Kilim River, Langkawi, Malaysia. In *Malaysian Forester* (Vol. 75, Issue 1, pp. 81–86).

Mohamed, S., Zamri, K. M., Zullkeflee, A., Sajili, M. H., Roseli, M., & Mahmud, K. (2019). Insects Diversity and Abundance in Coastal and Inland Forest of Perhentian Island, Terengganu, Peninsular Malaysia. *Bioscience Research*, *16*(S1), 53–58. https://www.researchgate.net/publication/338252616

Mohamed Shaffril, H. A., D'Silva, J. L., Kamaruddin, N., Omar, S. Z., & Bolong, J. (2015). The coastal community awareness towards the climate change in Malaysia. *International Journal of Climate Change Strategies and Management*, *7*(4), 516–533. https://doi.org/10.1108/IJCCSM-07-2014-0089

Mohamed Shaffril, H. A., Hamzah, A., Md. Yassin, S., Abu Samah, B., D'Silva, J. L., Tiraieyari, N., & Muhammad, M. (2015). The Coastal Community Perception on the Socio-Economic Impacts of Agro-Tourism Activities in Coastal Villages in Malaysia. *Asia Pacific Journal of Tourism Research*, *20*(3), 295–313. https://doi.org/10.1080/10941665.2013.877048

Mohamed Shaffril, H. A., Samah, A. A., Samsuddin, S. F., & Ali, Z. (2019). Mirror-mirror on the wall, what climate change adaptation strategies are practiced by the Asian's fishermen of all? *Journal of Cleaner Production*, *232*, 104–117. https://doi.org/10.1016/j.jclepro.2019.05.262

Mohamed Yusof, Z. F., Kamaruddin, N., Omar, S. Z., Bolong, J., D`Silva, J. L., & Mohamed Shaffril, H. A. (2014). Gratification towards weather information via television: An analysis of the coastal communities in Malaysia. *The Social Sciences*, *9*(3), 195–199. https://doi.org/http://dx.doi.org/10.36478/sscience.2014.195.199

Mohammed, K., Samat, N., & Elhadary, Y. (2014). Bottom up Approach: Urbanization in the Perception of the Local Communities of Balik Pulau, Penang Island, Malaysia. *British Journal of Applied Science & Technology*, *4*(32), 4533–4549. https://doi.org/10.9734/bjast/2014/11034

Mohammed, N., Aziz, Y. A., Awang, K. W., & Samdin, Z. (2020). Influence of Destination Attractiveness On Place Satisfaction and Environmentally Responsible Behaviour in Marine Parks. *Journal of Sustainability Science and Management*, *15*(1), 52–67.

Mohd. Shariff, N., & Tahir, S. (2003). Residents' Attitudes toward Impacts of Tourism: A Case Study of Langkawi, Malaysia. *Malaysian Management Journal*, *7*(2), 13–24. https://doi.org/10.32890/mmj.7.2.2003.8609

Mohd Azhar, M., Nizam, K., Maulud, A., Selamat, S. N., Khan, F., Jaafar, O., Shafrina, W., Mohd Jaafar, W., Mastura, S., Abdullah, S., Toriman, M. E., Khairul, M., Kamarudin, A., Gasim, M. B., & Juahir, H. (2018). Impact of Shoreline Changes to the Coastal Development. In *International Journal of Engineering & Technology* (Vol. 7, Issue 3). www.sciencepubco.com/index.php/IJET

Mohd Bukhari, A. M., & Hilmi, M. F. (2012). Challenges and Outcome of Innovative Behavior: A Qualitative Study of Tourism Related Entrepreneurs. *Journal of Technology Management and Innovation*, *7*(2), 131–143. https://doi.org/10.4067/S0718-27242012000200011

Mohd, F. A., A. Karim, P. D. I. D. O., Abdul Maulud, S. D. K. N., Ibrahim, M. A., Anak Benson, Y., &

Abd. Wahab, A. K. (2018a). Integration of Geospatial Method and Hydrodynamic Modelling to Study the Impact of Sea Level Rise on the Coastal Area. *Jurnal Kejuruteraan*, *30*(1), 65–75. https://doi.org/10.17576/jkukm-2018-30(1)-09

Mohd, F. A., A. Karim, P. D. I. D. O., Abdul Maulud, S. D. K. N., Ibrahim, M. A., Anak Benson, Y., & Abd. Wahab, A. K. (2018b). Integration of Geospatial Method and Hydrodynamic Modelling to Study the Impact of Sea Level Rise on the Coastal Area. *Jurnal Kejuruteraan*, *30*(1), 65–75. https://doi.org/10.17576/jkukm-2018-30(1)-09

Mohd, F. A., Abdul Maulud, K. N., Karim, O. A., Begum, R. A., Awang, N. A., Ahmad, A., Wan Mohamed Azhary, W. A. H., Kamarudin, M. K. A., Jaafar, M., & Wan Mohtar, W. H. M. (2019). Comprehensive coastal vulnerability assessment and adaptation for Cherating-Pekan coast, Pahang, Malaysia. *Ocean & Coastal Management*, *182*, 104948. https://doi.org/10.1016/j.ocecoaman.2019.104948

Mohd, F. A., Maulud, K. N. A., Begum, R. A., Karim, O. A., Khan, M. F., Selamat, S. N., Ab Rahman, A. A., Bahri, M. A. S., Abdullah, S. M. S., Kamarudin, M. K. A., Gasim, M. B., & Juahir, H. (2018). Variation of beach profile along Pahang Coast in Malaysia. *International Journal of Engineering and Technology(UAE)*, *7*(3.14 Special Issue 14), 196–201. https://doi.org/10.14419/ijet.v7i3.14.16884

Mohd, F. A., Rahman, A. A. A., Maulud, K. N. A., Kamarudin, M. K., Majid, N. A., & Rosli, A. (2021). Geospatial Approach for Coastal Vulnerability Assessment of Selangor Coast, Malaysia. *IOP Conference Series: Earth and Environmental Science*, *767*(1), 1–10. https://doi.org/10.1088/1755-1315/767/1/012025

Mohd, H. A., Sarva, M. R., & Aris, A. Z. (2010). A numerical modelling of seawater intrusion into an oceanic island aquifer, Sipadan Island, Malaysia. *Sains Malaysiana*, *39*(4), 525–532.

Mohd Salim, J., Azwa Radzi, M., Mohd Razali, S., & Majid Cooke, F. (2020). Coastal Landscapes of Peninsular Malaysia: The Changes and Implications for Their Resilience and Ecosystem Services. In *Landscape Reclamation - Rising From What's Left*. IntechOpen. https://doi.org/10.5772/intechopen.82155

Mohd Salleh, N. H., Othman, R., Mohd ldris, S. H., Abdul Halim, S., Shukor, M. S., Yussof, I., Samsudin, M., & Omar, M. (2014). Development of Tourism Industry and Its Impact on Langkawi Island Community. *Jurnal Ekonomi Malaysia*, *48*(2), 71–82. https://doi.org/10.17576/jem-2014-4802-07

Mohd Salleh, N. H., Othman, R., Sarmidi, T., & Darawi, Z. (2011). A comparison of local community sustainability of livelihood: A case study in Redang and Tioman Islands, Malaysia. *2011 IEEE International Summer Conference of Asia Pacific Business Innovation and Technology Management*, 144–148. https://doi.org/10.1109/APBITM.2011.5996310

Mohd Shariff Shaharuddin Tahir, N. (2003). Residents' Attitudes toward Impacts of Tourism: A Case Study of Langkawi, Malaysia. In *Malaysian Management Journal* (Vol. 7, Issue 2). http://mmj.uum.edu.my

Mohd Yusof, M. F., Ismail, H. N., & Ahmad, G. (2019). Branding Langkawi Island As a Geopark Destination. *International Journal of Built Environment and Sustainability*, *6*(1–2), 7–14. https://doi.org/10.11113/ijbes.v6.n1-2.377

Mohee, R., Mauthoor, S., Bundhoo, Z. M. A., Somaroo, G., Soobhany, N., & Gunasee, S. (2015). Current status of solid waste management in small island developing states: A review. *Waste Management*, *43*, 539–549. https://doi.org/10.1016/j.wasman.2015.06.012

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & The PRISMA Group. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *Annals of Internal Medicine*, *151*(4), 264. https://doi.org/10.7326/0003-4819-151-4-200908180-00135

Mokhtar, M. Z., Adrianza, M. A., & Syazwani, H. (2020). Cost-Benefit Analysis on Marine Parks in Terengganu. *Journal of Business and Social Development*, *8*(2), 1–12.

Moomaw, W. R., Chmura, G. L., Davies, G. T., Finlayson, C. M., Middleton, B. A., Natali, S. M.,

Perry, J. E., Roulet, N., & Sutton-Grier, A. E. (2018). Wetlands In a Changing Climate: Science, Policy and Management. *Wetlands*, *38*(2), 183–205. https://doi.org/10.1007/s13157-018-1023-8

Muda, J. (2016). Geological indicators of sea-level changes at northern sabah, malaysia: Tools for instilling public awareness on global climate changes. *Bulletin of the Geological Society of Malaysia*, *62*(December), 31–35. https://doi.org/10.7186/bgsm62201605

Muhibudin, M., & Mohamed, B. (2014). An Assessment on Destination Characteristics: The Case Study of Pulau Perhentian. In M. A. Othuman Mydin & A. Marzuki (Eds.), *SHS Web of Conferences* (Vol. 12, p. 01095). https://doi.org/10.1051/shsconf/20141201095

Mukrimah, A. #, Mamat, P., Naseha, F., & Hussain, T. (2019). Rehabilitation of Malaysia Coastline: An Economic Perspective. In *Transactions on Science and Technology* (Vol. 6, Issue 2).

Musa, F., Fozi, N. M., & Hamdan, D. D. M. (2020). Coastal communities' willingness to pay for mangrove ecotourism in Marudu Bay, Sabah, Malaysia. *Journal of Sustainability Science and Management*, *15*(4), 130–140. https://doi.org/10.46754/jssm.2020.06.013

Mustapha, N. A., Azman, I., & Ibrahim, Y. (2013). Barriers To Community Participation In Tourism Development In Island Destination. *Journal of Tourism, Hospitality & Culinary Arts*, *5*(1), 102–124.

Najiah, M., Nadirah, M., Lee, K. L., Lee, S. W., Wendy, W., Ruhil, H. H., & Nurul, F. A. (2008). Bacteria flora and heavy metals in cultivated oysters Crassostrea iredalei of Setiu Wetland, East Coast Peninsular Malaysia. *Veterinary Research Communications*, *32*(5), 377–381. https://doi.org/10.1007/s11259-008-9045-y

Narayan, K. A., & Khan, A. R. (2007). Body mass index and nutritional status of adults in two rural villages in Northern Malaysia. *Malaysian Journal of Nutrition*, *13*(1), 9–17.

Nazaruddin, D. A., Mansor, H. E., & Wali, S. S. A. S. (2016). Geoheritage of labuan island. *Bulletin of the Geological Society of Malaysia*, *62*(100), 117–129. https://doi.org/10.7186/bgsm62201613

Nazri, N., Anuar, S., Basrawi, F., Shukrie, A., & Aishah, S. (2018). Evaluation of Potential Sites for Harnessing Tidal Energy around Coastal Area of Malaysia. *MATEC Web of Conferences*, *225*, 1–11. https://doi.org/10.1051/matecconf/201822506015

Neumann, B., Ott, K., & Kenchington, R. (2017). Strong sustainability in coastal areas: a conceptual interpretation of SDG 14. *Sustainability Science*, *12*(6), 1019–1035. https://doi.org/10.1007/s11625-017-0472-y

Ngui, R., Halim, N. A. A., Rajoo, Y., Lim, Y. AL, Ambu, S., Rajoo, K., Chang, T. S., Woon, L. C., & Mahmud, R. (2016). Epidemiological Characteristics of Strongyloidiasis in Inhabitants of Indigenous Communities in Borneo Island, Malaysia. *The Korean Journal of Parasitology*, *54*(5), 673–378. https://doi.org/10.3347/kjp.2016.54.5.673

Nicholls, R. J., Woodroffe, C., & Burkett, V. (2009). Coastline Degradation as an Indicator of Global Change. In *Climate Change: Observed impacts on planet earth* (pp. 409–424). Elsevier.

Noor, A. Y. M., & Shah, N. A. M. (2017). Islamic tourism in langkawi island: Enhancing sustainability of islamic value. *International Journal of Applied Business and Economic Research*, *15*(24), 59–71.

Nuramirah Jaafar, S., Yusoff, M. M., & Ghaffar, F. A. (2016). *Ancaman hakisan pantai dan adaptasi komuniti pesisir pantai di Malaysia: Kajian kes Kampung Kemeruk, Kota Bharu, Kelantan*.

Okoli, C. (2015). A guide to conducting a standalone systematic literature review. *Communications of the Association for Information Systems*, *37*(1), 879–910. https://doi.org/10.17705/1cais.03743

Omar, S. Z., Hassan, M. A., Shaffril, H. A. M., Bolong, J., & D'SILVA, J. L. (2011). Information and Communication Technology for Fisheries Industry Development in Malaysia. *African Journal of Agricultural Research*, *6*(17), 4166–4176.

Omar, S. Z., Shaffril, H. A. M., Kamaruddin, N., Bolong, J., & D'Silva, J. L. (2013). Weather forecasting as an early warning system: Pattern of weather forecast usage among coastal communities in Malaysia. *Life Science Journal*, *10*(4), 540–549.

Omar, S. Z., Shaffril, H., Kamaruddin, N., Bolong, J., & Silva, D. (2013). Weather Forecasting as an Early Warning System: Pattern of Weather Forecast Usage among Coastal Communities in Malaysia. In *Life Science Journal* (Vol. 10, Issue 4). http://www.lifesciencesite.comhttp//www.lifesciencesite.comhttp://www.lifesciencesite.com.70

Ong, T. F., & Musa, G. (2011). An examination of recreational divers' underwater behaviour by attitude-behaviour theories. *Current Issues in Tourism*, *14*(8), 779–795. https://doi.org/10.1080/13683500.2010.545370

Osman, N. H., Mohtar, S., Juli, A. M., Ahmad, A., Chan, A. A., & Ibrahim, J. A. (2017). A Proposed TEV Framework for Pulau Payar Marine Park. *Journal of Business Management and Accounting*, *7*(2), 77–84. http://e-journal.uum.edu.my/index.php/jbma/article/view/8820

Othman, N., Mohamed, S., & Aziz, F. K. (2012). Tourism activities and its impact on environmental sustainability in coastal areas. *International Business Management*, *6*(6), 629–633. https://doi.org/10.3923/ibm.2012.629.633

Palmer, C., & Bolderston, A. (2006). A Brief Introduction to Qualitative Research. *Canadian Journal of Medical Radiation Technology*, *37*(1), 16–19. https://doi.org/10.1016/s0820-5930(09)60112-2

Pardi, F., N Mohd Said, M., Ismail, A., J Sidik, N., A Radzun, K., N Ruziman, H., & S Kasri, S. (2019). Tree Diversity, Stand Structure, and Community Composition in an Island Forest of Pulau Perhentian Besar, Terengganu. *International Journal of Engineering & Technology*, *7*(4.14), 31. https://www.sciencepubco.com/index.php/ijet/article/view/27466

Pascoe, S., Doshi, A., Thébaud, O., Thomas, C. R., Schuttenberg, H. Z., Heron, S. F., Setiasih, N., Tan, J. C. H., True, J., Wallmo, K., Loper, C., & Calgaro, E. (2014). Estimating the potential impact of entry fees for marine parks on dive tourism in South East Asia. *Marine Policy*, *47*, 147–152. https://doi.org/10.1016/j.marpol.2014.02.017

Patton, M. Q. (2002). *Qualitative Research & Evaluation Methods*. Sage.

Paula, Y. (2010). Using Google Scholar to conduct a literature search. *Nursing Standard*, *24*(45), 40–48.

Pearce, P. L. (1991). Analysing tourist attractions. *Journal of Tourism Studies*, *2*(1), 46–55.

Ponnan, R. (2013). Broadcasting and socially responsible rural tourism in Labuan, Malaysia. *Worldwide Hospitality and Tourism Themes*, *5*(4), 398–411. https://doi.org/10.1108/WHATT-03-2013-0019

Praveena, S. M., & Lin, C. L. S. (2015). Assessment of heavy metal in self-caught saltwater fish from Port Dickson coastal water, Malaysia. *Sains Malaysiana*, *44*(1), 91–99. https://doi.org/10.17576/jsm-2015-4401-13

Praveena, S. M., Siraj, S. S., & Aris, A. Z. (2012). Coral reefs studies and threats in Malaysia: A mini review. *Reviews in Environmental Science and Biotechnology*, *11*, 27–39. https://doi.org/10.1007/s11157-011-9261-8

Raduan, M., Hock Lai -Penilaian Semula Program Pembasmian Kemiskinan Nelayan Tradisional Di Sabah, Y., Raduan bin Mohd Ariff, M., Bin Majid, M., & Hock Lai, Y. (2009). Penilaian Semula Program Pembasmian Kemiskinan Nelayan Tradisional Di Sabah: Kajian Kes Di Daerah Kota Belud. *Borneo Research Journal*, *3*(93–113).

Raduan, M., Sharir, M., Aziz -Masalah, Z., Tradisional, N., Malaysia, S., Raduan, M., Sharir, M., & Aziz, Z. (2007). Masalah Nelayan Tradisional Di Semenanjung Malaysia: Penyelesaian Tanpa Kesudahan. *JATI*, *12*, 247–258.

Rahim, H. L., Faizah, N., & Lajin, M. (2015). Perhentian Island : A Social Entrepreneurship Initiative. *International Academic Research Journal*, *1*(1), 29–33.

Rahim, R. A., Salleh, M. Z., Ismail, Z., Uli, J., Ismail, A., & Kuzi, F. (2014). Security Perception of

Sabah's Maritime Community Against Threats. *ZULFAQAR International Journal of Politics, Defence & Security*, *1*(2), 109–117. www.zulfaqar.upnm.edu.my

Ramdas, M., & Mohamed, B. (2014). Visitor Perceptions on the Impacts of Tourism Activities, Development and Infrastructure on the Environment of Perhentian Islands. *SHS Web of Conferences*, *12*, 01081. https://doi.org/10.1051/shsconf/20141201081

Ramli, M. F., & Idris, H. (2016). Pembangunan Mampan Pelancongan Maritim Di Pulau Perhentian, Terengganu. *Journal of Southeast Asian Studies*, *21*(1), 108–124. https://doi.org/10.22452/jati.vol21no1.5

Ramli, R., Nik Hassan, N. M. K., & Kassim, Z. (2005). Current Threats and Future Development of Setiu Wetlands Malaysia. *Proceedings of the Korea Water Resources Association Conference*, 893–894.

Rashidi, A. H. M., Jamal, M. H., Hassan, M. Z., Sendek, S. S. M., Sopie, S. L. M., & Hamid, M. R. A. (2021). Coastal structures as beach erosion control and sea level rise adaptation in malaysia: A review. *Water (Switzerland)*, *13*(13), 1–34. https://doi.org/10.3390/w13131741

Rawi, S. B. (2012). *The Use of Choice Modelling in Assessing Tourists Destinations: A Case Study of Redang Marine Park (RMP) Malaysia*.

Razak, M. S. A., Suryadi, F. X., Jamaluddin, N., & Nor, N. A. Z. M. (2018). Shoreline Planform Stability of Embayed Beaches Along the Malaysian Peninsular Coast. *Journal of Coastal Research*, *85*, 631–635. https://doi.org/10.2112/SI85-127.1

Rodríguez-Vargas, L. H., Rajamani, L., Dolar, L., & Porter, L. (2019). Population size, distribution and daylight behaviour of Irrawaddy dolphins (Orcaella brevirostris) in Penang Island, Malaysia. *Raffles Bulletin of Zoology*, *67*, 671–683. https://doi.org/10.26107/RBZ-2019-0048

Rosly, M. A., Ahmad, A., Tarmidi, Z., Khair, Z., & Zulkifli, N. (2020). Towards a Collaborative Strategy for Land and Marine Geospatial Data Integration: A Review. *IOP Conference Series: Earth and Environmental Science*, *494*(1), 1–10. https://doi.org/10.1088/1755-1315/494/1/012004

Rukmana, D., Diansari, P., Nadja, R. A., Rahmadanih, Fahmid, I. M., Syahrullah, & Akhsan. (2020). Livelihood strategy in fulfilling household needs of coastal communities. *IOP Conference Series: Earth and Environmental Science*, *486*(1), 1–8. https://doi.org/10.1088/1755-1315/486/1/012013

Sa'at, N. H. (2011). Social Mobility Among the Coastal Community: A case Study in Kuala Terengganu. *Kajian Malaysia*, *29*(1), 95–123. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84864464557&partnerID=40&md5=a70e16a4926f1ff808545d1f6f4c456b

Sah, S. S., Maulud, K. N. A., Rahim, N. A. A., Karim, O. A., & Sharil, S. (2021). Submerging paddy cultivation area due to coastal flooding in Kuala Kedah, Malaysia. *IOP Conference Series: Earth and Environmental Science*, *880*(1), 012015. https://doi.org/10.1088/1755-1315/880/1/012015

Sahdan, Z., Rose, R. A. C., & Ahamad, H. (2009). Perubahan Budaya Orang Bateq Dalam Situasi Ekopelancongan di Taman Negara. *Journal of Social Sciences and Humanities*, *4*(1), 159–169.

Said, A. M., Ahmadun, F. R., Mahmud, A. R., & Abas, F. (2011). Community preparedness for Tsunami disaster: A case study. *Disaster Prevention and Management: An International Journal*, *20*(3), 266–280. https://doi.org/10.1108/09653561111141718

Said, H. M., & Pegah, A. (2011). An exploratory study on a potential ecotourism destination in Kampung Merchong, Mukim Bebar, Pekan, Pahang. *UNIVERSITI TUN ABDUL RAZAK E-JOURNAL*, *7*(1), 1–14.

Salleh, N. H. M., & Abdul Halim, M. A. (2018). Enhancing environmental sustainability over fisheries industry through proactive risk evaluation: A case of Tok Bali fishing port. *Journal of Sustainability Science and Management*, *Specialissue4*, 51–63.

Salleh, N. H. M., Othman, R., Idris, S. H. M., Halim, S. A., Shukor, M. S., Yussof, I., Samsudin, M., & Omar, M. (2014). Development of tourism industry and its impact on Langkawi Island community. *Jurnal Ekonomi Malaysia*, *48*(2), 71–82. https://doi.org/10.17576/jem-2014-4802-07

Sandelowski, M. (1995). Qualitative analysis: What it is and how to begin. *Research in Nursing & Health*, *18*(4), 371–375. https://doi.org/10.1002/nur.4770180411

Saufi, N. A., & Salleh, F. (2018). Does Coastal Community Need Takaful Protection From Coastal Erosion? *Journal of Tourism, Hospitality and Environment Management*, *3*(7), 43–56. http://www.jthem.com/PDF/JTHEM-2018-07-03-06.pdf

Selamat, A. M., Ramdas Chelamuthu, M., & Suhaili, M. S. (2016). The impact of tourism on the marine environment of small islands: The case of Pangkor Island, Malaysia. *Journal of Modern Education Review*, *6*(9), 639–647. https://doi.org/https://doi.org/10.15341/jmer(2155- 7993)/09.06.2016/008

Shaffril, H. A. M., Abu Samah, B., D`Silva, J. L., & Uli, J. (2011). Global Warming at the East Coast Zone of Peninsular Malaysia. *American Journal of Agricultural and Biological Sciences*, *6*(3), 377–383. https://doi.org/10.3844/ajabssp.2011.377.383

Shaffril, H. A. M., Abu Samah, B., Lawrence D'Silva, J., & Sulaiman. (2013). The Process of Social Adaptation Towards Climate Change Among Malaysian Fishermen. *International Journal of Climate Change Strategies and Management*, *5*(1), 38–53. https://doi.org/10.1108/17568691311299354

Shaffril, H. A. M., Hassan, M. S., Abu Samah, B., Ali, M. S., & Ramli, N. S. (2012). Satisfaction Received Towards Agricultural Information from Television Programs Among Farmers. *International Research Journal Of Humanities*, *4*(2), 27–42.

Shaffril, H. A. M., Samah, A. A., & Samsuddin, S. F. (2021). Guidelines for developing a systematic literature review for studies related to climate change adaptation. *Environmental Science and Pollution Research*, 22265–22277. https://doi.org/10.1007/s11356-021-13178-0

Shafie, A., Roslan, M. A., Ngui, R., Lim, Y. A. L., & Sulaiman, W. Y. W. (2016). Mosquito Biology and Mosquito-Borne Disease Awareness among Island Communities in Malaysia. *Journal of the American Mosquito Control Association*, *32*(4), 273–281. https://doi.org/10.2987/16-6604.1

Shah, K., Kamal, A. H. M., Adrain, D., Rosli, Z., Hakeem, K. R., & Hoque, M. N. (2016). Community awareness about tangible and intangible benefits of Sibuti mangrove forest, Sarawak, Malaysia. *Malaysian Forester*, *79*(1–2), 119–132.

Shahar, M. A., Ghani, L., Omar, A. M., Loh, H., MY, Y., Wahab, L. and A., Sukor, N. and, Zain, N. and M., & Al., E. (2015). Prevalence of thyroid disorders and thyroid autoantibodies among coastal communities of Malaysia (part of nationwide study of thyroid disorders in Malaysia). *ASEAN Federation of Endocrine Societies*, 220.

Shahar, M. A., Omar, A. M., Wahab, A. B. N., Sukor, N., & Kamaruddin, N. A. (2020). High prevalence of thyroid antibodies in urban population of peninsular Malaysia. *IIUM Medical Journal Malaysia*, *19*(2), 3–12.

Shahid, S., Pour, S. H., Wang, X., Shourav, S. A., Minhans, A., & Ismail, T. bin. (2017). Impacts and adaptation to climate change in Malaysian real estate. *International Journal of Climate Change Strategies and Management*, *9*(1), 87–103. https://doi.org/10.1108/IJCCSM-01-2016-0001

Shahruzaila bin Abdullah. (1993). *Coastal developments in Malaysia: scope, issues and challenges. Department of Irrigation and Drainage Malaysia*.

Shaila Sarmin, N., Hasmadi Ismail, M., Hassan Zaki, P., Wahidin Awang, K., Rahman, M., & Imran, K. (2018). Community Perception on Mangrove Change Issue in Southwest Johor, Malaysia. *International Journal of Engineering & Technology*, *7*(3.7), 171–173. https://doi.org/10.14419/ijet.v7i3.7.16265

Shamshiry, E., Nadi, B., Mokhtar, M. Bin, Komoo, B., Hashim, H. S., & Yahaya, N. (2012). Impact

of landfill leachate on water quality in Langkawi Island using management of environmental system. *Asian Journal of Chemistry*, *24*(5), 1919–1923.

Shanbudin, S., Fikri Akmal, K., Faris, S., Normawaty, M.-N., & Mukai, Y. (2017). Current status of coral reefs in Tioman Island, Peninsular Malaysia. *TURKISH JOURNAL OF ZOOLOGY*, *41*, 294–305. https://doi.org/10.3906/zoo-1511-42

Sia, E. S. A., Zhang, J., Jiang, S., Zhu, Z., Carrasco, G., Holt Jang, F., Mujahid, A., & Müller, M. (2019). Behaviour of Dissolved Phosphorus with the associated nutrients in relation to phytoplankton biomass of the Rajang River-South China Sea continuum. *Biogeosciences Discussions*, 1–35. https://doi.org/http://dx.doi.org/10.5194/bg-2019-219

Sierra-Correa, P. C., & Cantera Kintz, J. R. (2015). Ecosystem-based adaptation for improving coastal planning for sea-level rise: A systematic review for mangrove coasts. *Marine Policy*, *51*, 385–393. https://doi.org/10.1016/j.marpol.2014.09.013

Siow, K. T., & Moll, E. O. (1982). Status and Conservation of Estuarine and Sea Turtles in West Malaysian Waters. *Biology and Conservation of Sea Turtles: Proceedings of the World Conference on Sea Turtle Conservation.*, 497–502.

Sirakaya, E., Jamal, T. B., & Choi, H. S. (2001). Developing indicators for destination sustainability. In *The Encyclopedia of Ecotourism* (pp. 411–432). CABI Publishing. https://doi.org/10.1079/9780851993683.0411

Sulaiman, F. C., Jaini, N., Jamaluddin, E. R., & Hashim, N. I. (2018). The Impact of Marine Tourism Towards the Local Community at Pulau Pangkor, Perak. *Asian Journal of Quality of Life*, *3*(13), 168–176. https://doi.org/10.21834/ajqol.v3i13.174

Syarifuddin, N., Sukimi, M. F., & Abdul Aziz, R. (2018). Socialization Agent's Knowledge Dissemination Among Bajau-Laut Community: Tun Sakaran Marine Park Conservation Zone, Sabah. *Journal of Social Sciences and Humanities*, *13*(2), 249–259.

Syerrina, Z., Naeim, A. R., Safiih, L. M., & Nuredayu, Z. (2017). Explorative Spatial Analysis of Coastal Community Incomes in Setiu Wetlands: Geographically Weighted Regression. *International Journal of Applied Engineering Research ISSN*, *12*(18), 973–4562. http://www.ripublication.com

Tajul Baharuddin, M. F., Taib, S., Hashim, R., Abidin, M. H. Z., & Rahman, N. I. (2013). Assessment of seawater intrusion to the agricultural sustainability at the coastal area of Carey Island, Selangor, Malaysia. *Arabian Journal of Geosciences*, *6*(10), 3909–3928. https://doi.org/10.1007/s12517-012-0651-1

Tan, A. N., Christianus, A., Shakibazadeh, S., & Hajeb, P. (2012). Horseshoe Crab, Tachypleus gigas (Muller, 1785) Spawning Population at Balok Beach, Kuantan, Pahang, Malaysia. *Pakistan Journal of Biological Sciences*, *15*(13), 610–620. https://doi.org/10.3923/pjbs.2012.610.620

Tang, K. H. D. (2019). Climate change in Malaysia: Trends, contributors, impacts, mitigation and adaptations. *Science of The Total Environment*, *650*, 1858–1871. https://doi.org/10.1016/j.scitotenv.2018.09.316

Teh, L. S. L., Teh, L. C. L., & Jolis, G. (2018). An Economic Approach to Marine Megafauna Conservation in the Coral Triangle: Marine Turtles in Sabah, Malaysia. *Marine Policy*, *89*, 1–10. https://doi.org/10.1016/j.marpol.2017.12.004

Teh, L. S. L., Teh, L. C. L., & Sumaila, U. R. (2011). Quantifying the overlooked socio-economic contribution of small-scale fisheries in Sabah, Malaysia. *Fisheries Research*, *110*(3), 450–458. https://doi.org/10.1016/j.fishres.2011.06.001

Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology*, *8*(1), 45. https://doi.org/10.1186/1471-2288-8-45

Tolochko, P., & Vadrot, A. B. M. (2021). Selective world-building: Collaboration and regional specificities in the marine biodiversity field. *Environmental Science and Policy*, *126*(October), 79–89. https://doi.org/10.1016/j.envsci.2021.09.003

Townsley, P. (2010). *Review of coastal and marine livelihoods and food security in the bay of Bengal large marine ecosystem region*.

Været, L., Kelbe, B., Haldorsen, S., & Taylor, R. H. (2009). A modelling study of the effects of land management and climatic variations on groundwater inflow to Lake St Lucia, South Africa. *Hydrogeology Journal*, *17*(8), 1949–1967. https://doi.org/10.1007/s10040-009-0476-5

Vianna, G. M. S., Meekan, M. G., Rogers, A. A., Kragt, M. E., Alin, J. M., & Zimmerhackel, J. S. (2018). Shark-diving tourism as a financing mechanism for shark conservation strategies in Malaysia. *Marine Policy*, *94*, 220–226. https://doi.org/10.1016/j.marpol.2018.05.008

Wan Nawang @ Wan Ahmad, W. M. Z., Mamat, I., & Mohd Isa, A. M. (2009). Faktor Peramal Minat Belia Untuk Menjadi Nelayan: Satu Kajian Di Mukim Kuala Besut, Terengganu. *Sains Humanika*, *50*, 29-52.

Wang, K. C. M., Lee, K. E., & Mokhtar, M. (2021). Solid waste management in small tourism islands: An evolutionary governance approach. *Sustainability (Switzerland)*, *13*(11). https://doi.org/10.3390/su13115896

Whittemore, R., & Knafl, K. (2005). The integrative review: updated methodology. *Journal of Advanced Nursing*, *52*(5), 546–553. https://doi.org/10.1111/j.1365-2648.2005.03621.x

Willmott, L., & Graci, S. R. (2016). Solid Waste Management in Small Island Destinations. *Téoros*, 71–76. https://doi.org/10.7202/1036566ar

Xiao, Y., & Watson, M. (2019). Guidance on Conducting a Systematic Literature Review. *Journal of Planning Education and Research*, *39*(1), 93–112. https://doi.org/10.1177/0739456X17723971

Yacob, M. R., Radam, A., & Shuib, A. (2009). A Contingent Valuation Study of Marine Parks Ecotourism: The Case of Pulau Payar and Pulau Redang in Malaysia. *Journal of Sustainable Development*, *2*(2), 95–105. https://doi.org/10.5539/jsd.v2n2p95

Yacob, M. R., Shuib, A., Mamat, M. F., & Radam, A. (2007). Local economic benefits of ecotourism development in Malaysia: The case of Redang Island Marine Park. *International Journal of Economics and Management*, *1*(3), 365–386.

Yacob, M. R., Shuib, A., & Mamat, M. P. (2009). The Application of Choice Experiments in the Analysis of Visitors' Preferences for Ecotourism Facilities and Services in Redang Island Marine Park. *International Journal of Business and Society*, *10*(2), 39–52.

Yanda, P. Z., Mabhuye, E., Johnson, N., & Mwajombe, A. (2019). Nexus between coastal resources and community livelihoods in a changing climate. *Journal of Coastal Conservation*, *23*(1), 173–183. https://doi.org/10.1007/s11852-018-0650-9

Yang, L., Wang, C., Yu, H., Yang, M., Wang, S., Chiu, A. S. F., & Wang, Y. (2020). Can an island economy be more sustainable? A comparative study of Indonesia, Malaysia, and the Philippines. *Journal of Cleaner Production*, *242*, 118572. https://doi.org/10.1016/j.jclepro.2019.118572

Yeo, B. H. (2004). The Recreational Benefits of Coral Reefs : A Case Study of Pulau Payar Marine Park , Kedah , Malaysia. *Environmental and Resource Economics*, 108–117. http://www.worldfishcenter.org/Pubs/coral_reef/pdf/section2-7.pdf

Yousef, M., & Marzuki, A. (2015). *Social carrying capacity in Cenang Beach, Langkawi Island*. 224–233.

Yousefi, M., & Marzuki, A. (2010). *Social Carrying Capacity in Cenang Beach, Langkawi Island*. 56–59. http://www.kuleuven.be/steunpunttoerisme/main/files/nieuwsbrief/oktober20

Yu, X., Geng, Y., Dong, H., Fujita, T., & Liu, Z. (2016). Emergy-based sustainability assessment on natural resource utilization in 30 Chinese provinces. *Journal of Cleaner Production*, *133*, 18–27. https://doi.org/10.1016/j.jclepro.2016.05.103

Yuliana, L., Widiono, S., & Cahyadinata, I. (2016). Strategi Nafkah Rumah Tangga Nelayan Tradisional Dan Modern Pada Komunitas Nelayan Sekunyit, Kaur, Provinsi Bengkulu/Livelihood Strategy of Traditional and Modern Fisheries Household in Sekunyit Fishermen Community , Kaur Bengkulu Province. *Agrisep*, *15*(2 September), 163–175.

https://ejournal.unib.ac.id/index.php/agrisep/article/view/1181

Yunus, S. M., Hamzah, Z., Khalik, A., Wood, H., & Saat, A. (2015). Natural Radionuclides and Heavy Metals Pollution In Seawater At Kuala Langat Coastal Area. In *Malaysian Journal of Analytical Sciences* (Vol. 19).

Yusof, J. N., Said, I., Aziz, N. F., & Rusli, N. (2021). Afford to paddle, afford to swim: exploring the affordances of the outdoor environment at a coastal community in affecting young children's play behaviour. *Children's Geographies*, 1–17. https://doi.org/10.1080/14733285.2021.1919997

Yusoff, F. M., Shariff, M., & Gopinath, N. (2006). Diversity of Malaysian aquatic ecosystems and resources. *Aquatic Ecosystem Health & Management*, *9*(2), 119–135. https://doi.org/10.1080/14634980600713315

Yusoh, M. P., Mohd Salleh, N., Mapjabil, J., & M.Z., R. (2021). An Investigation Of Tunku Abdul Rahman Marine Park, Sabah's Attractions And Tourism Infrastructure Management. *Journal of Tourism, Hospitality and Environment Management*, *6*(24), 87–99. https://doi.org/10.35631/jthem.624008

Zainudin, L. M., Zein, A., Idris, M. H., & Luqman, W. (2019). Socio-Economic Profile Comparison of Fishermen Community in Kuala Marang and Seberang Takir, Terengganu, Malaysia. *Journal of Sustainability Science and Management*, *14*(6), 145–157.

Zaiton, S., Huda-Farhana, M., & Hasan-Basri, B. (2019). Conservation of Mangroves in Kuala Perlis, Malaysia – A Case Study of Socio-Economic Attributes of Fishermen Driving Valuation in Sustaining Livelihoods through Forest Management. *JOURNAL OF TROPICAL FOREST SCIENCE*, *31*(4), 433–442. https://doi.org/10.26525/jtfs2019.31.4.433

Zakaria, F. (2011). Social enterprise in Malaysia: The UMK experience. *In Developments in Solidarity Economy in Asia*, 123–138.

Zubir Ibrahim, A., Hassan, K. H., Kamaruddin, R., & Rahim Anuar, A. (2018). Measuring Sustainable Livelihood for Malaysia's Poor: The Sustainable Livelihoods Index and the B40 Group of Coastal Fishermen in Northern Peninsular Malaysia. *International Journal of Society, Development and Environment in the Developing World*, *2*(1), 39–47. www.lifewaysjournal.com

Zulhilmi Mohd Johan, M., & Begam Yusof, Z. (2021). Marine Rehabilitation And Research Centre At Perhentian Kecil Island, Terengganu. *Design Ideals Journal (DIJ)*, *3*(2), 74–82.

Zulkifli, N. H., Ibrahim, P. H., & Zakariya, K. (2020). The significance of coastal landscape characters among locals and tourism: A case study of Gebeng-Kuala Terenggunu Tourism Route. *Journal of Architecture,Planning & Construction Management*, *10*(1), 44–54.