

POST COVID-19 MARINE LIFE STATUS

at Marine Park Islands
of Terengganu Report

**Zainudin Bachok
Azlan Bin Md Nor
Izarenah Md Repin**

Jabatan Perikanan Malaysia
Kementerian Pertanian dan Industri
Makanan
2021



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Final Report

**Zainudin Bachok
Azlan Bin Md Nor
Izarenah Md Repin**

Jabatan Perikanan Malaysia
Kementerian Pertanian dan Industri Makanan
2021

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Post COVID-19 Marine Life Status at Marine Park Islands of Terengganu

EDITOR:

**ZAINUDIN BACHOK
AZLAN BIN MD NOR
IZARENAH MD REPIN**

AUTHORS:

Universiti Malaysia Terengganu

Muhammad Hafiz Borkhanuddin
Siti Nurtahirah Jaafar
Muhammad Rafiq Hakimi Mohd Noor
Nurzahirah Kamarudin
Tan Chun Hong
Nursalwa Baharuddin
Afiq Durrani Mohd Fahmi
Siti Nur Hakimah Zainuddin
Izwandy Idris
Tulio F. Villalobos Guerrero
Isabel C. Molina Acevedo
Fatin Sharmimi Muhammad
Maizah Mohd Abdullah
Zalina Bashir Ali
Jen Nie Lee
Meii Mohamad Norizam

Yusri Yusuf
Nur Hidayah Roseli
Yuzwan Mohamad
Munawwarah Abdul Aziz
Nurul Maisarah
Yusof Shuaib Ibrahim
Sabiqa T. Anuar
Wan Mohd Afiq Wan Mohd Khalik Maisarah Jaafar
Noorlin Mohamad
Ku Mohd Kalkausar Ku Yusof
Yuzwan Mohamad
Zainudin Bachok
Poh Seng Chee
Yong Jaw Chuen
Zaleha Mohamad
Noorhaslinda Kulub Abd Rashid

**Jabatan Perikanan Malaysia
Universiti Malaysia Terengganu**

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CHAPTER 1

PROGRAM BACKGROUND

Zainudin Bachok, Azlan Md Noor and Izarenah Md Repin

1.1 BACKGROUND OF THE STUDY

In order to counter the COVID-19 pandemic, the government of Malaysia initiated the Movement Control Order (MCO), effective on 18 March 2020. The initiative aims to increase social distancing and slow down the transmission rate of the virus. The MCO order was extended three times, each for another two weeks period, until 12 May 2020. On 13 May 2020, Malaysia moved into the Conditional Movement Control Order (CMCO) and on 8 June 2020, Malaysia moved into the Recovery Movement Control Order (RMCO).

Since the spread of COVID-19 and the implementation of Movement Control Order (MCO), most human activities that usually take place have now stopped for longer than usual, and this has resulted in a quick and drastic change in the way human population uses and occupies the marine ecosystem such as coral reef. The outcome is not only that there are less people moving around, but also that pollution linked to the functioning of society has also decreased.

The pandemic COVID-19 has created a chaos around the world. Many activities are halted with tourism related industries received the severe backlash. This include marine tourism in Malaysian marine park which reduced significantly during the Movement Control Order (March-June 2020). The tourism activity in the marine park, although generate financial subsistence to both government and community is known to have detrimental impacts to the environment. The monsoon season occurs between October until February serves as buffer period for marine ecosystem in the marine park to recover from the tourism pressure. Nonetheless, the MCO has extended the buffer period from 5 months to 9 months. It is expected that the coral reef ecosystems in the marine park are in better condition due to this prolonged buffer period.

Hence, Marine Park and Resources Management Section, Department of Fisheries Malaysia, in collaboration with Universiti Malaysia Terengganu was initiated the project entitled "Post COVID-19 Marine Life Status at Marine Park Islands of Terengganu". The research team from Universiti Malaysia Terengganu have been conducted the study at four marine park islands, Pulau Redang, P. Perhentian, P. Kapas and P. Tenggol in the Terengganu.

1.2 OBJECTIVE

Objective of the study are:

1. To determine the coral reef status and health condition.
2. To determine fish community structure.
3. To determine the occurrence of epibenthic mobile/sessile invertebrates, large marine animals and other important marine organisms including macroalgae and seagrass.
4. To determine the physico-chemical characteristics and water quality of sea water.
5. To determine socio-economy impacts of COVID-19 on local communities and tourism operators.

1.3 PROJECT TEAM

The team for the project comprises two marine park officers, 24 researchers with specialist expertise crucial to the study. In addition, to assist the field survey, sample and data analysis, 3 technical staffs, 2 postdoctoral candidates, 11 research assistants, 7 postgraduate students and 9 internship training students from the Universiti Malaysia Terengganu also participate as a project member. The project team members are given in Table 1.1.

Table 1.1. Project team members from UMT during 2020 post COVID-19 survey.

NAME	FIELD/POSITION
Marine Park and Resource Management Section, DoFM	
1. Azlan Md Noor	Head, Ecosystem Conservation and Biodiversity Branch Fisheries Officer
2. Izarenah Md Repin	
Researcher	
Prof. Dr. Zainudin Bachok (Project Leader)	Marine Ecology - INOS
Assoc. Prof. Dr. Poh Seng Chee	Chemistry – FSSM
Dr. James Tan Chun Hong	Coral Biology & Ecology – FSSM
Dr. Izwandy Idris	Invert. Biol. & Ecology – INOS
Dr. Zaleha Mohamad	Socio-economy – FPEPS
Dr. Lee Jen Nie	Coral Biology – FSSM
Dr. Noorhaslinda Kulup Abdul Rashid	Socio Economy– FPEPS
Dr. Nursalwa Baharuddin	Malacology – FSSM
Dr. Maizah M. Abdullah	Marine Ecology) – FSSM
Dr. Yusof Shuaib Ibrahim	Invertebrate Taxonomy – FSSM
Dr. Muhammad Hafiz Borkhanuddin	Parasitology – FSSM
Dr. Siti Nur Tahirah Jaafar	Proteomic – FSSM
Dr. Afiq Durani Mohd Fahmi	Conservation Biology – FSSM
Dr. Wan Mohd Afiq Wan Mohd Khalid	Chemistry – FSSM
Dr. Nur Hidayah Roseli	Physical Oceanography – FSSM
Dr. Yusof Shuaib Ibrahim	Microplastics – FSSM
Dr. Mohd Wan Mohd Afiq Wan Mohd Khalid	Environmental Chemistry – FSSM
Dr. Tuan Nurul Sabiqah Tuan Anuar	Micro-plastics Analysis – FSSM
Dr. Maisarah Jaafar	Environmental Chemistry – FSSM
Dr. Noorlin Mohamad	Environ-Human Health – FSSM
Dr. Ku Mohd Kalkausar Ku Yusof	Chemometric – FSSM
Yusri Yusuf	Coral Reef Fish – FSSM
Meii Mohamad Norizam	Fish Ecology – FSSM
Yong Jaw Chuen	Chemical Oceanography – FSSM
Technical Staff	
Azwarina bt Mohd Azmi Ramasamy	Senior Curator – INOS
Ahmad Nazila Ali	Senior Asst. Sc. Officer – INOS
Yuzwan Mohamad	Senior Laboratory Assistant – FSSM

Postdoctoral 1. Tulio Fabio Villalobos Guerrero – INOS 2. Isabel Cristina Molina Acevedo – INOS	Research Assistant 1. Nur Amalina Mohd Razikin – INOS 2. Nurzahirah Kamarudin – INOS 3. Najwa Nasuha Nor Din – INOS 4. Noor Suhadah Muhamad Isa – INOS 5. Haminuddin Abd Halim – FPEPS 6. Abdul Usaid Musa – FPEPS 7. Mohd Fadli Hussin – FPEPS 8. Mohd Noor Afiq Ramlee – FPEPS 9. Nur Munirah Zainuddin – FPEPS 10. Siti Shuhada Mustaffa – FPEPS 11. Khyrizan Abu Jalil – FPEPS
Postgraduate Student 1. Nur Fazne Ibrahim, PhD – INOS 2. Zalina Bashir Ali, MSc – INOS 3. Maria Juliana V. Gonzalez, MSc – INOS 4. Muhammad Rafiq Hakimi M. Noor, MSc – INOS 5. Fatin Sharmimi Mohammad, MSc – FSSM 6. Nur Atiqah Maznan, MSc – FSSM 7. Siti Nur Hikmah Zainuddin – FPES	
Internship Student 1. Farhana Izzati January – INOS 2. Mohamad Redzuan Awang Ahmad – INOS 3. Norazima Idris – INOS 4. Nur Syahirah Mohd Safri – INOS 5. Wan Nurul Syaheera Atiqah Wan Sukandar – INOS	6. Fatin Ilyana Mohd Tabaroni – INOS 7. Muhamad Ikram Zuraini – INOS 8. Nur Fadzira Anua – INOS 9. Siti Nur Atikah Mohammad – INOS

DoFM – Department of Fisheries Malaysia; INOS – Institute of Oceanography and Environment; FSSM – Faculty of Science and Marine Environment; FPEPS – Faculty of Business, Economics and Social Development; FPSM – Faculty of Fisheries and Food Science

1.4 SCOPE OF WORK AND APPROACHES

The study comprises the survey on benthic life form of coral reef, epibenthic invertebrates and any associated organisms and fishes; marine food web; measurement of *in-situ* and physical parameters of seawater; collection of seawater for water quality analysis; microplastic occurrence, and socio-economy (Table 1.2)

Table 1.2. Scope of work and field work approaches for post COVID-19 survey.

WORK SCOPE	FIELD WORK APPROACHES
Coral reef benthic structure: life form category, hard coral community, coral cover, coral reef condition, associated invertebrates	Coral Video Transect Belt transect Photo quadrat Visual census
Shallow coral reef survey: corallivores gastropod, <i>Drupella</i> spp. prevalence, rubble cryptofauna diversity	Belt transect Photo quadrat Visual census
Coral reef food web construction using stable isotope analysis	Collection of food web component specimen (invertebrate, algae, fishes)
Coral reefs health: view from benthic and fish populations	Belt transect Visual census
Physical parameter and water quality	CTD castaway – conductivity-temperature-depth Multiparameter Hydrolab DS5X – dissolved oxygen and pH Acoustic Doppler and Current Profiler (ADCP) – <i>in-situ</i> currents Niskin Water Sampler – seawater samples (chlorophyll- <i>a</i> , nutrient, total suspended solid, faecal coliform) Carbon dioxide meter
Microplastic occurrence	Neuston Net – microplastics collection
Socio-economic impact on local communities and tourism activities	Face to face interview Questionnaire

1.5 SURVEY ISLANDS

Survey was conducted at four Marine Park Islands, Redang, Perhentian, Kapas and Tenggol (Figure 1). These Island located in the state of Terengganu and have been well known for tourism activities.



Figure 1.1: Location of Pulau Perhentian (A), Redang (B), Kapas (C) and Tenggol (D).

The Redang archipelago comprises Pulau Redang, P. Lima, P. Paku Besar, P. Paku Kecil, P. Kerengga Kecil, P. Kerengga Besar, P. Ekor Tebu, P. Ling and P. Pinang. Redang archipelago is the biggest Marine Park in Terengganu state, approximately 7 km (4.3 mi) long and 6 km (3.7 mi) wide.

Perhentian archipelago are located in the northern part of Terengganu waters. The larger islands are Perhentian Besar and Perhentian Kecil Islands. Beside both islands, there are another five small inhabited slands in the archipelago. On the other hand, Pulau Kapas located about 6 kilometres east of Marang, Terengganu, with a smaller island, Pulau Gemia, located north of it. It measures roughly 1.5 by 2.5 km. Besides, Pulau Tenggol is an island off the coast of Dungun, Terengganu. It is the last island in a string of islands located at the southern part of Terengganu waters.

1.6 FIELD SURVEY

Field survey was conducted from August to October 2020. Specific schedule of each survey team is shown in Table 1.3. The survey time were selected based on the weather and tidal condition.

Table 1.3: Schedule of sampling activities for each survey team during post COVID-19 expedition at marine park islands of Terengganu in the year 2020.

SURVEY TEAM	REDANG	PERHENTIAN	KAPAS	TENGGOL
Coral reef benthic structure: life form category, hard coral community, coral cover, coral reef condition, associated invertebrates	18-20 July	23-26 Aug	22-23 Sept	12-13 Oct
Shallow coral reef survey: corallivores gastropod, <i>Drupella</i> spp. prevalence, rubble cryptofauna diversity	16-19 July	23-27 Aug	22-23 Sept	12-13 Oct
Coral reef food web construction using stable isotope analysis	16-19 July	-	-	-
Coral reefs health: view from benthic and fish populations	16-19 July	23-27 Aug	22-23 Sept	12-14 Oct
Physical parameter and water quality	21 July	23-26 Aug	24 Sept	11-12 Oct
Microplastic occurrence	16 Aug	26 Aug	19 Sept	11 Oct
Socio-economic impact on local communities and tourism activities	16-19 July	23-26 Aug	21 Sept	11-12 Oct

CHAPTER 2

CORAL REEF BENTHIC COMMUNITIES USING CORAL VIDEO TRANSECT SURVEY

Tan Chun Hong, Muhammad Hafiz Borkhanuddin, Siti Nurtahirah Jaafar, Nurzahirah Kamarudin, Muhammad Rafiq Hakimi Mohd Noor

2.1 INTRODUCTION

Malaysia is known as part of the countries classified with 'mega-diversity' of flora and fauna (Napis et al., 2001). In particular, Malaysia harbour an extraordinary diversity of coral reefs organisms. Thus, investigating the benthic coral reefs composition can provide valuable information concerning the health status of the reefs. Natural stress associated with coral reefs area are coral bleaching, rough sea condition, predation by the *Acanthaster planci* and coral disease (Chak et al., 2016; Hoeksema et al., 2014; Tan and Heron, 2011; Toda et al., 2007). Rising sea surface temperature (SST) cause coral bleaching in Southeast Asia in 1997/1998, 2010 and 2016 (Tan and Heron, 2011; Wouthuyzen et al., 2017).

Threats to the coral reef ecosystem are rapidly growing and magnified by climate-related events such as tropical storms. The phenomenon not only deteriorates the coral cover, but also causes the loss of invertebrates' diversity and abundance. As one of the key elements in coral reefs health (Glasl, et al., 2018; Edmunds et al., 2018), invertebrate diversity and abundance in response to coral reefs recovery could provide an additional insight about the recovery process. The ecological importance of invertebrates towards marine ecosystems is essential, as they are converting large quantities of organic matter into protein. With a focus on assessment of the resilience of reef communities, invertebrate's survey should be focused on the major functional groups that may be indicators of resilience (in the coral community). However, some invertebrates such as crown of thorns (COT – *Acanthaster planci*) and *Drupella* sp. snails possess threats to corals by predating on them.

Tourism impact is known as one of the major threats to the coral reefs in Malaysia (Praveena et al., 2012). Island tourism is one of the fastest growth sector in Malaysia and the number of visitors come to the islands are increasing year by year (Department of Marine Park Malaysia, 2017). Pulau Redang, Perhentian, Kapas and Tenggol in the state of Terengganu are among the most popular islands in east coast of Peninsular Malaysia. Evidence shows that heavy influx of visitors to the island partly promote the physical damage towards the reef (Jaafar and Maideen, 2012). In another survey, trampling of coral by inexperienced snorkelers and scuba divers is the main cause of coral mortality at the heavily used reefs in Peninsular Malaysia (Shahbudin et al., 2017; Toda et al., 2007). The physical damage caused by diving and snorkelling activities can increase the mortality rate and reduce the growth of coral (Hawkins and Roberts, 1993), allowing other non-reef-building organisms colonising the reefs.

The implementation of Movement Control Order (MCO) due to COVID-19 pandemic in Malaysia from March to May 2020, significantly reduced the tourism related activity in most islands in Terengganu. Due to this, detrimental impacts to the environment and socio-economy of the island might occurred. The monsoon season occurs

between October until February serves as buffer period for marine ecosystem in the marine park to recover from the tourism pressure. Nonetheless, the MCO has extended the buffer period from 5 months to 9 months. It is expected that the coral reef ecosystems in the marine park are in better condition due to this prolonged buffer period.

In the course of our study the abundance of coral associated invertebrates were investigated among four archipelagos of marine parks namely Pulau Redang, Pulau Perhentian, Pulau Kapas, and Pulau Tenggol. The study was completed using the common benthic validation exercise such as line intersect transect and CVT. Specifically, a 100 m line transect was placed on the reef parallel to the shoreline at a constant depth (± 2.0 m). The surveys were conducted in buddy pairs, within an area of 2.5 m x 2.5 m belt, with the line transect as the middle guideline. The number of invertebrates' taxa and individuals found within the area of the belt transect were counted, recorded and further identified on in-silico basis. A total of 27 survey locations has been investigated amongst the four archipelagos.

2.2 METHODOLOGY

Site Survey

Terengganu have few islands with high diversity of marine ecosystem. This includes Pulau Perhentian, Pulau Redang, Pulau Kapas and Pulau Tenggol (Figure 2.1). All these four islands are famous for tourism activities including snorkelling, diving, resorts and others.

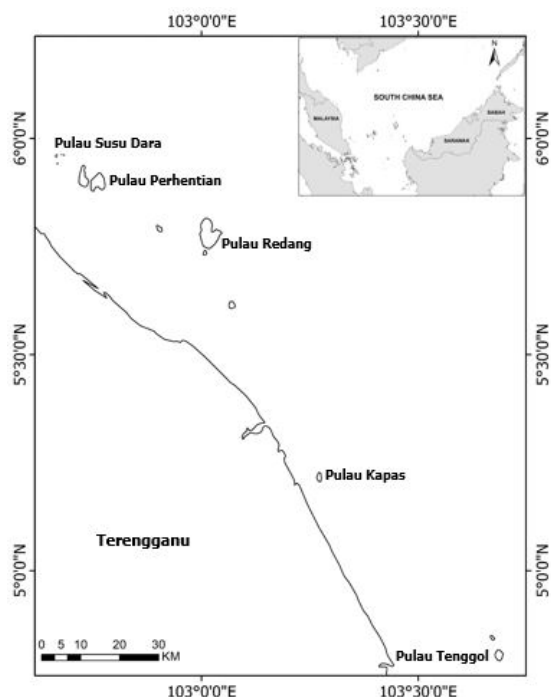


Figure 2.1: Location of selected islands (Pulau Perhentian, Pulau Redang, Pulau Kapas and Pulau Tenggol) around Terengganu, Malaysia.

Surveys were conducted via SCUBA diving around each selected islands. Figure 2.2 to Figure 2.5 show survey sites from July 2020 to October 2020 by UMT team on coral reef benthic survey.

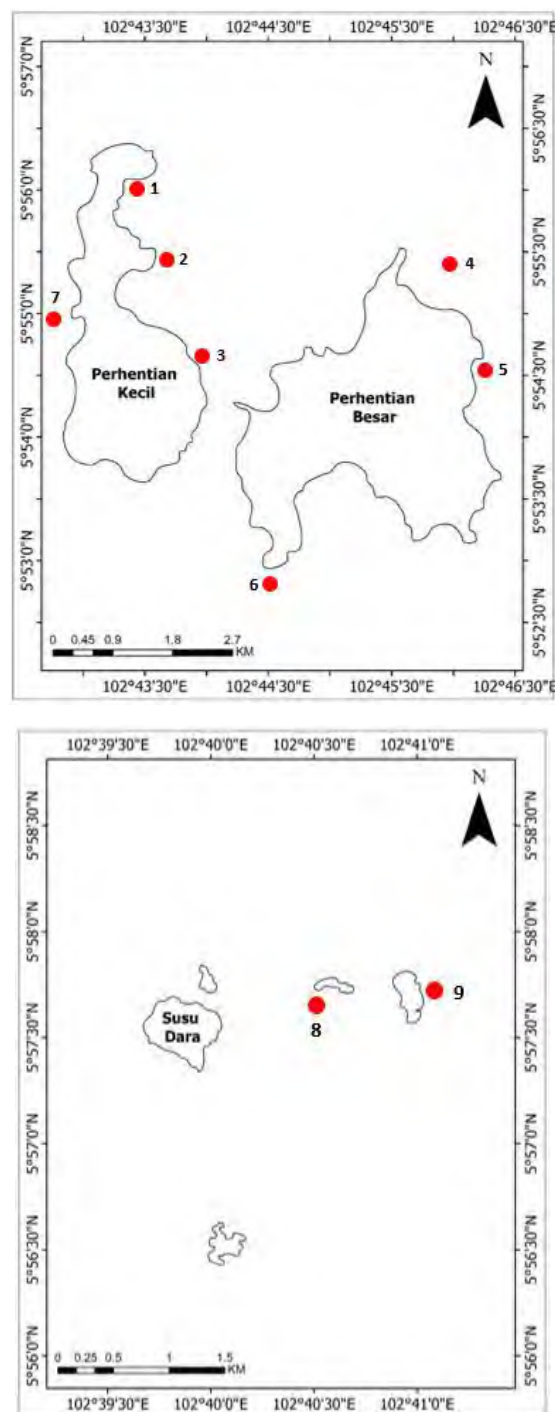


Figure 2.2: Sampling sites around Pulau Perhentian. (1 = D'Lagoon, 2 = Batu Nisan, 3 = Turtle Point, 4 = Tanjong Basi, 5 = Terumbu Tiga, 6 = Shark Point, 7 = Seabell, 8 = Tokong Burung, 9 = Pulau Rawa).

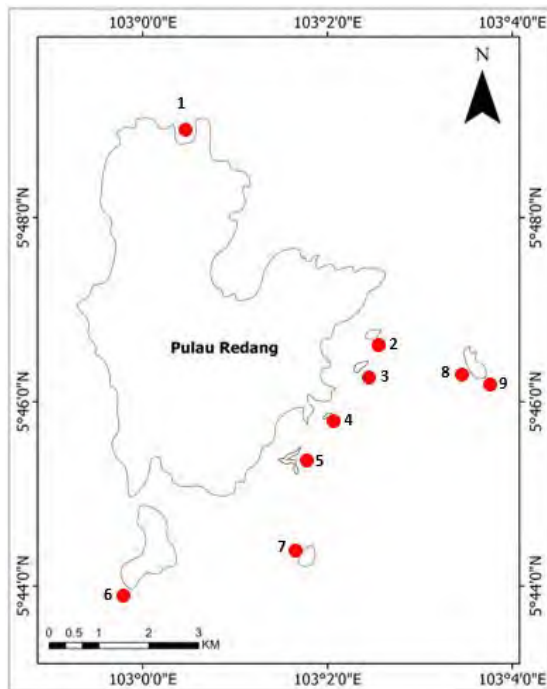


Figure 2.3: Sampling sites around Pulau Redang. (1 = Chagar Hutang, 2 = Paku Besar, 3 = Paku Kecil, 4 = Mak Cantik, 5 = Kerengga, 6 = Terumbu Kili, 7 = Ekor Tebu, 8 = Pulau Lima, 9 = Southern Tip).

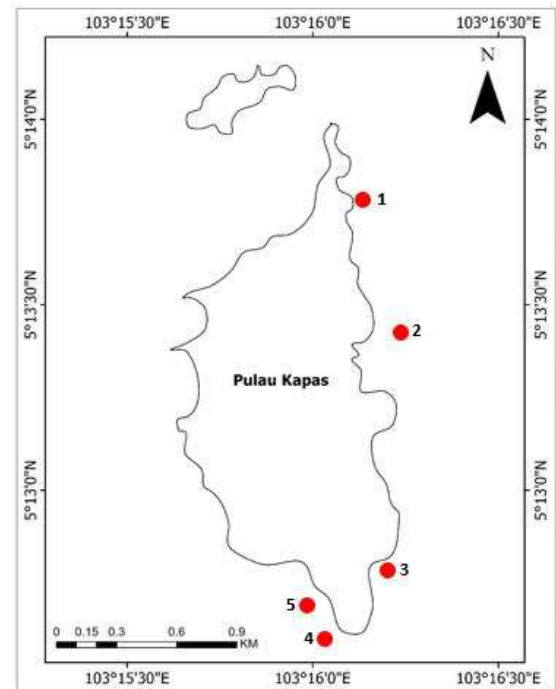


Figure 2.4: Sampling sites around Pulau Kapas. (1 = Silent Reef, 2 = Kapas Tengah, 3 = Nudi Rock, 4 = Teluk Jawa, 5 = Southern Tip).

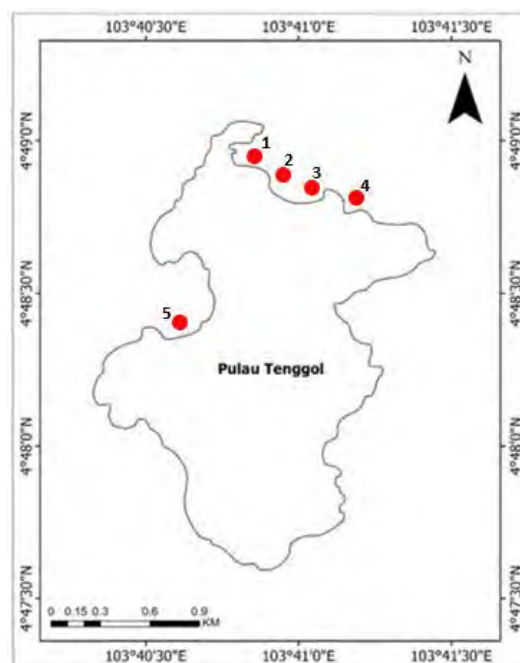


Figure 2.5: Sampling sites around Pulau Tenggol. (1 = Teluk Rajawali, 2 = Rajawali, 3 = Lost World, 4 = Sri Nakhota, 5 = Turtle Point).

Field Survey and Data Collection

Surveys were conducted via SCUBA diving. At each site, a 100 m transect was laid along the coral reefs area by following the reef contour. Quantification of reef benthic cover as done using a standard protocol of Coral Video Transect (CVT) method following Safuan et al. (2015). The CVT technique was conducted using an underwater camera (Olympus TG-5 set in underwater mode and enclosed in an underwater casing). Video taken by

diver along the transect line, slowly swim at a speed of approximately 5 m per minute. To facilitate the video recording, the 100 m transect line were divided into four 20 m segments as shown in Figure 2.6. Recording was done along the transect length by pointing the camera lens down at a vertical elevation of 0.5 m from the substrate (Safuan et al., 2015). To maintain the vertical elevation during the video recording, a reference bar attached to the underwater video housing was used. Some cryptic coral species were photographed in close-up settings to facilitate the identification process during the analysis. On board, all the footages were transferred into computer prior to analysis.

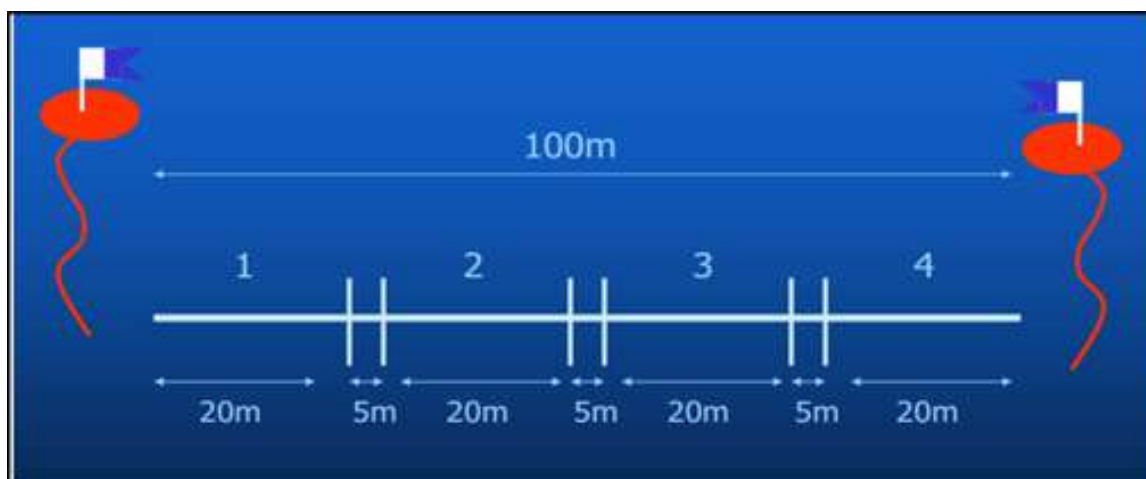


Figure 2.6: A 100m transect with 20m recording length and 5m no recording length in between (Image from: Reef Check Malaysia, 2014)

Data Analysis

The videos were analysed using Coral Point Count with Excel extension (CPCe) version 4.1 software to quantify the percentage cover of the benthic components in the coral reef (Kohler and Gills, 2006). First, the videos were extracted into 50 non-overlapping frames using Vidoe Image Master software. Each video frame then was analysed using CPCe software with 50 points per frame (Safuan et al., 2015). The points were arranged and set randomly. Any living or non-living organism present beneath the points were visually identified. In total, 10,000 points were analysed to determine the reef benthic cover for each 100 m transect. Scleractinian corals were classified up to genus level, following Veron (2000). The results obtained then were grouped as percentage cover in five categories; live coral (C), dead coral (DC), algae (ALG), other invertebrates (OT) and sand, silt or rock (SR). Percentage live coral cover was used to categorized the reef condition following the ASEAN-Australia Living Coastal Resource Project as 'excellent' (> 75%), 'good' (< 75% and > 50%), 'fair' (< 50% and > 25%) and 'poor' (< 25%) (Chou et al., 1994).

2.3 RESULT S

Four islands in Terengganu were surveyed within period of July to October 2020. These islands include Pulau Redang, Pulau Perhentian, Pulau Kapas and Pulau Tenggol. Live coral cover is important for a healthy reef, aside of other elements that completes the ecosystem. According to Chou et al (1994), percentage of live coral cover can be classified into four conditions; 'excellent' (>75% coral cover), 'good' (<75% and >50% coral cover), 'fair' (<50% and >25% coral cover) and 'poor' (<25% coral cover).

Coral Status at Pulau Redang

Pulau Redang is located about 25 km from Merang, Terengganu. This island was gazetted as Marine Park since 1994. Surveys and data collections were conducted at nine sites around Pulau Redang, related to corals and benthic community from 18 to 21 July 2020. Figure 2.7 shows the coral condition around Pulau Redang based on Coral Video Transect (CVT) at depth of 10 meter.

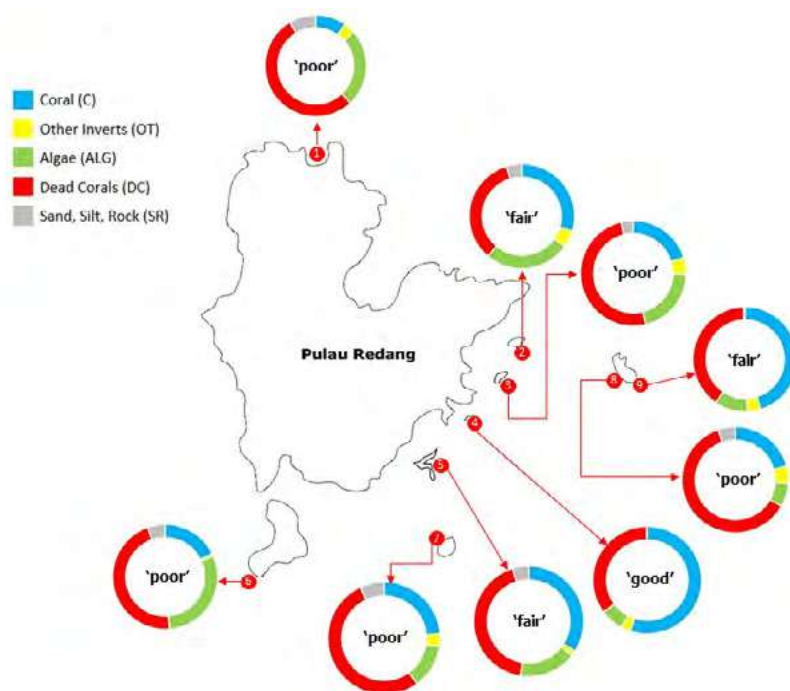


Figure 2.7: Relative percentage cover of biotic and abiotic components around Pulau Redang (1 = Chagar Hutang, 2 = Paku Besar, 3 = Paku Kecil, 4 = Mak Cantik, 5 = Kerengga, 6 = Terumbu Kili, 7 = Ekor Tebu, 8 = Pulau Lima, 9 = Southern Tip).

From the result shown, coral condition at five sites were classified as 'poor'; Chagar Hutang, Paku Kecil, Ekor Tebu, Terumbu Kili, and Pulau Lima. These sites have percentage of live coral cover less than 24%. On the other hand, three sites (Paku Besar, Kerengga and Southern Tip) were categorized as 'fair' and only one site was categorized as 'good' which is Mak Cantik with 54.96% live coral cover. Based on observation during the surveys, deeper area seems to have less coral cover compare to shallower area (depth 3 to 6 meter). Most sites have high percentage of Dead Corals (DC) which includes rubbles (R), dead coral with algae (DCA) and dead coral (DC). This may be due to slow recovery process of reefs after Pabuk storm in 2019.

Around Pulau Redang, coral covers were dominated by different coral genus at different site. In Figure 2.8 to Figure 2.16 below, graphs show nine most abundance coral genus for each site around Pulau Redang, and 'Others' is other coral genus presented at site surveyed along transect. From all nine sites, *Acropora*, *Porites*, *Fungia* and *Pocillopora* were found to be the most abundance coral genus at these different sites.

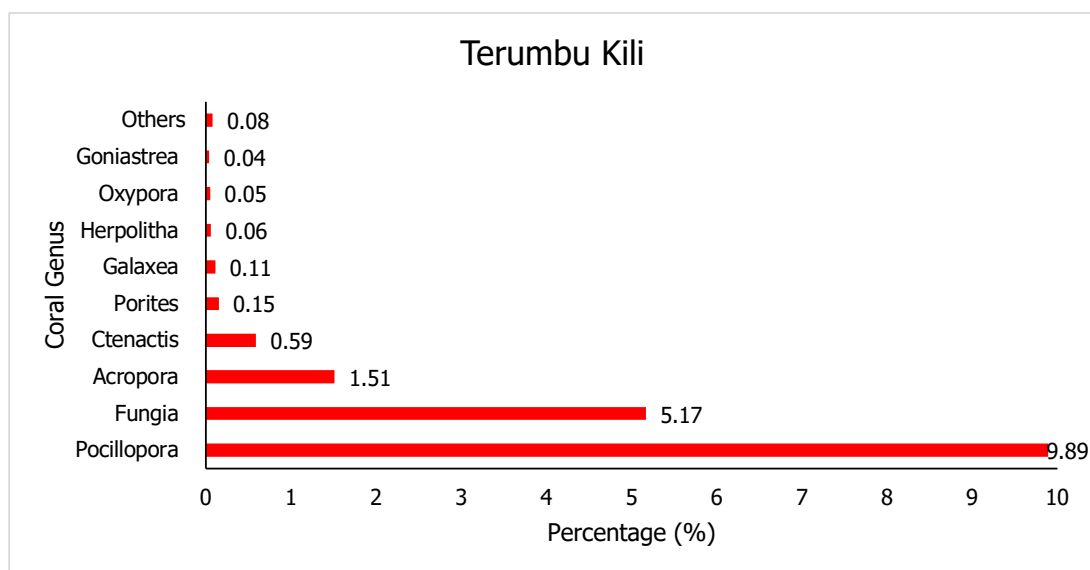


Figure 2.8: Percentage of coral genus identified at Terumbu Kili.

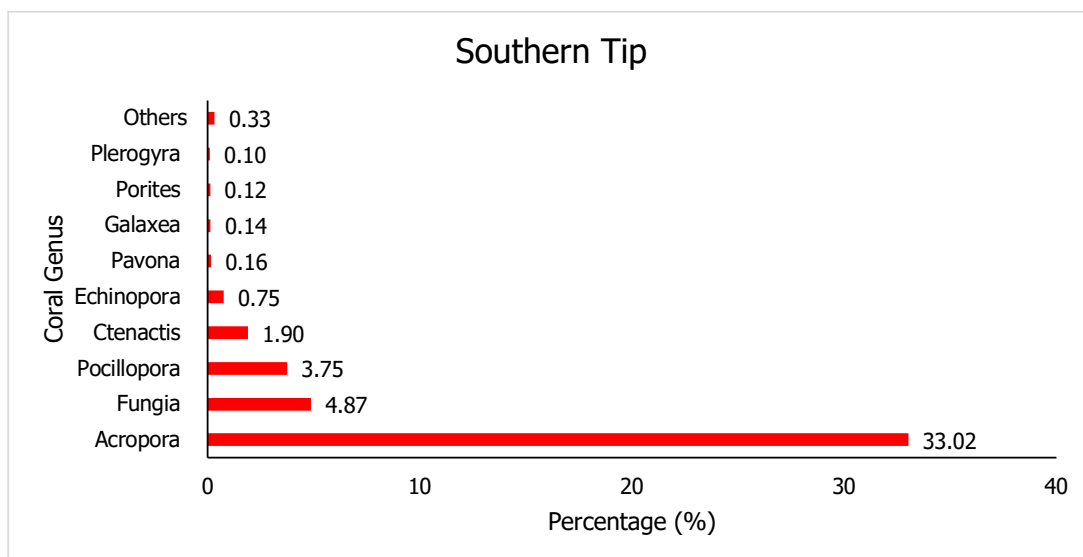


Figure 2.9: Percentage of coral genus identified at Southern Tip.

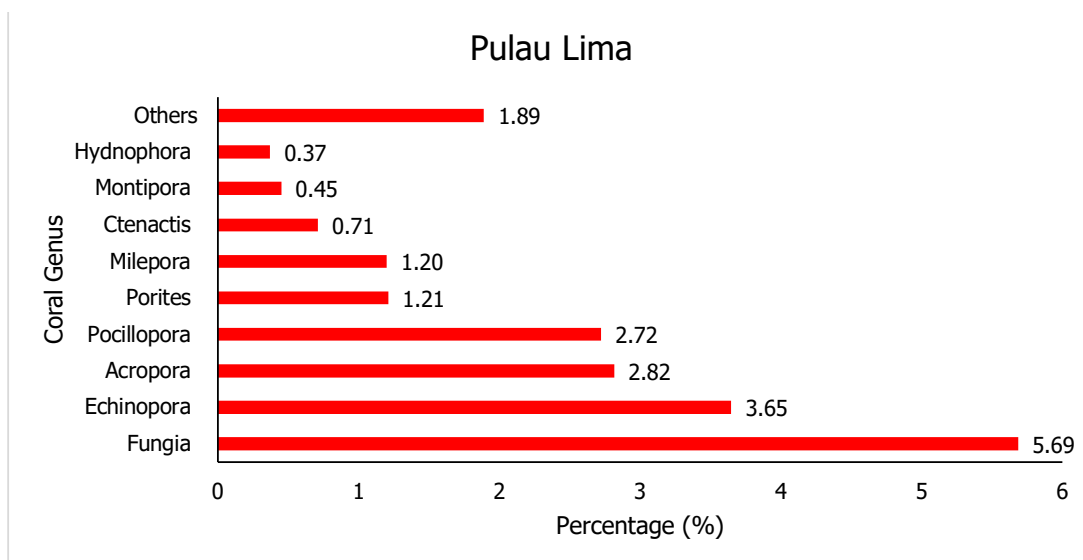


Figure 2.10: Percentage of coral genus identified at Pulau Lima.

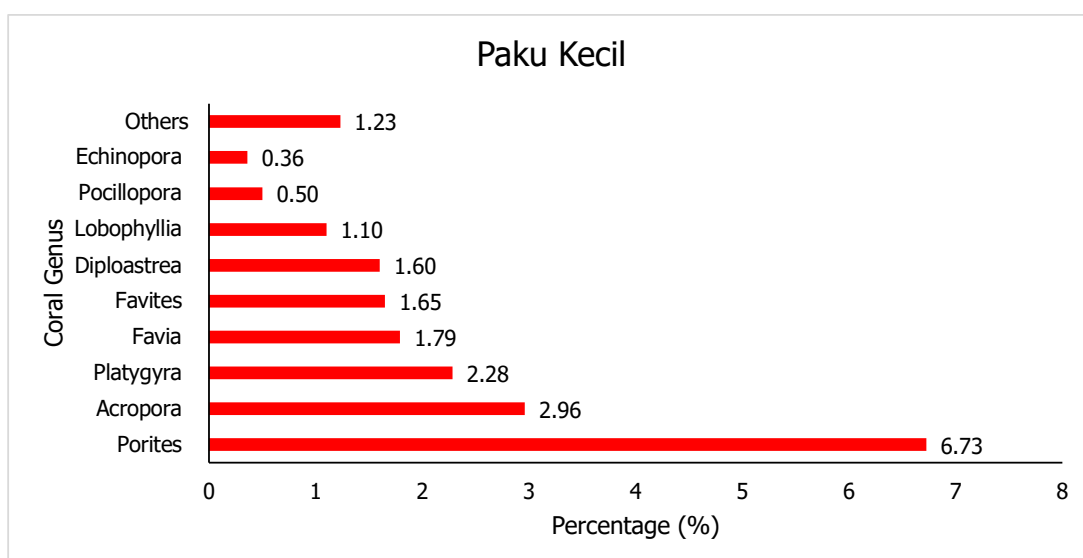


Figure 2.10: Percentage of coral genus identified at Paku Kecil.

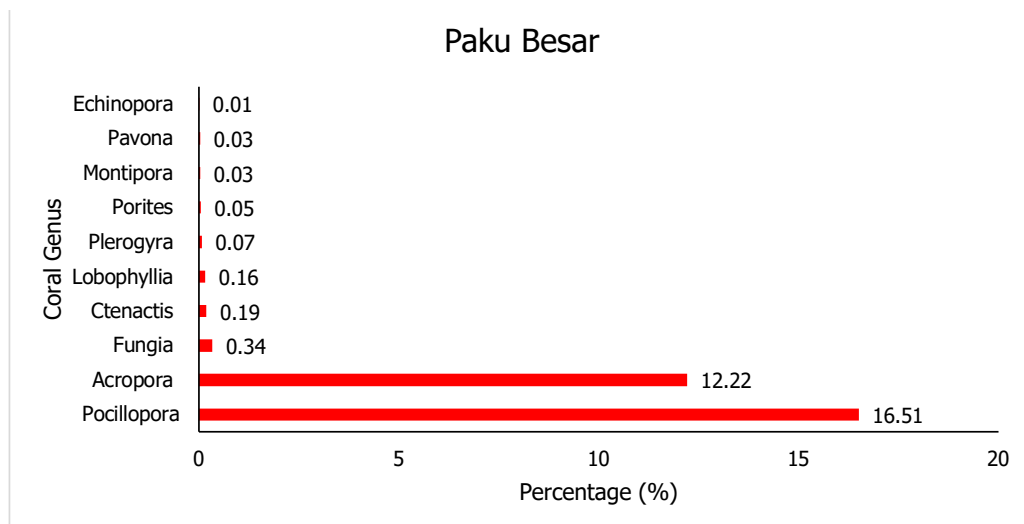


Figure 2.12: Percentage of coral genus identified at Paku Besar.

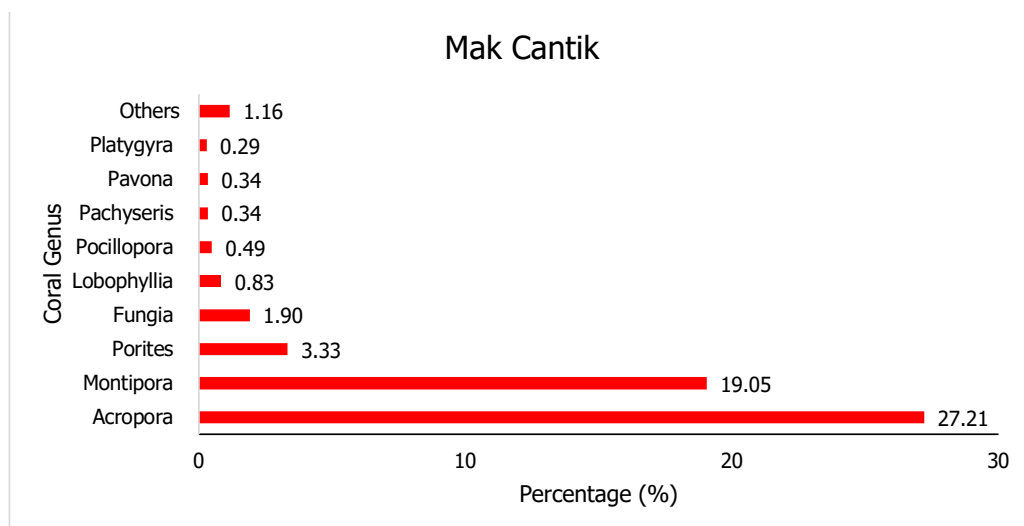


Figure 2.13: Percentage of coral genus identified at Mak Cantik.

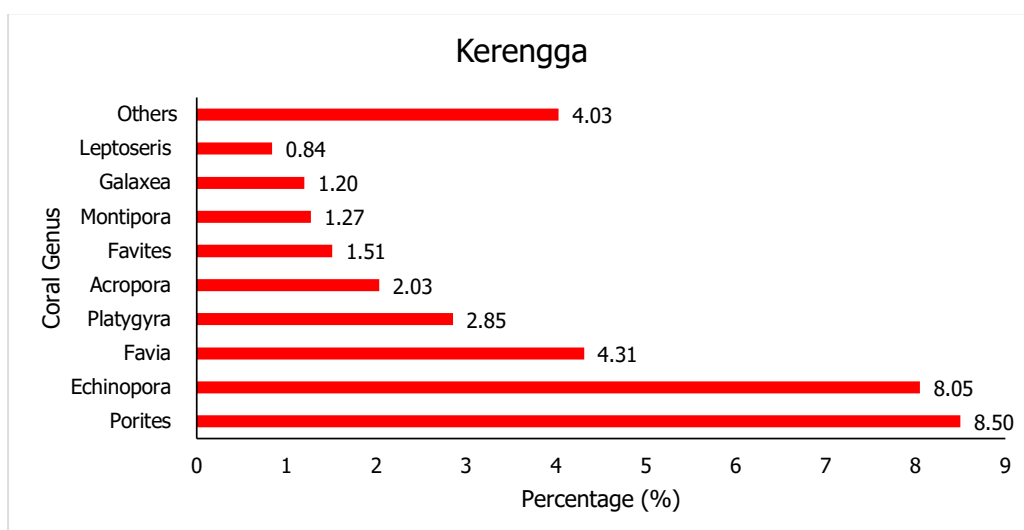


Figure 2.14: Percentage of coral genus identified at Kerengga.

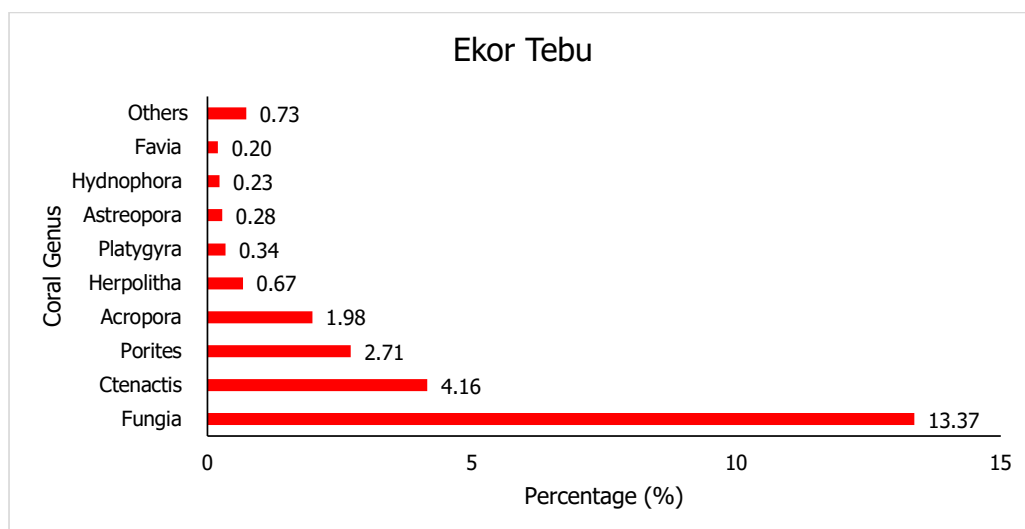


Figure 2.15: Percentage of coral genus identified at Ekor Tebu.

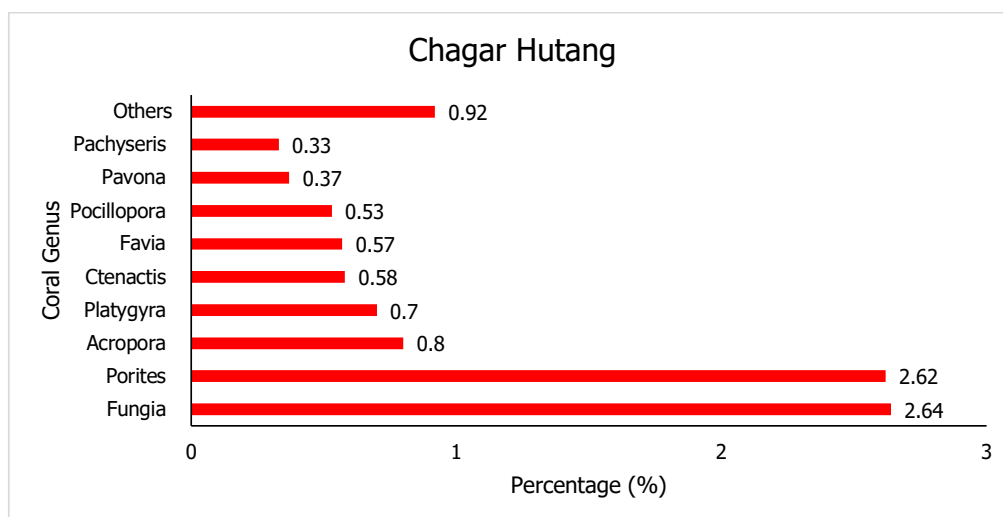


Figure 2.16: Percentage of coral genus identified at Chagar Hutang.

Invertebrates at Pulau Redang

Apart from live corals, other invertebrates were also recorded in Coral Video Transect as they are a part of benthic cover in a reef ecosystem. Table 2.1 shows the other invertebrates for all nine sites surveyed around Pulau Redang. All sites have sponges (SP) as this invertebrate are ubiquitous. They existed in different growth forms such as barrel and encrusting. Only one site has Crown of Thorns (COT) which is Southern Tip. COT feeds on live coral's tissue, act as a predator to corals. However, it also has its own importance to control coral abundance in competition matter. For example, fast growing branching *Acropora* competes with slow growing corals (eg massive corals: *Porites*, *Platygyra*, *Favia*), hence COT would feed on *Acropora* and other corals would have chance to grow in the area.

Table 2.1: Invertebrates found in Coral Video Transect at sites surveyed around Pulau Redang.

OTHER INVERTS	Terumbu Kili	Southern Tip	Pulau Lima	Paku Kecil	Paku Besar	Mak Cantik	Kerengga	Chagar Hutang	Ekor Tebu
Anemone (AN)		√	√	√	√	√	√	√	√
Ascidian (ASC)			√			√			
Crown of Thorn (COT)		√							
Giant Clam (GC)							√		
Gorgonians (G)	√		√	√	√	√		√	√

OTHER INVERTS	Terumbu Kili	Southern Tip	Pulau Lima	Paku Kecil	Paku Besar	Mak Cantik	Kerengga	Chagar Hutang	Ekor Tebu
Other invertebrates (OT)				√		√	√	√	
Sea Star, Cushion Star (SS)	√								
Sea cucumber (SCU)	√		√	√	√	√	√		
Sea urchins (URC)			√				√		√
Shells (SH)				√			√	√	√
Soft coral (SC)		√	√	√		√	√		√
Sponges (SP)	√	√	√	√	√	√	√	√	√
Zoanthids (Z)		√		√	√		√	√	√

Coral Status at Pulau Perhentian

Pulau Perhentian involves Perhentian Kecil and Perhentian Besar, located at about 20 km from Kuala Besut, Terengganu. This island was also being gazetted as one of Marine Park since 1994. At the North-West from Pulau Perhentian, there's located Pulau Susu Dara and Pulau Rawa.

Some reefs were submerged reefs and some were fringing off-shore reefs. Surveys and data collection were conducted by UMT on 23 to 26 August 2020. Figure 2.17 shows coral condition around Pulau Perhentian at depth of 10 meter, based on Chou et al (1994).

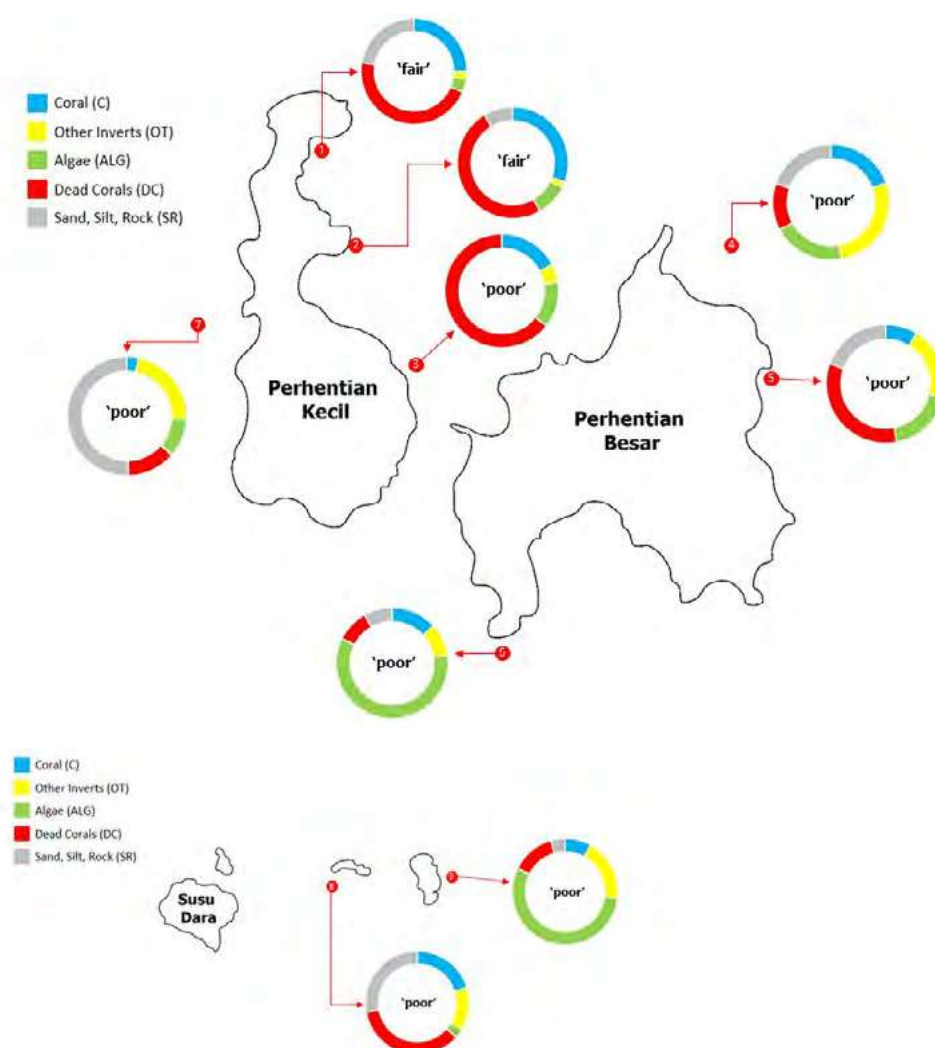


Figure 2.17: Relative percentage cover of biotic and abiotic components around Pulau Perhentian (1 = D'Lagoon, 2 = Batu Nisan, 3 = Turtle Point, 4 = Tanjung Basi, 5 = Terumbu Tiga, 6 = Shark Point, 7 = Seabell, 8 = Tokong Burung, 9 = Pulau Rawa).

Below show most abundance coral genus at each sites, Figure 2.18 to Figure 2.26. From the results, most sites were dominated by *Porites*. The *Porites* were observed to be in two main growth forms, which were massive and plate. Meanwhile, as for other sites, other coral genus dominated the area such as *Diploastrea* at Pulau Rawa, *Acropora* at Shark Point and *Platygyra* at Seabell.

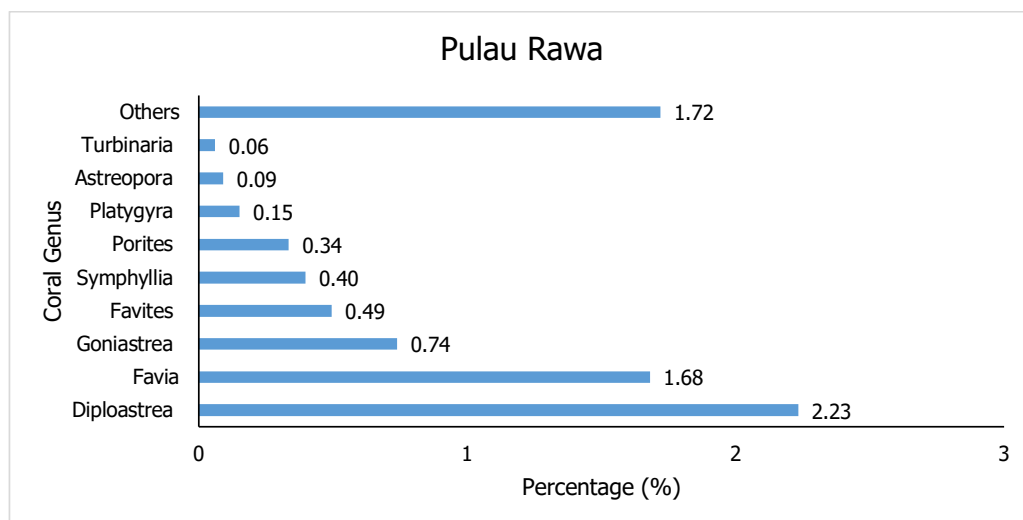


Figure 2.18: Percentage of coral genus identified at Pulau Rawa.

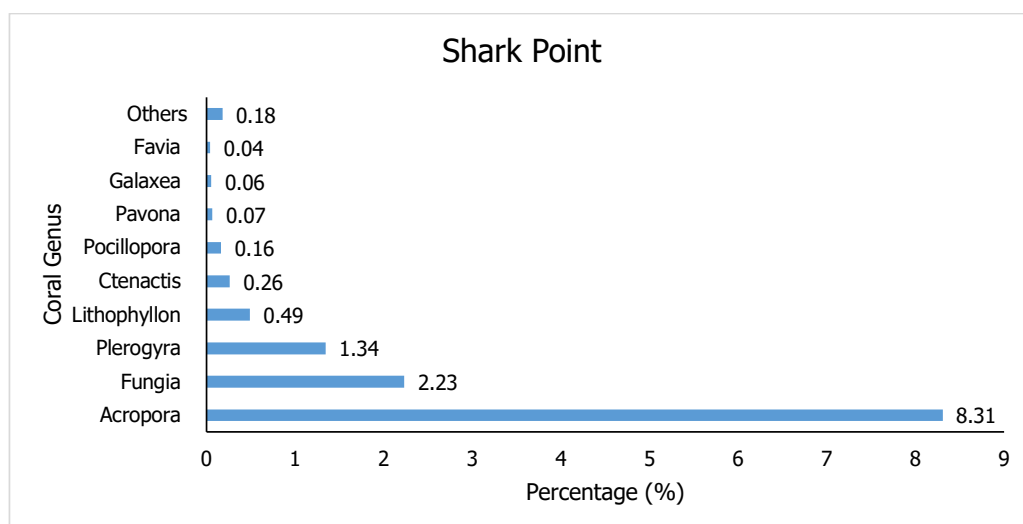


Figure 2.19: Percentage of coral genus identified at Shark Point.

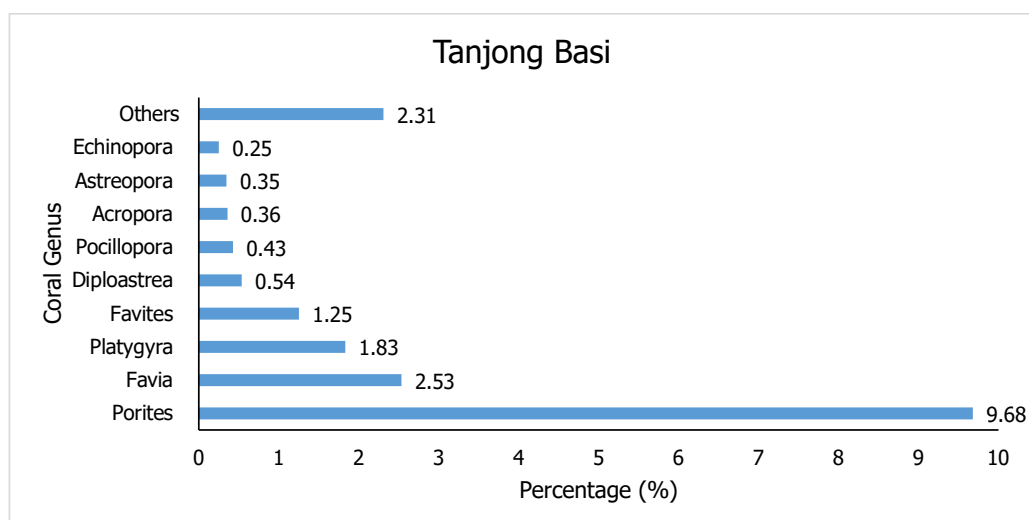


Figure 2.20: Percentage of coral genus identified at Tanjong Basi.

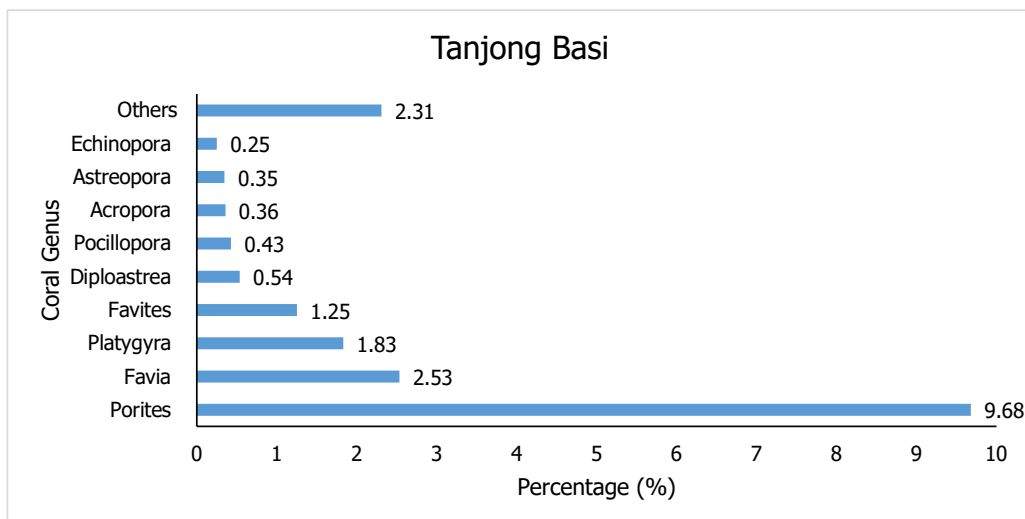


Figure 2.20: Percentage of coral genus identified at Tanjong Basi.

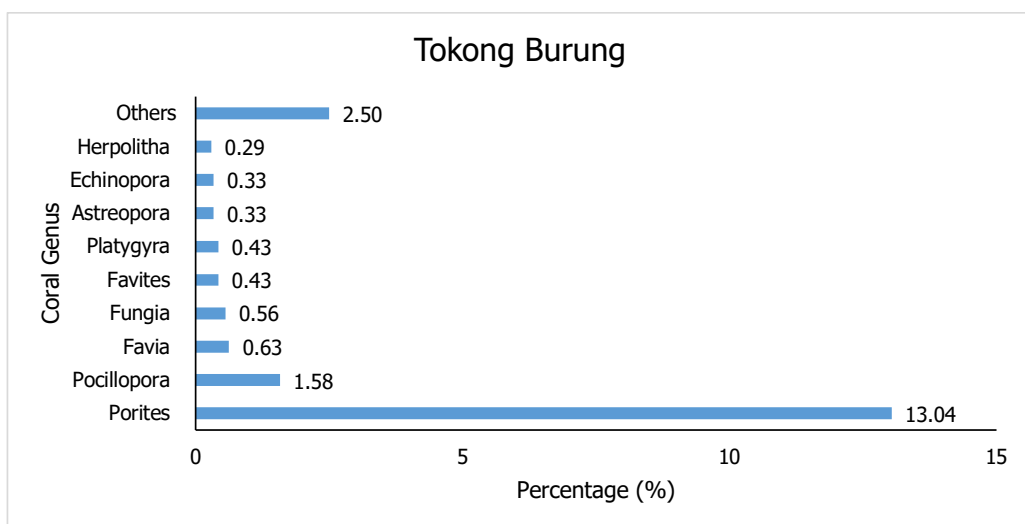


Figure 2.21: Percentage of coral genus identified at Tokong Burung.

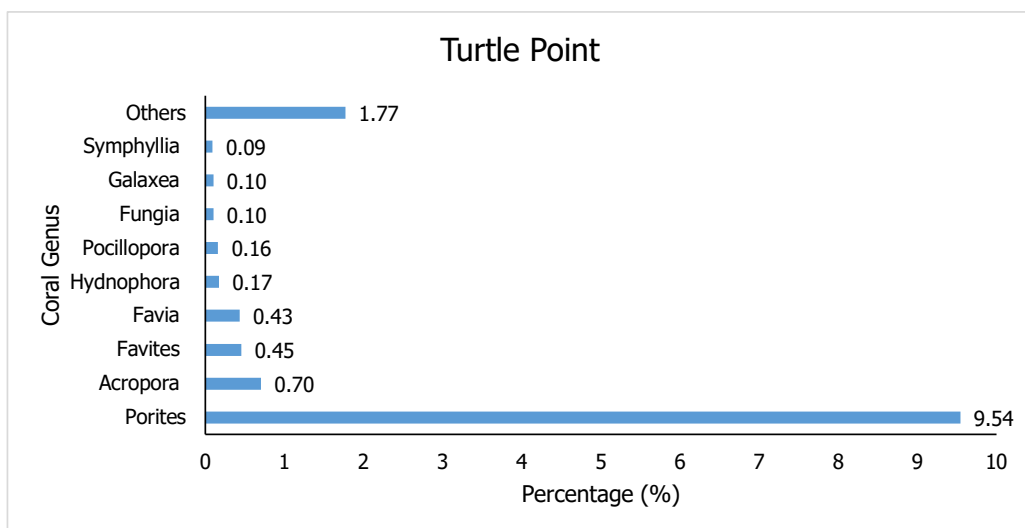


Figure 2.22: Percentage of coral genus identified at Turtle Point.

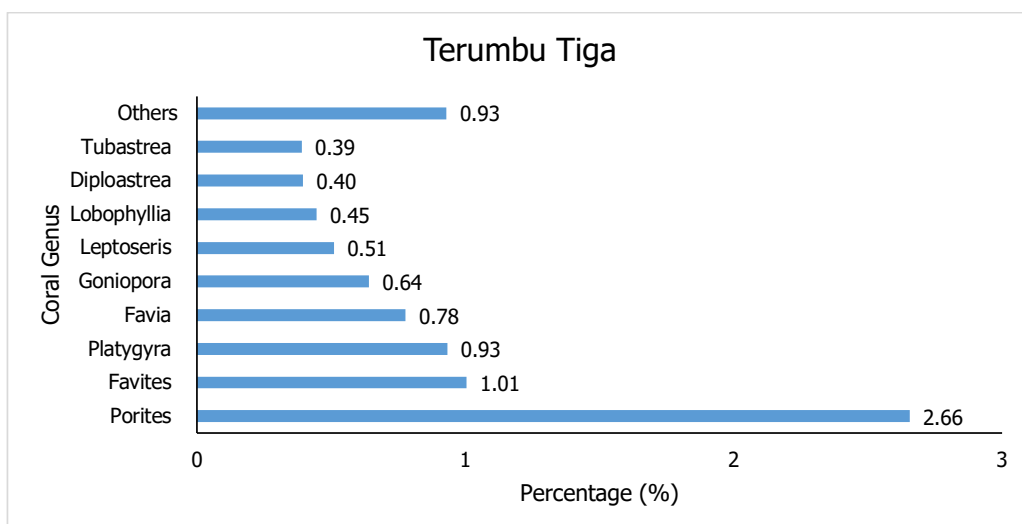


Figure 2.23: Percentage of coral genus identified at Terumbu Tiga.

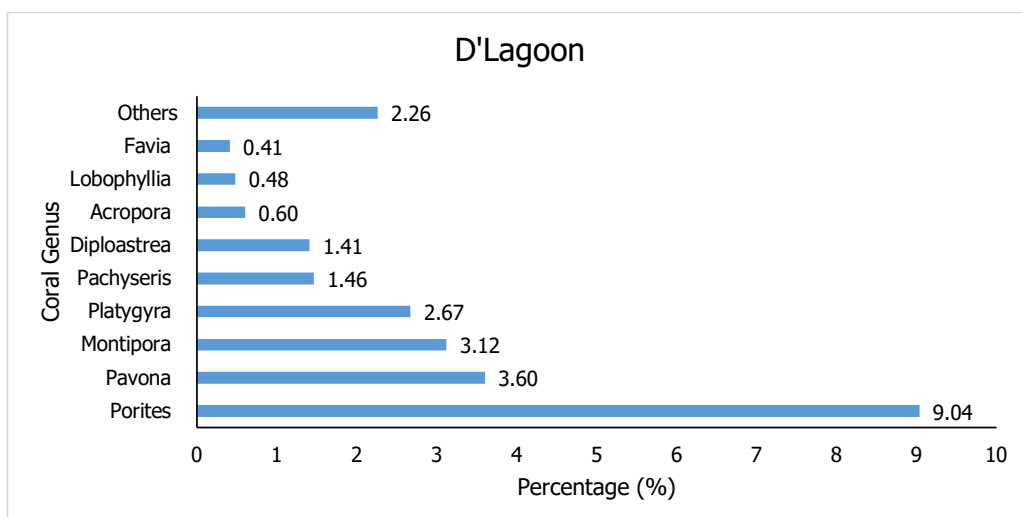


Figure 2.24: Percentage of coral genus identified at D'Lagoon.

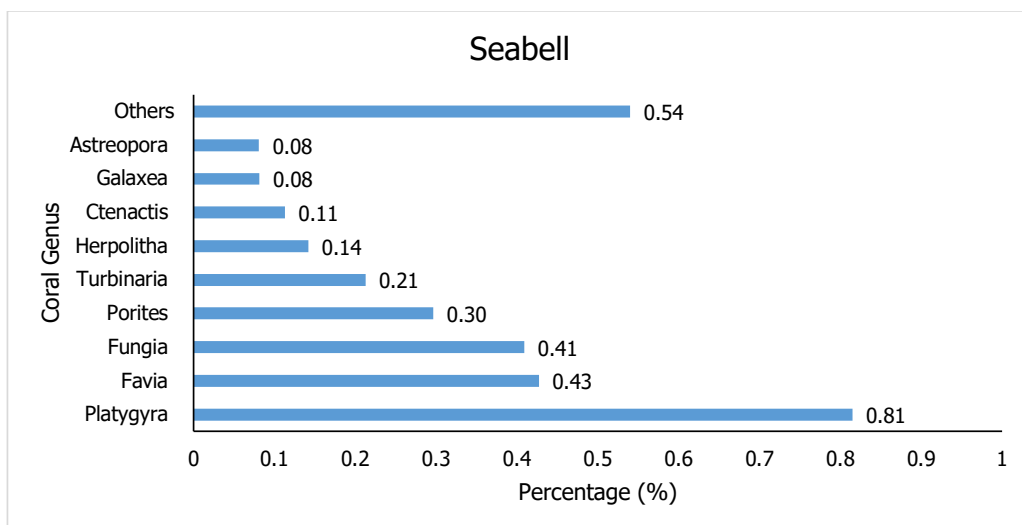


Figure 2.25: Percentage of coral genus identified at Seabell.

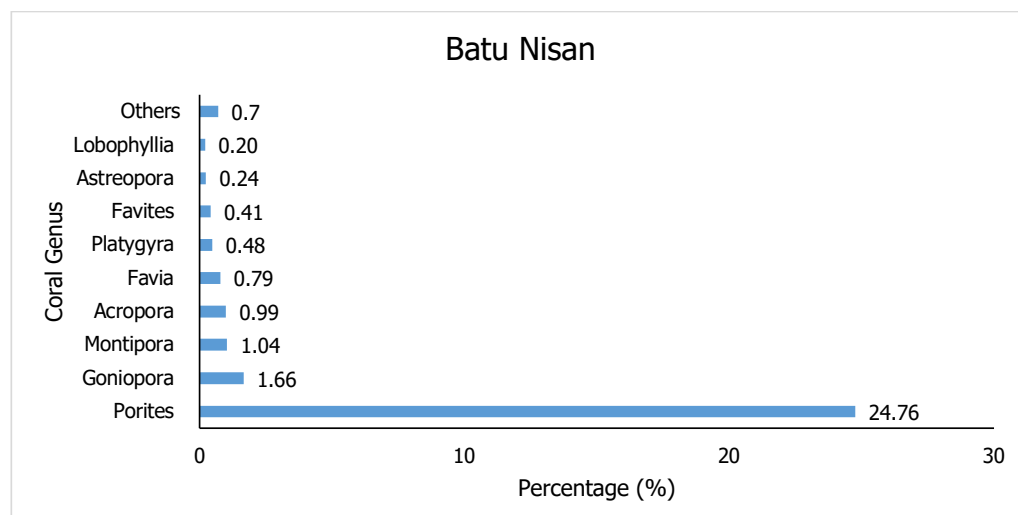


Figure 2.26: Percentage of coral genus identified at Batu Nisan.

Invertebrates at Pulau Perhentian

By referring Table 2.2, Shells (SH) and Sponges (SP) were present at all nine sites around Pulau Perhentian. For SH, most abundance type in this category was scallops that embedded in *Porites* coral. Sponges were present in different growth forms and can withstand harsh environments. Besides that, Crown of Thorns (COT) were spotted along transect at Shark Point and Seabell. Relating to previous data on coral genus abundance, Shark Point was dominated by *Acropora* corals hence it was COT's preferable type of corals. As for in Seabell, COTs were spotted feeding on large a *Turbinaria* coral. Giant Clam (GC) was also been recorded along transect and was found at Turtle Point, D'Lagoon and Batu Nisan.

Table 2.2: Invertebrates found in Coral Video Transect at sites surveyed around Pulau Perhentian.

OTHER INVERTS	Pulau Rawa	Shark Point	Tanjung Basi	Tokong Burung	Turtle Point	Terumbu Tiga	D'Lagoon	Batu Nisan	Sea Bell
Anemone (AN)			√				√	√	√
Ascidian (ASC)					√	√		√	
Crown of Thorn (COT)		√							√
Giant Clam (GC)					√		√	√	
Gorgonians (G)								√	√
Other invertebrates (OT)	√	√	√	√		√		√	√
Sea Star, Cushion Star (SS)	√			√				√	
Sea cucumber (SCU)	√			√	√		√	√	
Sea urchins (URC)				√	√			√	
Shells (SH)	√	√	√	√	√	√	√	√	√
Soft coral (SC)	√				√	√	√	√	√
Sponges (SP)	√	√	√	√	√	√	√	√	√
Zoanthids (Z)	√		√	√					√

Coral Status at Pulau Kapas

Pulau Kapas is located about 6 km from Marang, Terengganu. This island was gazetted as Marine Park since 1994. Surveys and data collection were conducted on 22 to 23 September 2020 around Kapas Island. Figure 2.27 shows the coral condition based on Chou et al (1994).

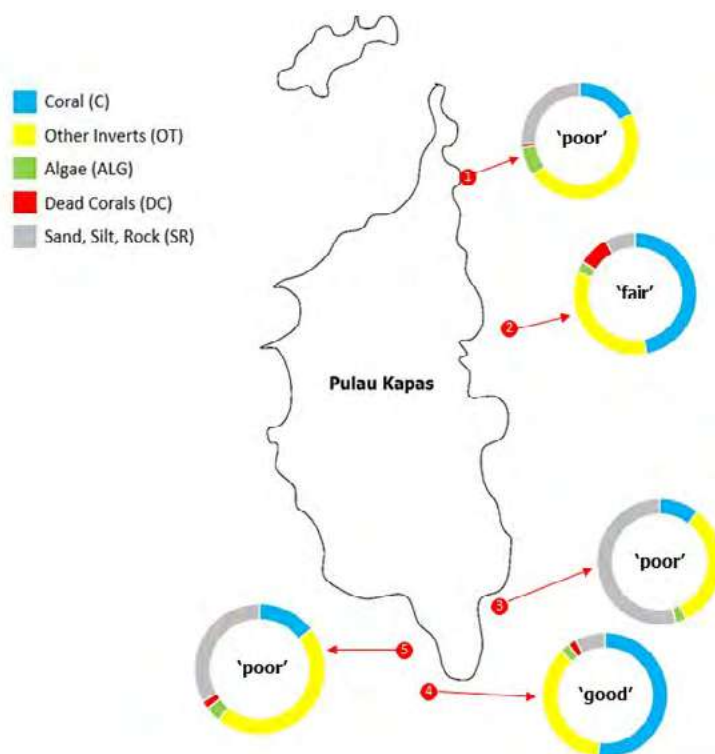


Figure 2.27: Relative percentage cover of biotic and abiotic components around Pulau Kapas (1 = Silent Reef, 2 = Kapas Tengah, 3 = Nudi Rock, 4 = Teluk Jawa, 5 = Southern Tip).

At depth of 10 meter, one site which was Teluk Jawa, categorized as 'good' with more than 50% live coral cover. Silent Reef, Nudi Rock and Southern Tip were categorized as 'poor' with less than 18% of live coral cover, and recorded high percentage of Sand, Silt and Rock (SR). Low substrates availability would limit the chance for coral juveniles' recruitment. Meanwhile, Kapas Tengah was categorized as 'fair', having 46.91% of live coral cover. Percentage of dead corals (DC) were low in all sites around Pulau Kapas. Overall, invertebrates at all sites surveyed were in good percentage.

As shown in Figure 2.28 to 2.32, different coral genus dominated different sites. *Favia* dominated Silent Reef and Nudi Rock, while *Porites* dominated Kapas Tengah and Southern Tip. As for Teluk Jawa, *Galaxea* is the most abundance coral genus. No branching coral dominates sites surveyed, all sites seems have higher abundance of massive corals hence may endure rough weather such as monsoon, strong current and storms.

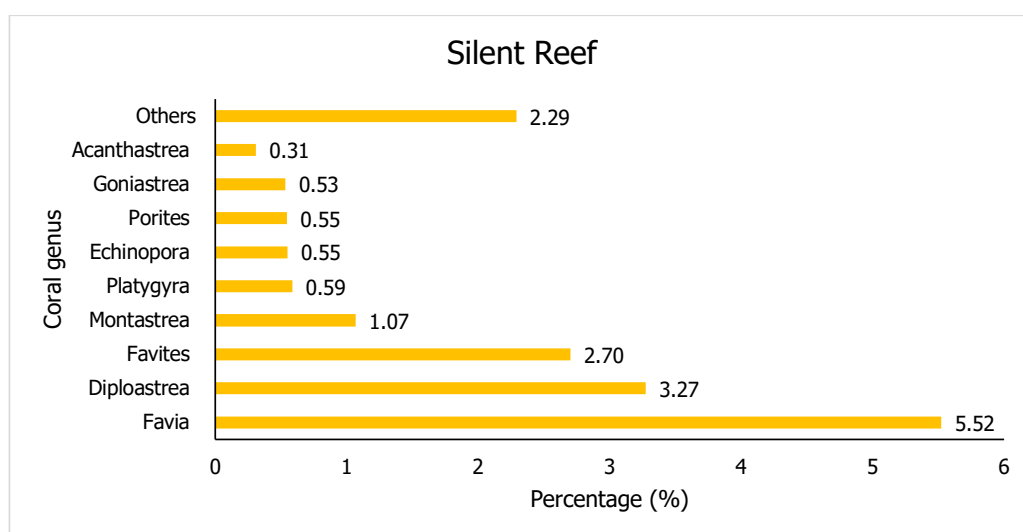


Figure 2.28: Percentage of coral genus identified at Silent Reef.

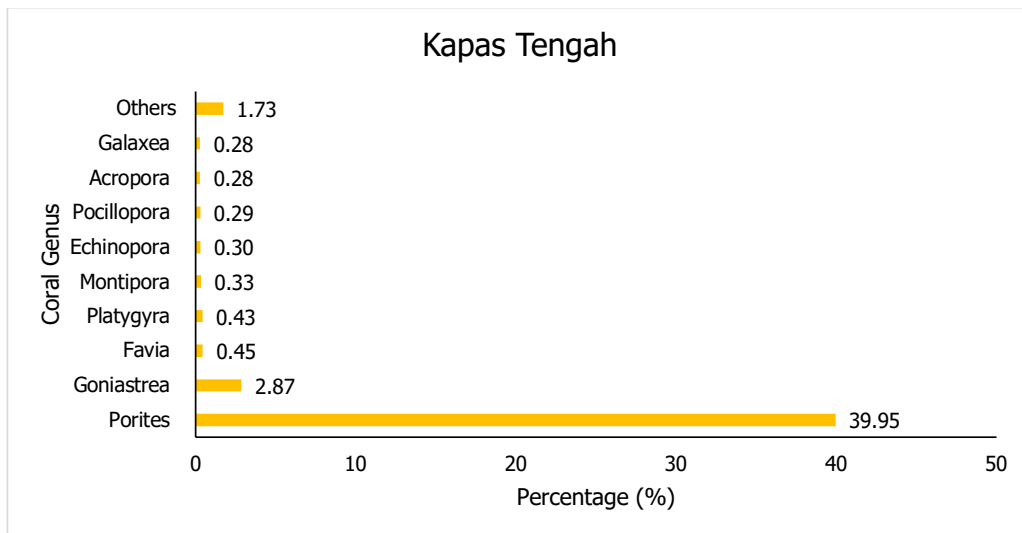


Figure 2.29: Percentage of coral genus identified at Kapas Tengah.

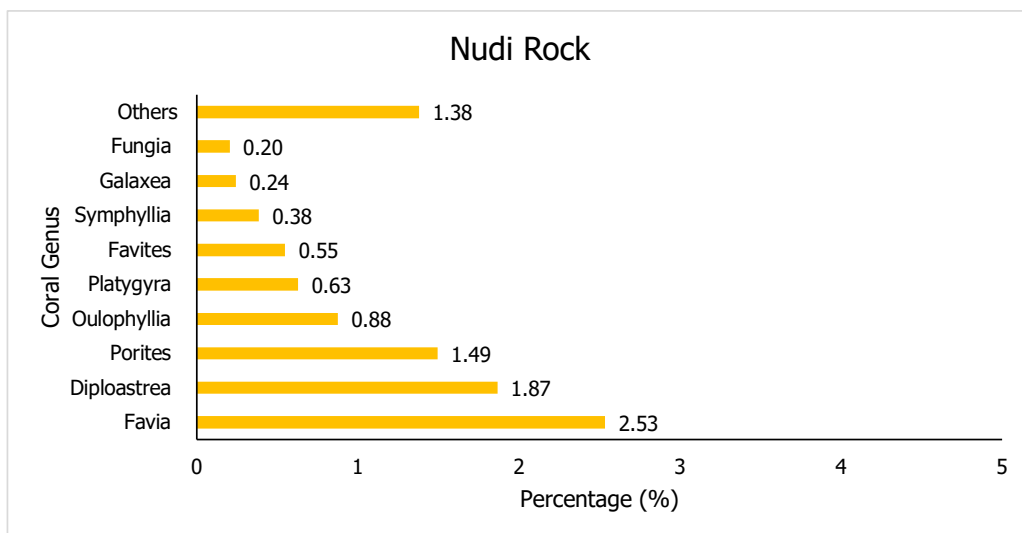


Figure 2.30: Percentage of coral genus identified at Nudi Rock.

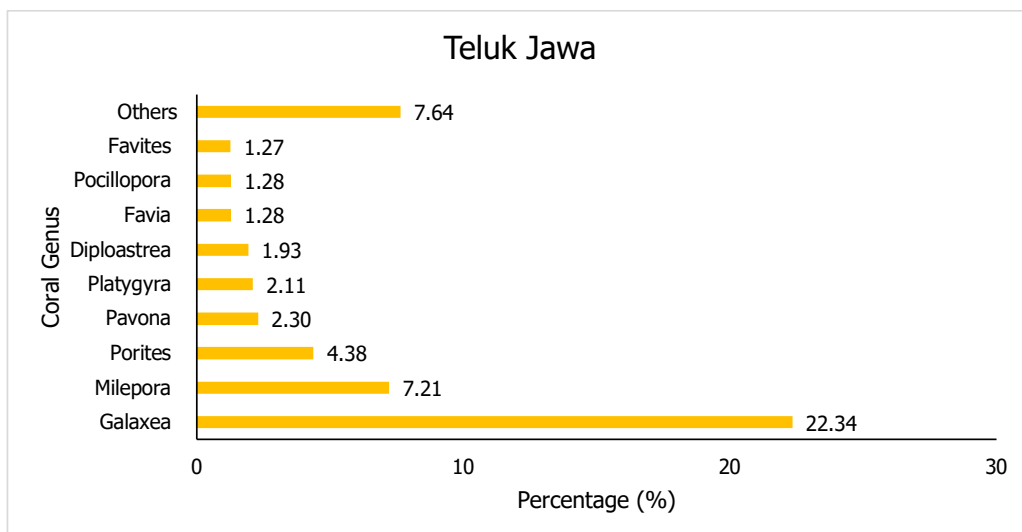


Figure 2.31: Percentage of coral genus identified at Teluk Jawa.

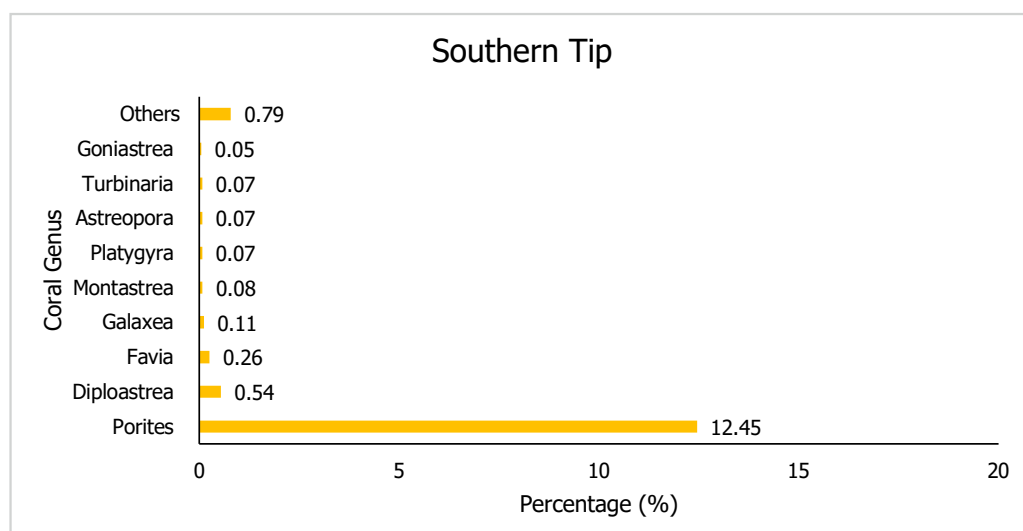


Figure 2.32: Percentage of coral genus identified at Southern Tip.

Invertebrates at Pulau Kapas

Based on results of coral condition around Pulau Kapas (Figure 2.27), percentage of invertebrates were in good condition. Table 3 shows invertebrates found at each sites surveyed. From the table, Soft Coral (SC), Sponge (SP) and Zoanthids (Z) were present at all five sites. Crown of Thorns (COT) and Sea Urchin (URC) were only found at Southern Tip within the transect area.

Table 2.3: Invertebrates found in Coral Video Transect at sites surveyed around Pulau Kapas.

OTHER INVERTS	Silent Reef	Kapas Tengah	Nudi Rock	Teluk Jawa	Southern Tip
Anemone (AN)		√			
Ascidian (ASC)					
Crown of Thorn (COT)					√
Giant Clam (GC)					
Gorgonians (G)					
Other invertebrates (OT)	√	√	√	√	√
Sea Star, Cushion Star (SS)					
Sea cucumber (SCU)		√			√
Sea urchins (URC)					√
Shells (SH)		√			
Soft coral (SC)	√	√	√	√	√
Sponges (SP)	√	√	√	√	√
Zoanthids (Z)	√	√	√	√	√

Coral Status at Pulau Tenggol

Another island, Pulau Tenggol was been gazetted as Marine Park in 1994 and located approximately 30 km from Dungun, Terengganu. This island has few beaches and most reefs were fringing reefs. Survey and data collection were conducted on 12 and 13 October 2020, nearly monsoon season in Terengganu. Five sites were survey (Figure 2.33) and the coral condition were categorized as Chou et al (1994).

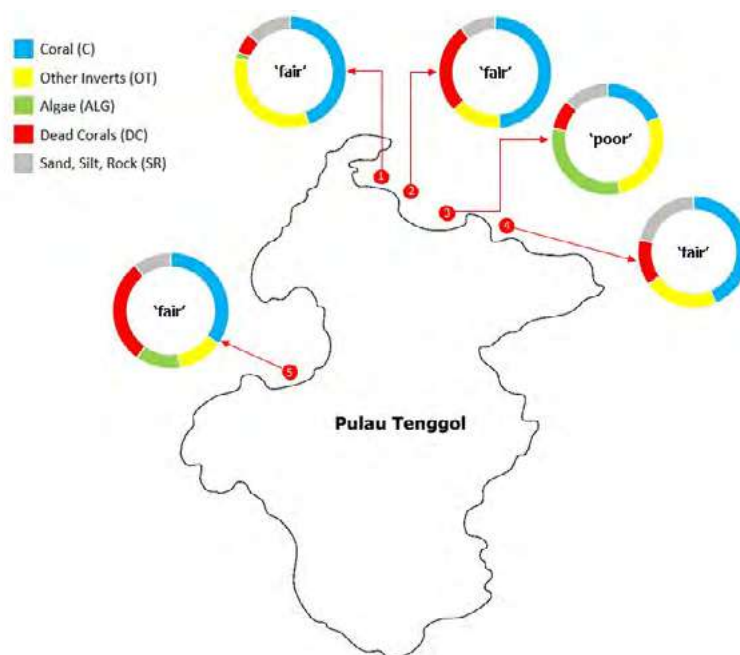


Figure 2.33: Relative percentage cover of biotic and abiotic components around Pulau Tenggol (1 = Teluk Rajawali, 2 = Rajawali, 3 = Sri Nakhkota, 4 = Lost World, 5 = Turtle Point).

From Figure 2.33, four sites around Pulau Tenggol were categorized as 'fair', and only one site was categorized as 'poor' which was Sri Nakhkota with 18.57% of live coral cover. At Sri Nakhkota, percentage of algae was the highest. As algae high, less corals would recruit with less substrate available. The other four sites, even at depth of 10 meter, the live coral cover were good with minimum record of 34.24% at Turtle Point.

Figure 2.34 to Figure 2.38 are graphs showing most abundant coral genus by sites around Pulau Tenggol. From five sites surveyed, three sites were dominated by *Porites* coral, which were Lost World, Teluk Rajawali and Sri Nakhkota. At Rajawali, *Galaxea* coral has the highest abundance among all coral genus while Turtle Point was dominated by *Goniopora*.

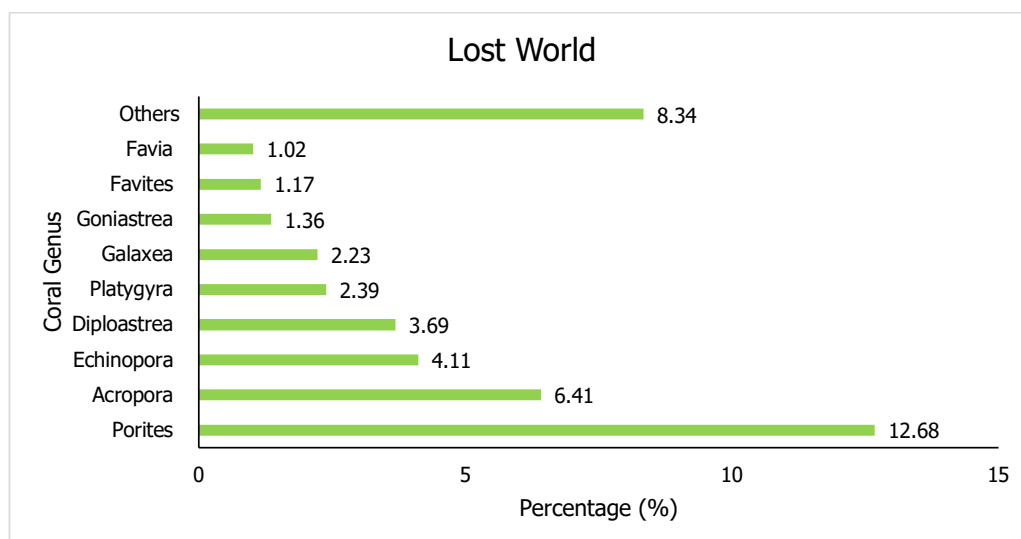


Figure 2.34: Percentage of coral genus identified at Lost World.

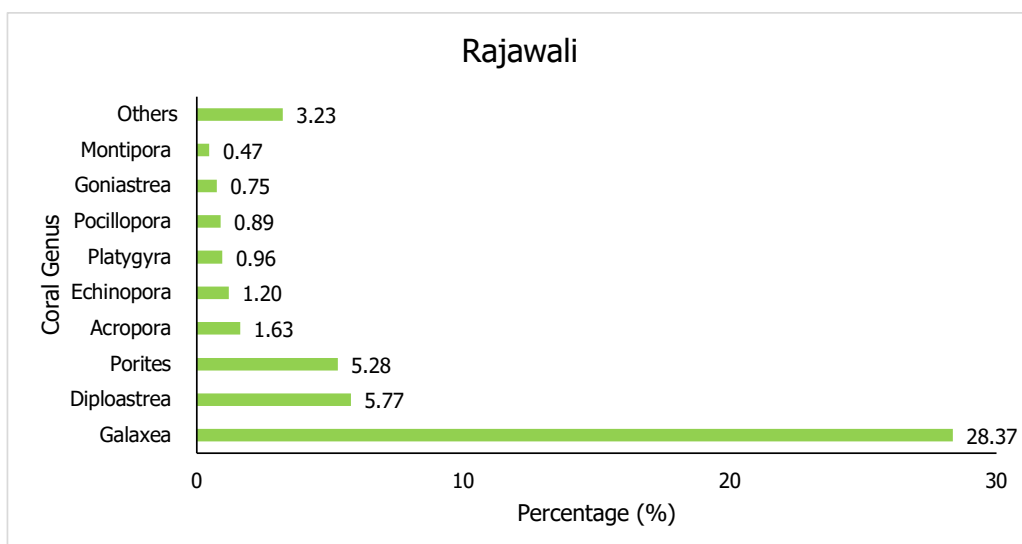


Figure 2.35: Percentage of coral genus identified at Rajawali.

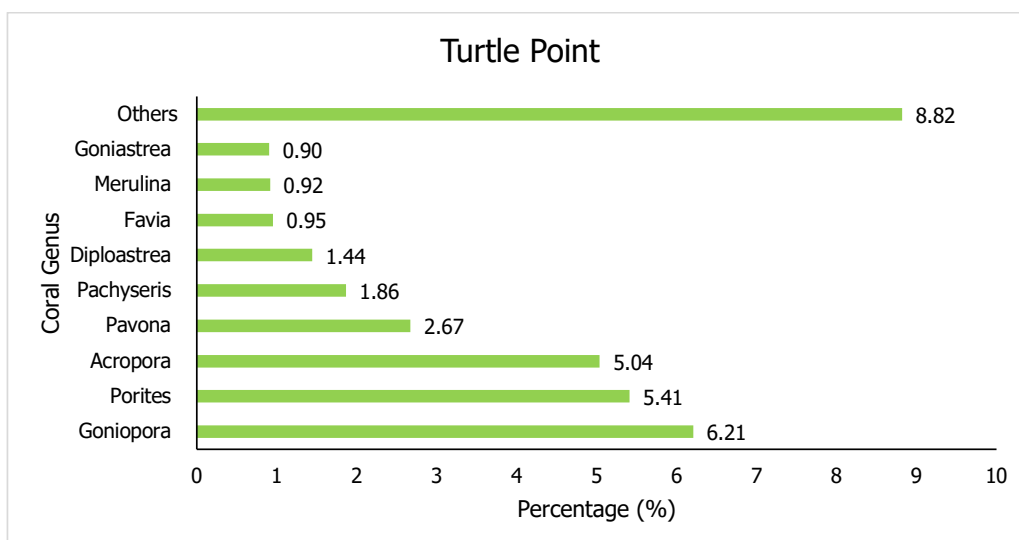


Figure 2.36: Percentage of coral genus identified at Turtle Point.

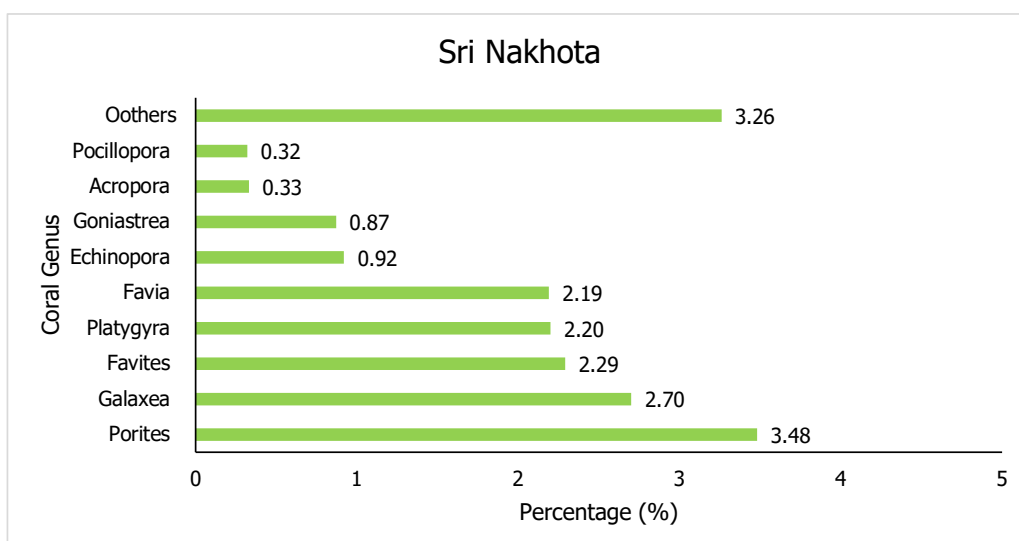


Figure 2.37: Percentage of coral genus identified at Sri Nakhota.

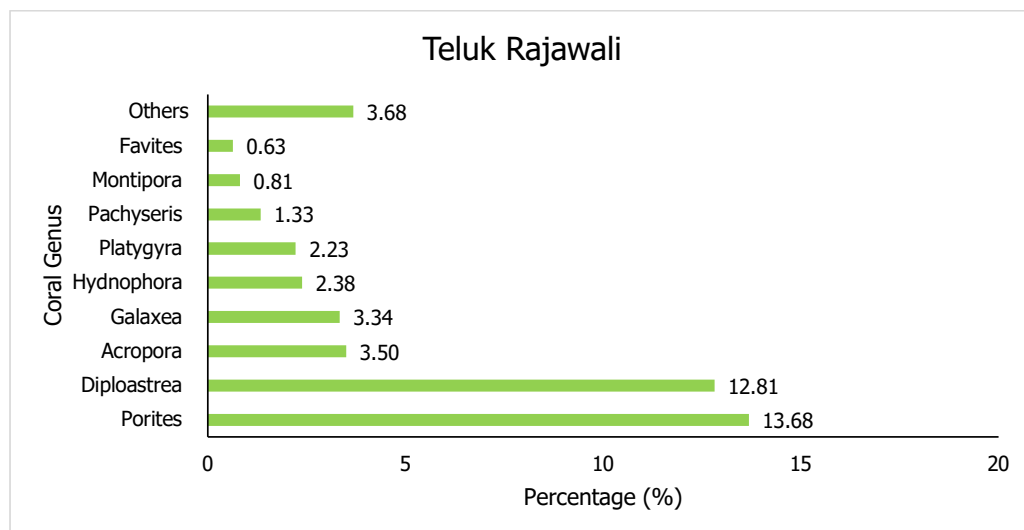


Figure 2.38: Percentage of coral genus identified at Teluk Rajawali.

Invertebrates at Pulau Tenggol

Invertebrates found along transect were varied among sites around Pulau Tenggol. As shown in Table 2.4, Soft Coral (SC) and Sponges (SP) were present at all sites. Soft corals are usually found at areas with high currents. Meanwhile sponges are well known for their ubiquitous and adaptive capability. Zoanthids (Z) were found nearly at all sites except at Lost World. Other invertebrates including nudibranch, hydroids, feather duster worms, Christmas tree worms and others.

Table 2.4: Invertebrates found in Coral Video Transect at sites surveyed around Pulau Tenggol.

OTHER INVERTS	Lost World	Rajawali	Turtle Point	Sri Nakhota	Teluk Rajawali
Anemone (AN)					
Ascidian (ASC)					
Crown of Thorn (COT)					
Giant Clam (GC)					
Gorgonians (G)					
Other invertebrates (OT)	√	√	√	√	√
Sea Star, Cushion Star (SS)			√		
Sea cucumber (SCU)					
Sea urchins (URC)		√			
Shells (SH)					
Soft coral (SC)	√	√	√	√	√
Sponges (SP)	√	√	√	√	√
Zoanthids (Z)		√	√	√	√

2.4 DISCUSSION

Hard corals are the main component in a coral reef ecosystem. Supported by soft corals, sponges, algae, invertebrates and other benthic components in a balance ratio creates a healthy coral reef. Surveys for benthic cover conducted were at 10-meter depth and from in-situ survey, shallower areas have more coral covers. In March 2020, pandemic Covid-19 caused Malaysia faced Movement Control Order (MCO) for few months, hence most of human activities including tourism were stopped.

Surveys and data collection were conducted to observe benthic cover condition after months' absence of high human activities. Among four selected islands around Terengganu, coral condition at Pulau Perhentian was categorized as 'poor' with only 15.74% of live coral cover from all nine sites. Meanwhile, the other three islands which are Pulau Redang, Pulau Kapas and Pulau Tenggol were categorized as 'fair'.

Pulau Perhentian has low percentage of live coral covers during survey in August 2020. Back in early 2019, Pabuk Storm had affected some islands in Terengganu and this included Pulau Perhentian. The storm caused strong current and affected shallow coral areas badly, also caused minor destruction to corals at deeper areas such as 7 to 10-meter depth. This scenario was supported by data of dead corals obtained from August survey (involving dead coral, dead coral with algae and rubbles) with 29.28%. Aside of that, other possible causes of low live coral cover might be due to human activities too (Reef Check Malaysia, 2020).

Pulau Kapas recorded as 'fair' coral condition with 28.14% live coral cover. Based on Reef Check Malaysia (2020), Pulau Kapas was also in 'fair' condition even though sites surveyed were different. However, it was reported that the substrates availability for coral recruitment were high by Reef Check Malaysia hence may give high chance for corals to grow and recover in few years' time. During the survey as well, invertebrates' percentage were high involving sponges, soft corals, zonthids, nudibranch and others. Crown of Thorns (COT) however were spotted in very low percentage, which was found only at Southern Tip of Pulau Kapas. The low percentage of COT was tally with Reef Check Malaysia survey report that stated the population of COT from 2018 to 2020 has decreased. Perhaps in condition of low threats, coral cover in Pulau Kapas will increase slowly in future.

On the other hand, Pulau Redang had 28.43% of live coral cover thus categorized as 'fair' coral condition. According to Reef Check Malaysia (2020), Pulau Redang reefs were deteriorated from 'good' to 'fair' condition due to high abundance of COT in 2016 to 2018, followed by the effect of Pabuk storm in early 2019. The percentage of dead corals was high in July 2020 with 46.11% from all nine sites surveyed around Pulau Redang. However, in 2020 survey, abundance of COT was low as spotted only at Southern Tip where high abundance of Acropora corals was recorded at that site. With minimum human activities and less disturbance, coral reefs around Pulau Redang may recover as substrates available for recruitment was high as reported by Reef Check Malaysia (2020).

Lastly, Pulau Tenggol recorded the highest percentage of live coral cover with 37.83% from all five sites surveyed in October 2020. Comparing to Reef Check Malaysia (2020), it was reported that reefs around Pulau Tenggol were categorized as 'good'. Due to strong current during that period, there was limitation in surveying sites. Hence, sites selection was not spread evenly around the island. Furthermore, sites surveyed by Reef Check Malaysia were different. That may lead to different category of coral condition at Pulau Tenggol. Invertebrates abundance was in good percentage, and mainly was soft corals, sponges, and other invertebrates such as sea whips, nudibranch, worms and others. Less disturbance and low human activities lead to higher percentage of coral cover compare to all other islands surveyed. Pulau Tenggol reefs was the healthiest according to data obtained from 2020's surveys.

APPENDICES

Benthic cover around Pulau Redang

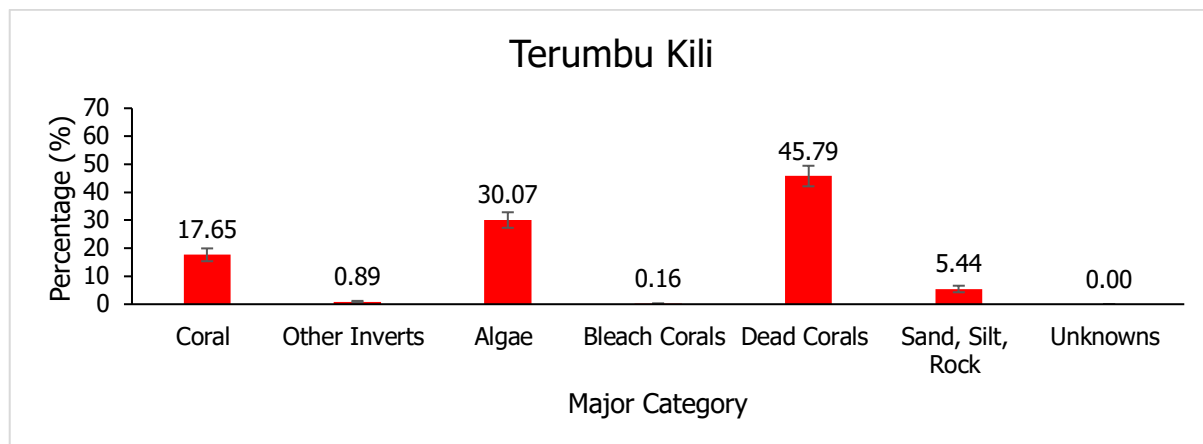


Figure A: Percentage of benthic cover at Terumbu Kili.

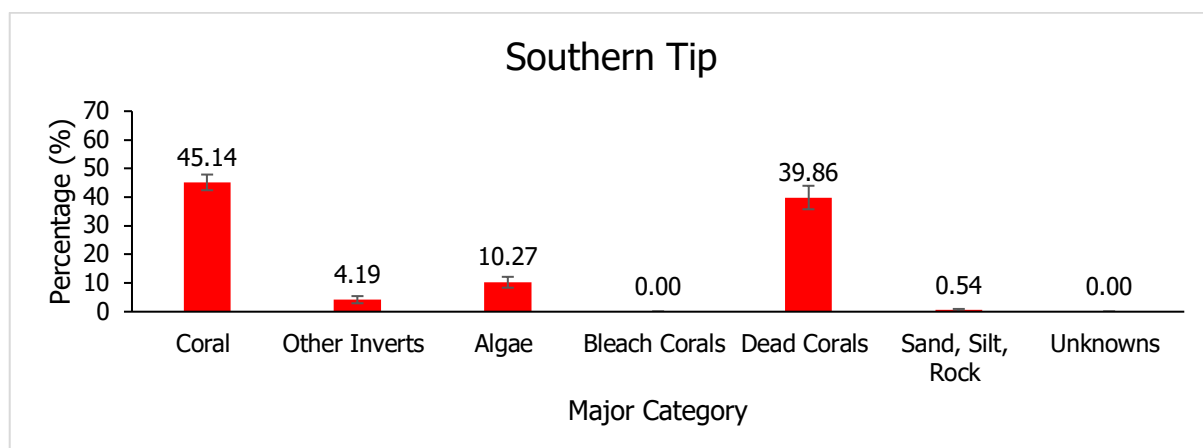


Figure B: Percentage of benthic cover at Southern Tip.

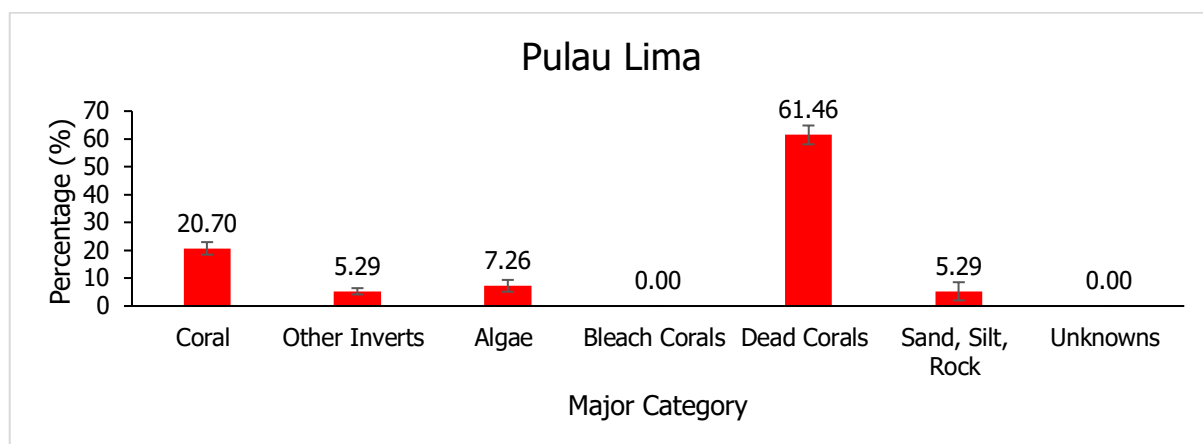


Figure C: Percentage of benthic cover at Pulau Lima.

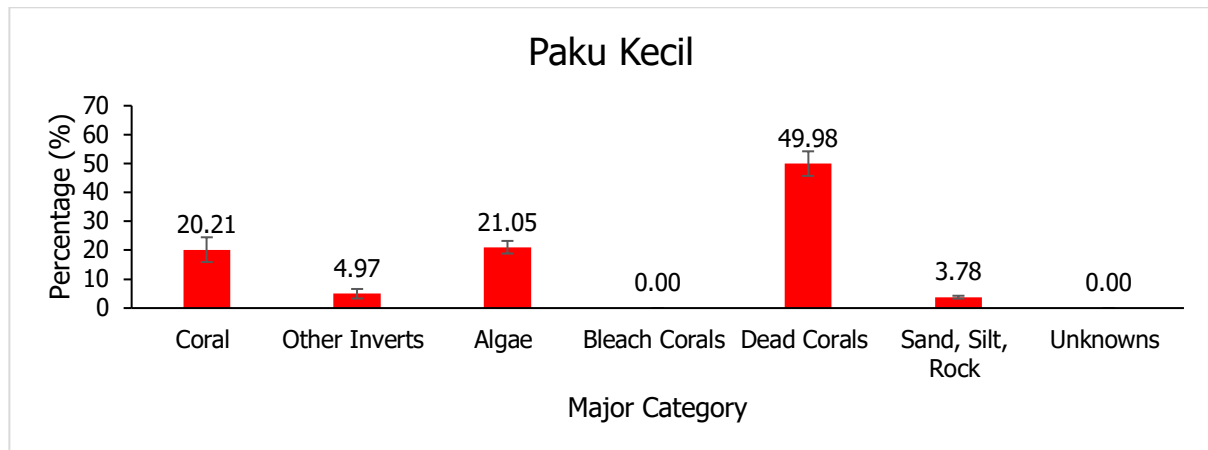


Figure D: Percentage of benthic cover at Paku Kecil.

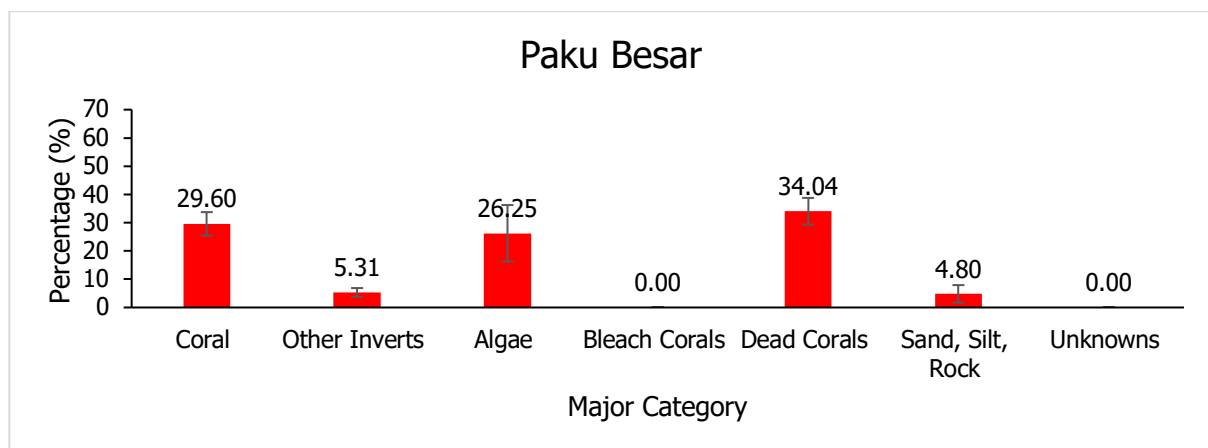


Figure E: Percentage of benthic cover at Paku Besar.

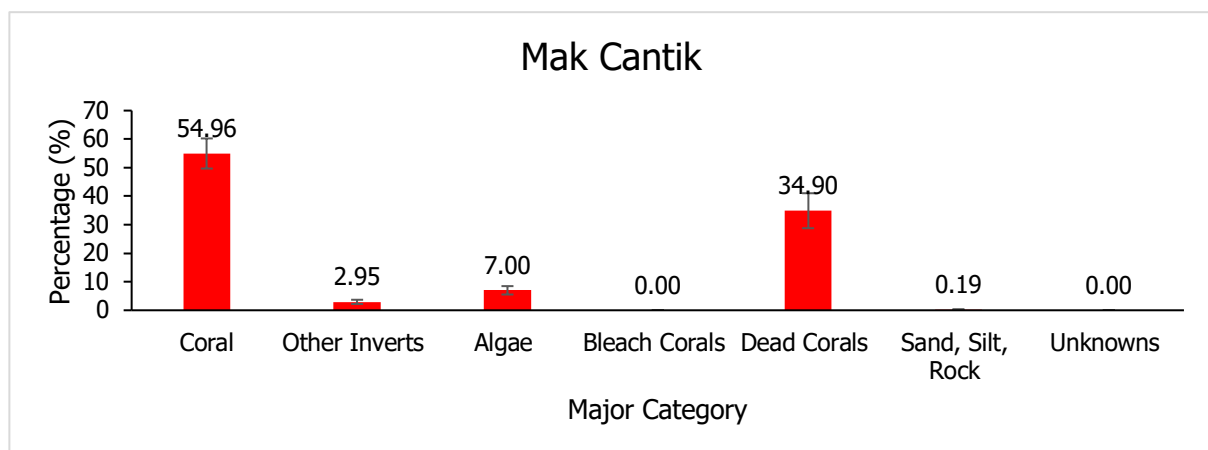


Figure F: Percentage of benthic cover at Mak Cantik.

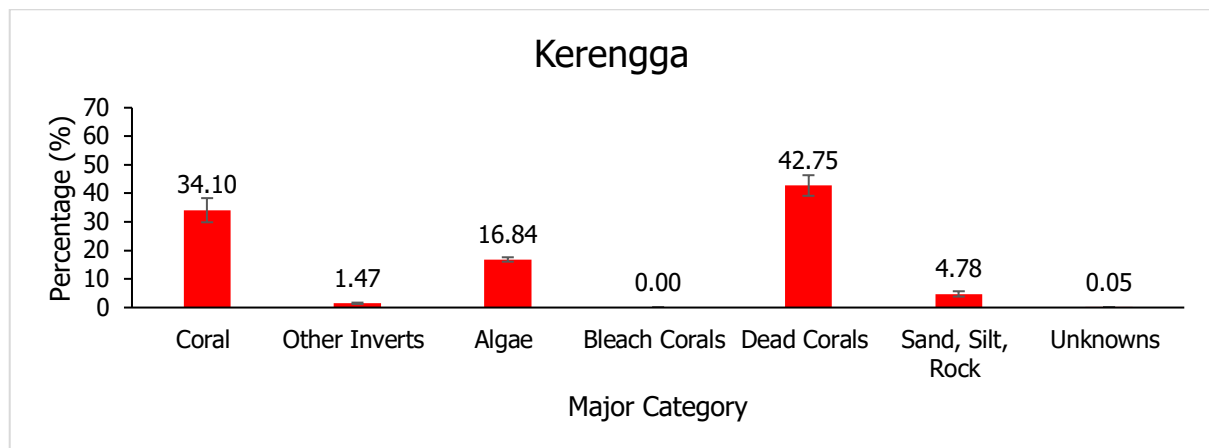


Figure G: Percentage of benthic cover at Kerengga.

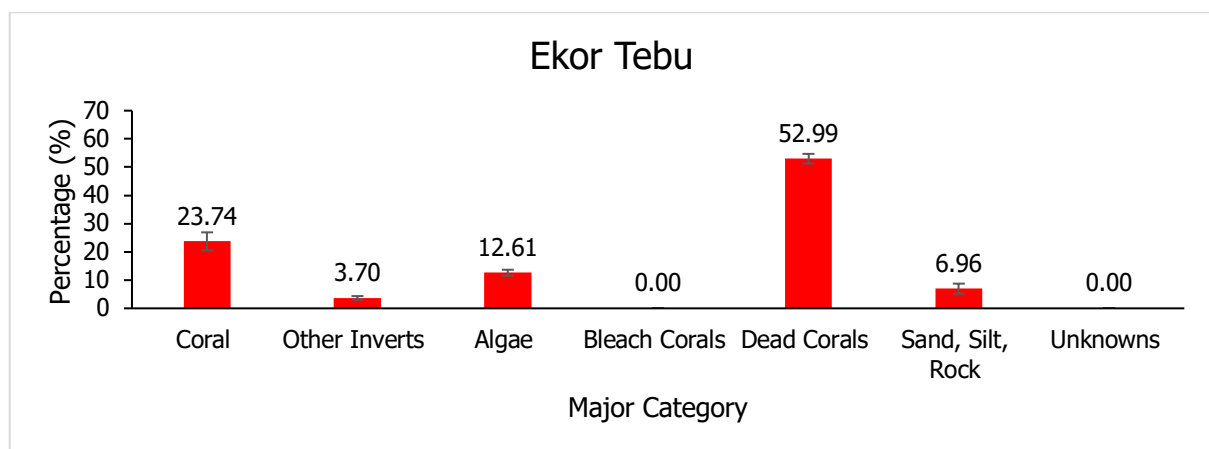


Figure H: Percentage of benthic cover at Ekor Tebu.

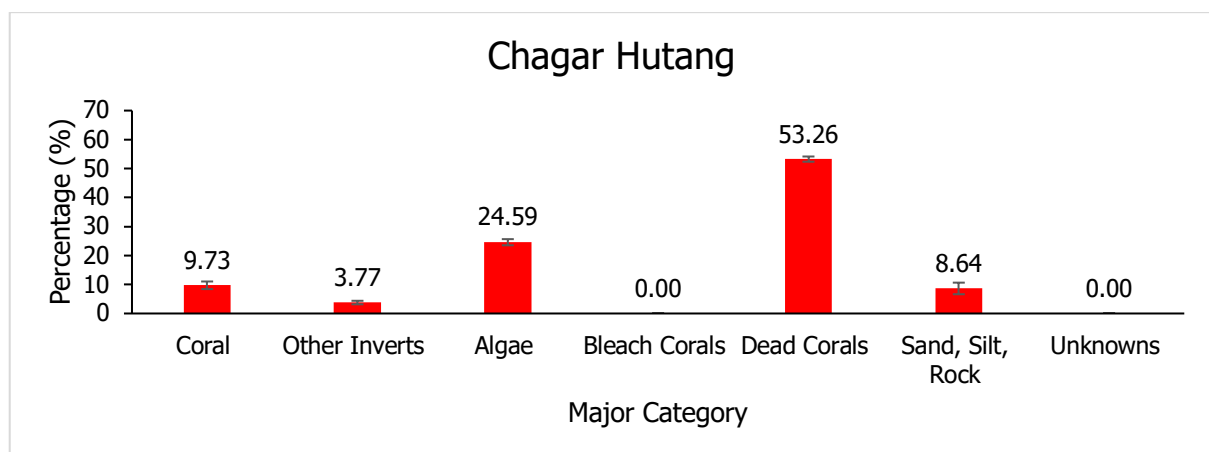


Figure I: Percentage of benthic cover at Chagar Hutang

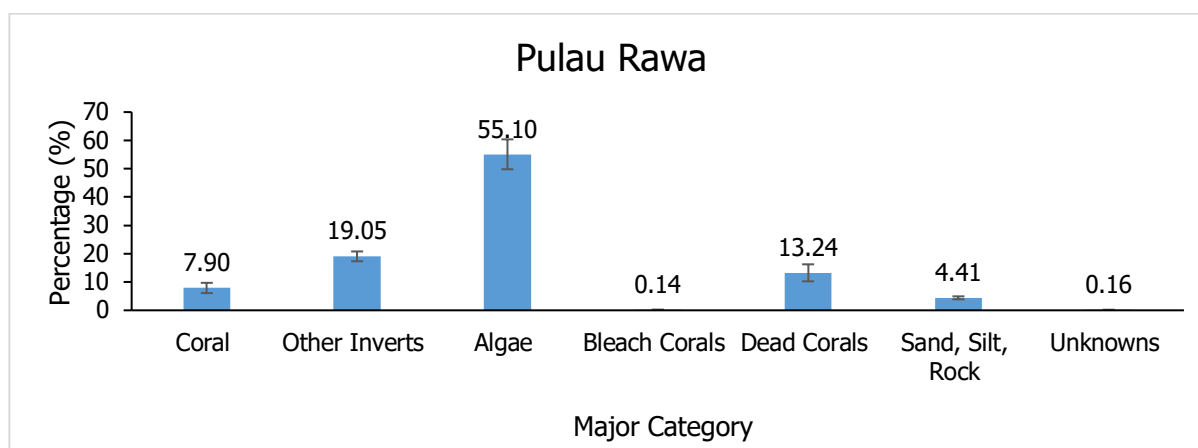
Benthic cover around Pulau Perhentian

Figure J: Percentage of benthic cover at Pulau Rawa.

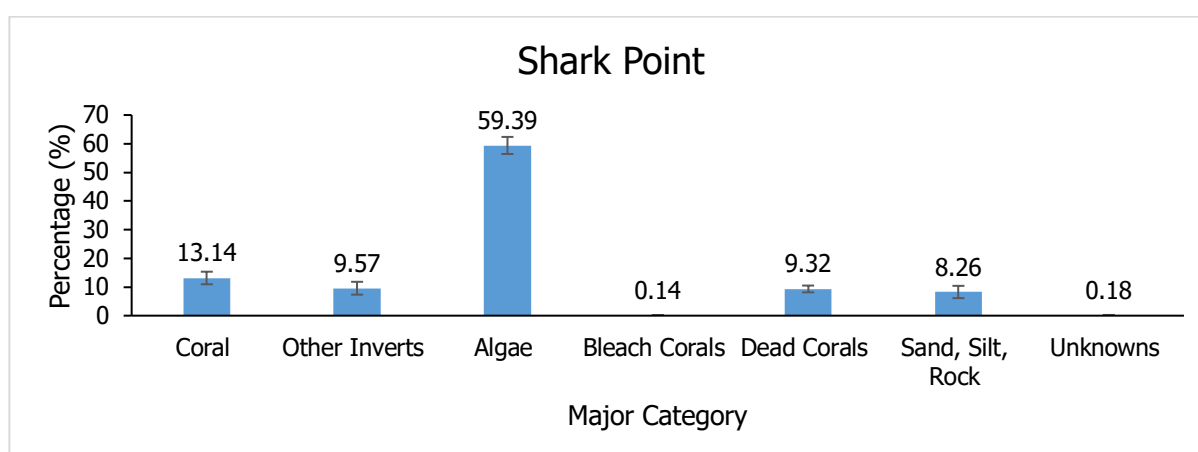


Figure K: Percentage of benthic cover at Shark Point.

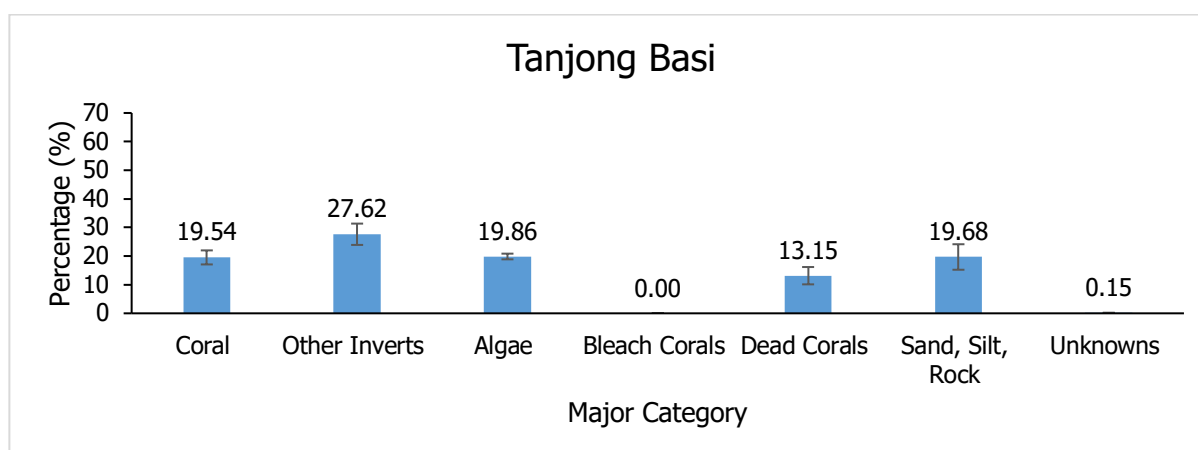


Figure L: Percentage of benthic cover at Tanjong Basi.

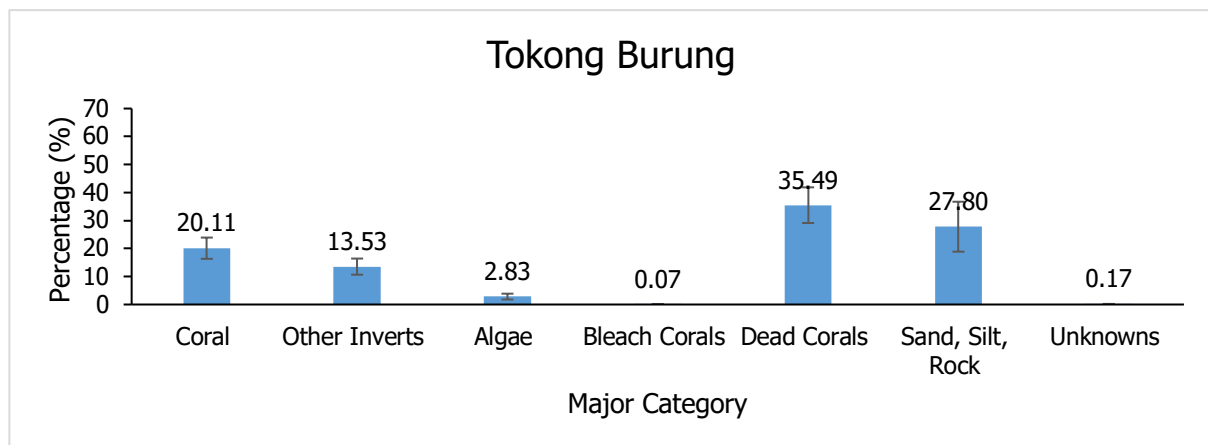


Figure M: Percentage of benthic cover at Tokong Burung.

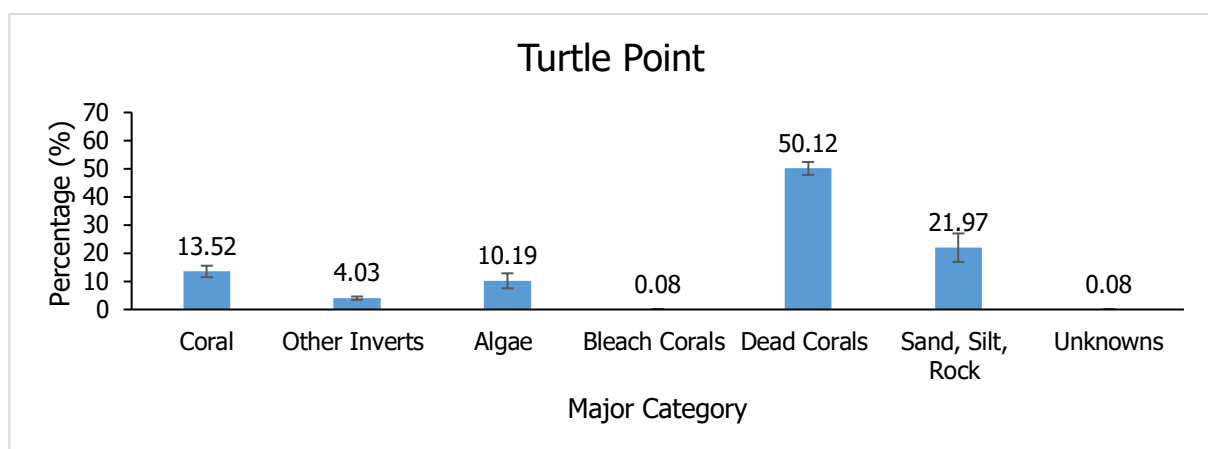


Figure N: Percentage of benthic cover at Turtle Point.

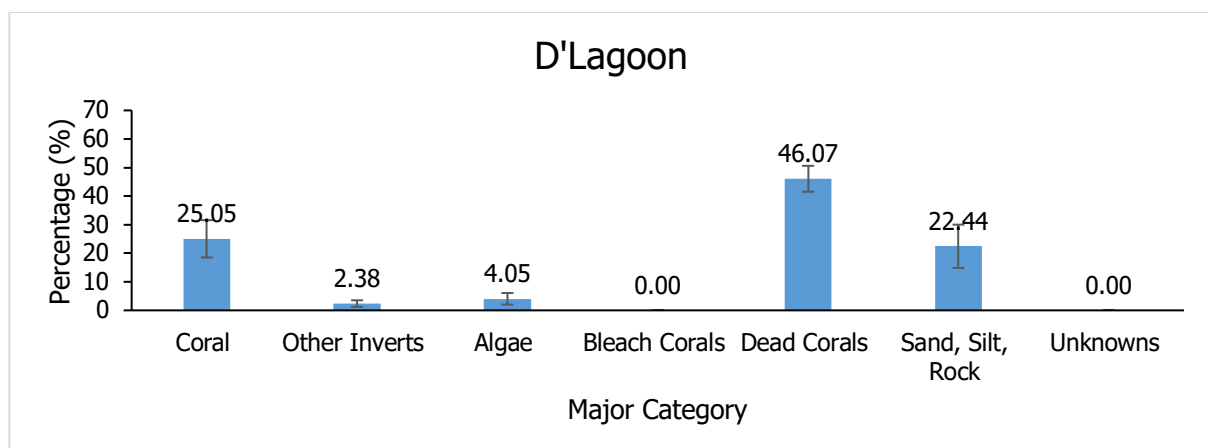


Figure O: Percentage of benthic cover at D'Lagoon.

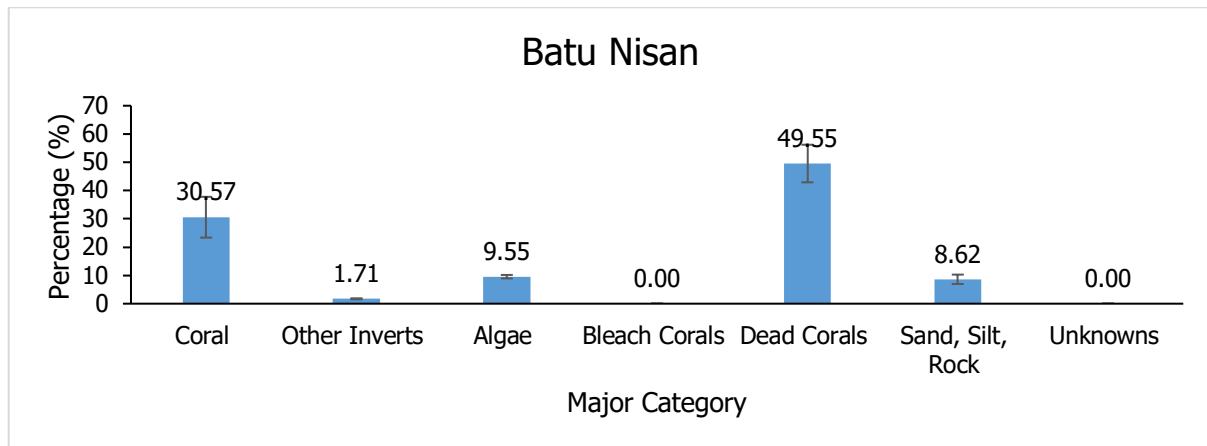


Figure P: Percentage of benthic cover at Batu Nisan.

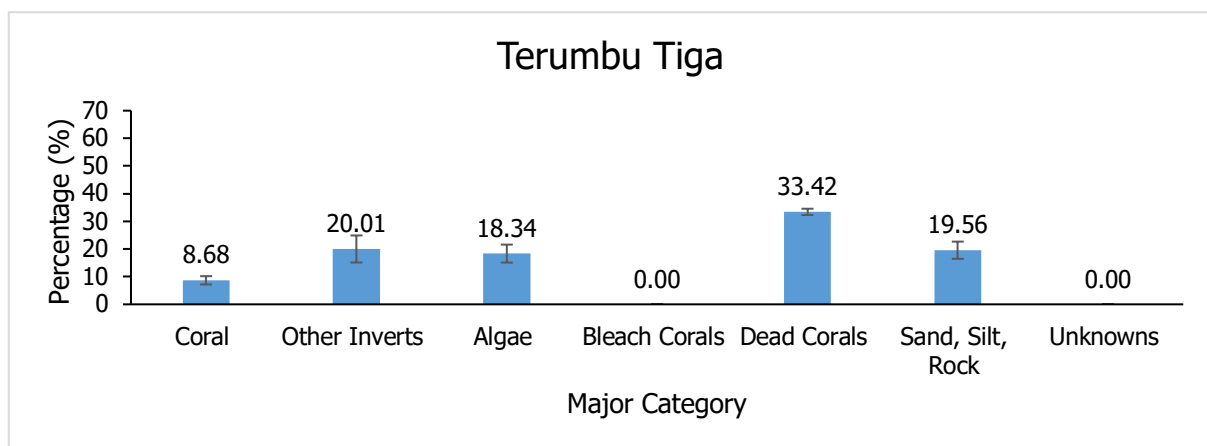


Figure Q: Percentage of benthic cover at Terumbu Tiga.

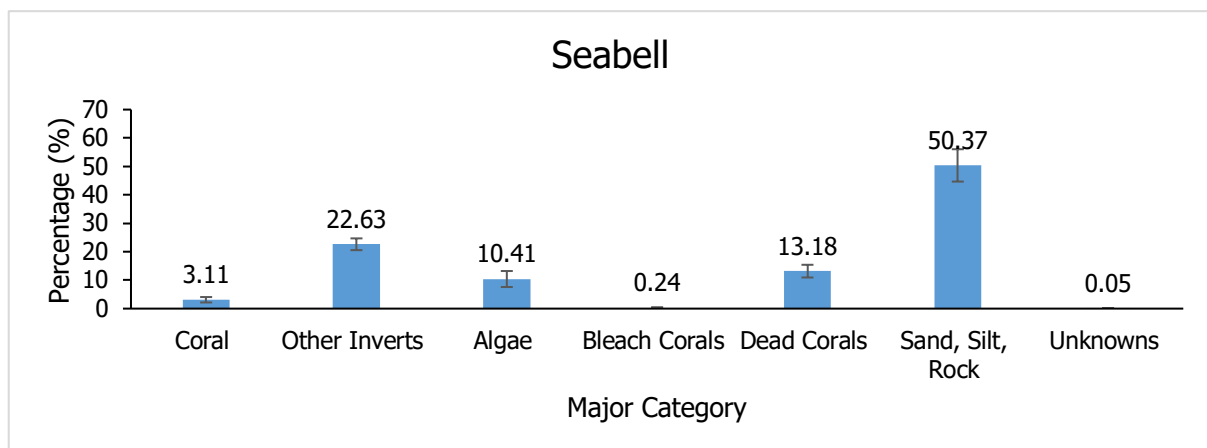


Figure R: Percentage of benthic cover at Seabell.

Benthic cover around Pulau Kapas

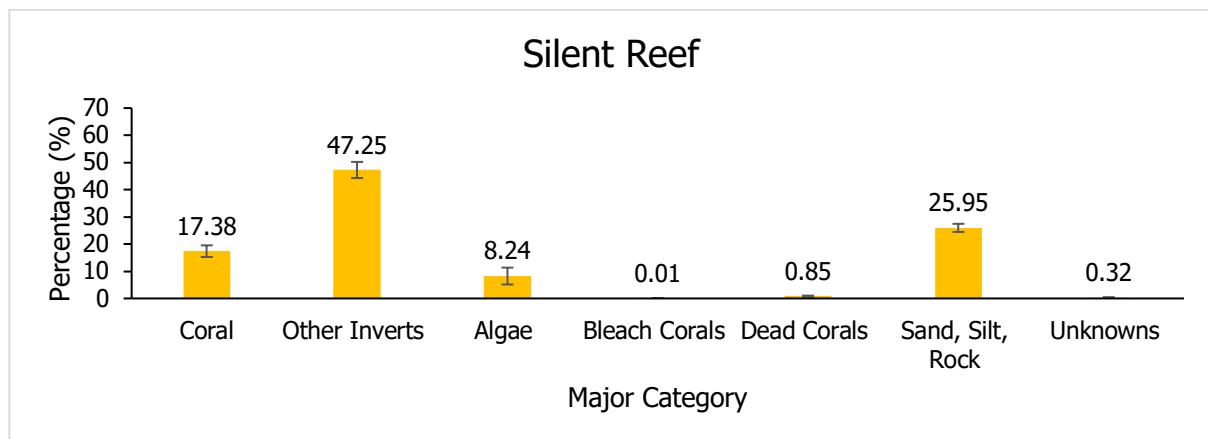


Figure S: Percentage of benthic cover at Silent Reef.

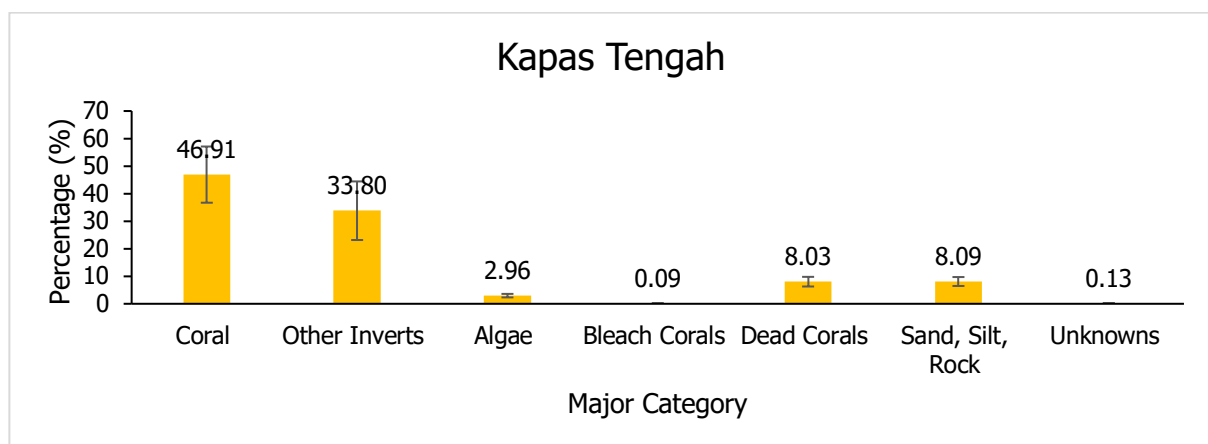


Figure T: Percentage of benthic cover at Kapas Tengah.

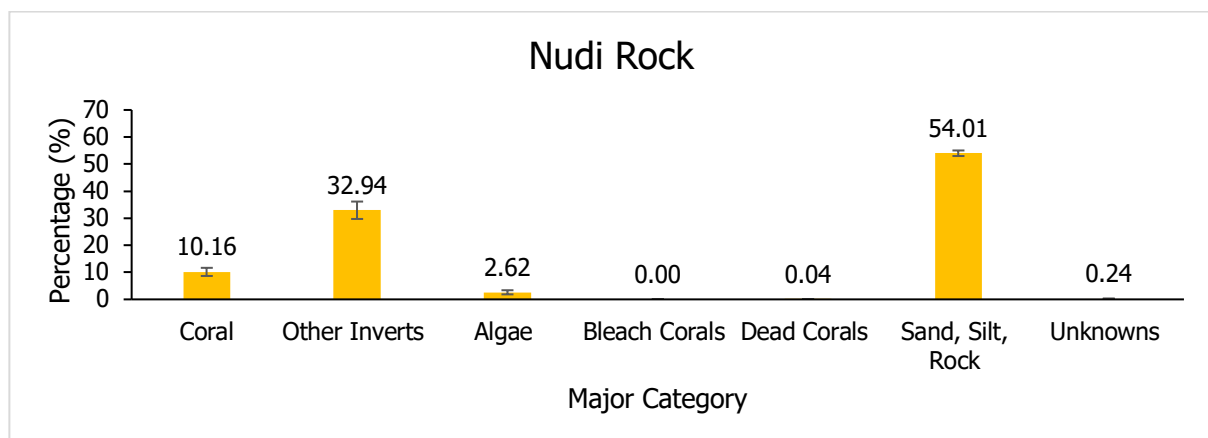


Figure U: Percentage of benthic cover at Nudi Rock.

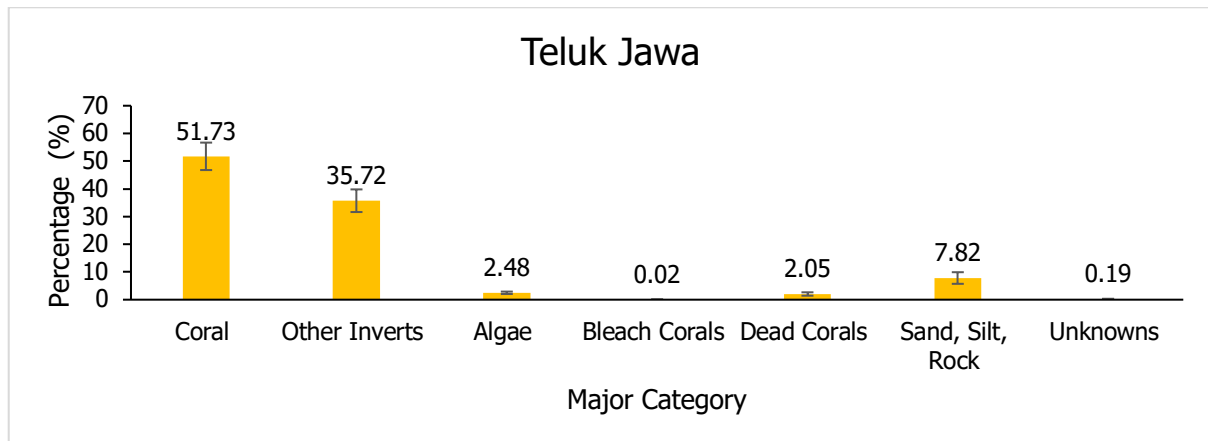


Figure V: Percentage of benthic cover at Teluk Jawa.

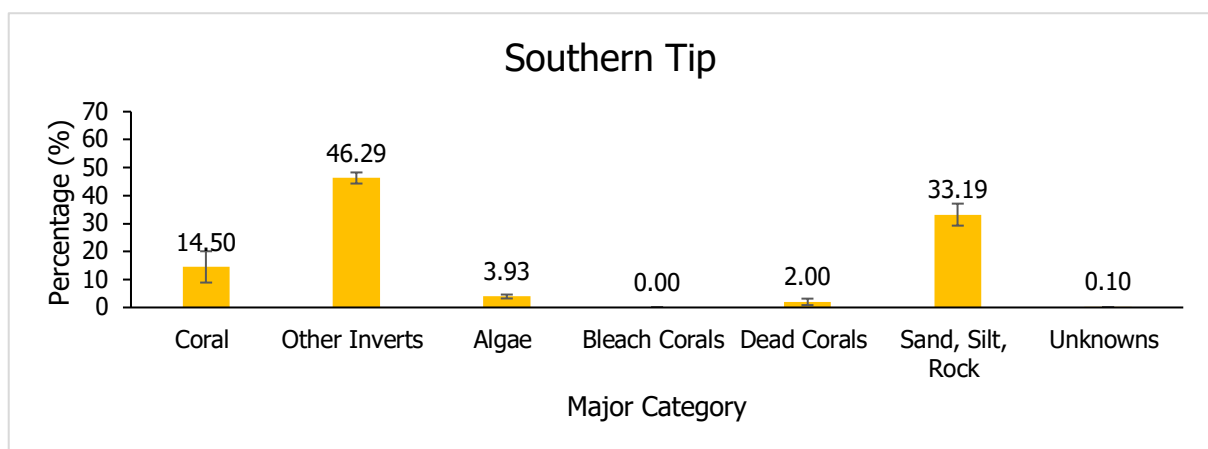


Figure W: Percentage of benthic cover at Southern Tip.

Benthic cover around Pulau Tenggol

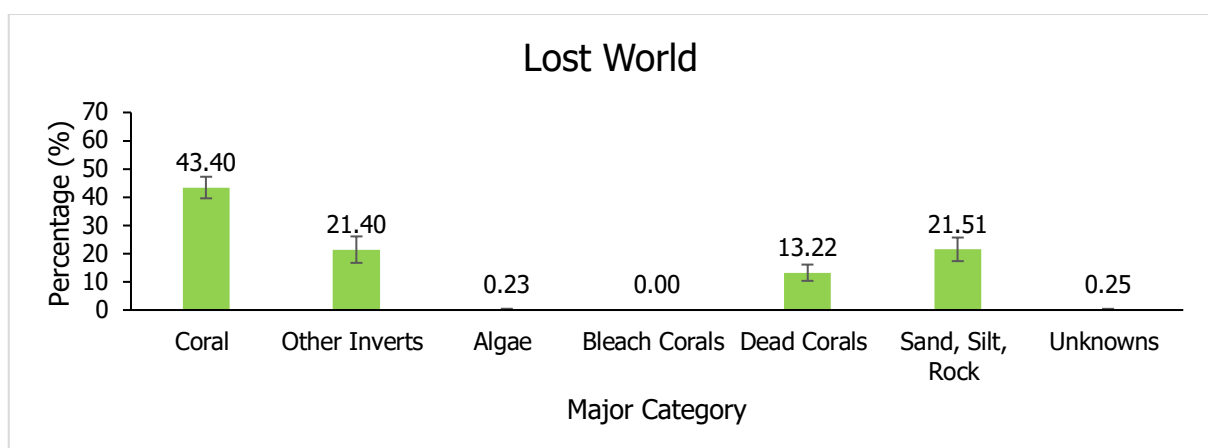


Figure X: Percentage of benthic cover at Lost World.

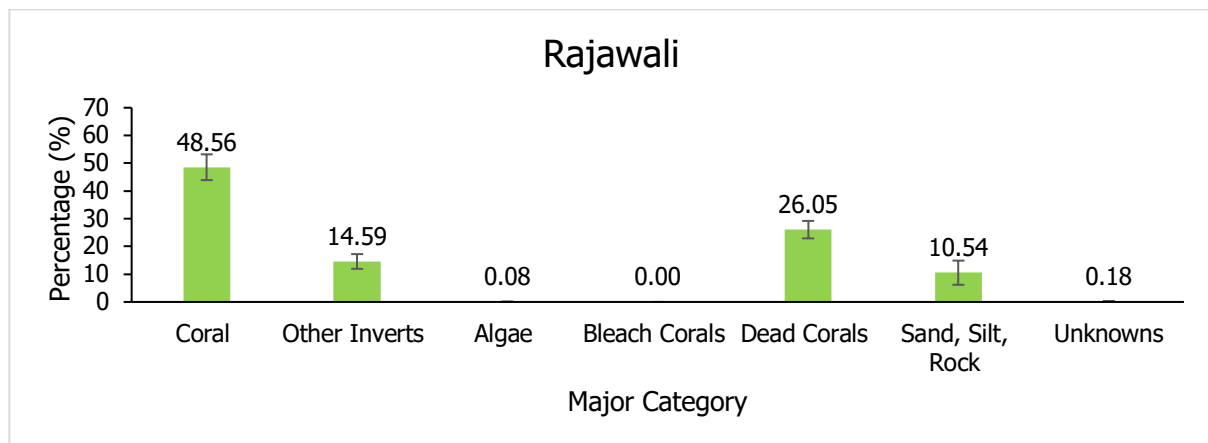


Figure Y: Percentage of benthic cover at Rajawali.

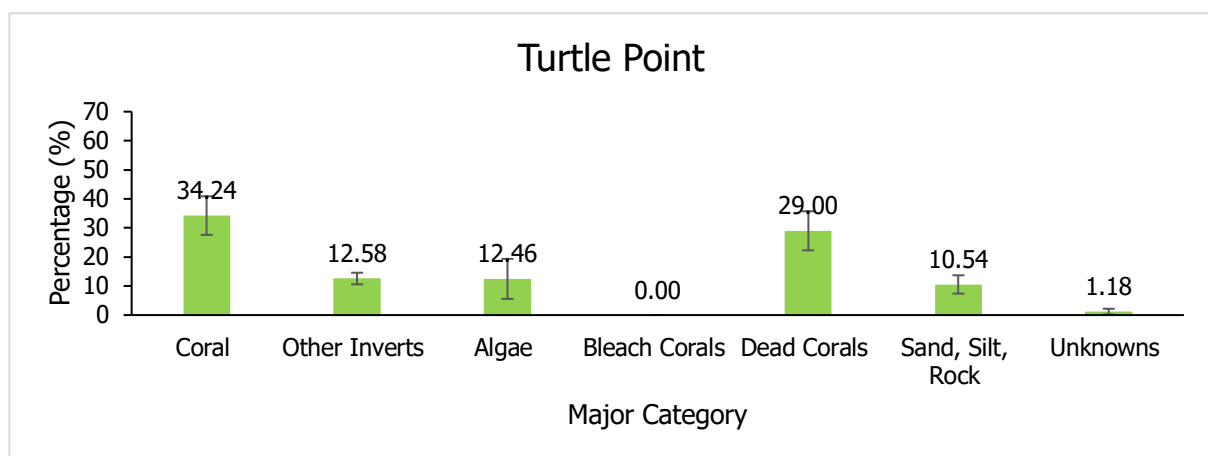


Figure Z: Percentage of benthic cover at Turtle Point.

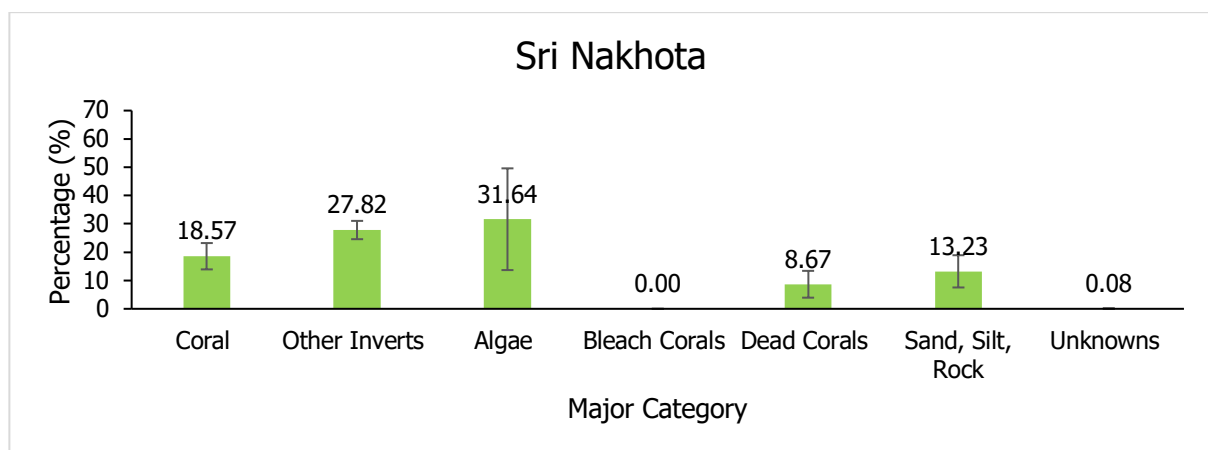


Figure AA: Percentage of benthic cover at Sri Nakhota.

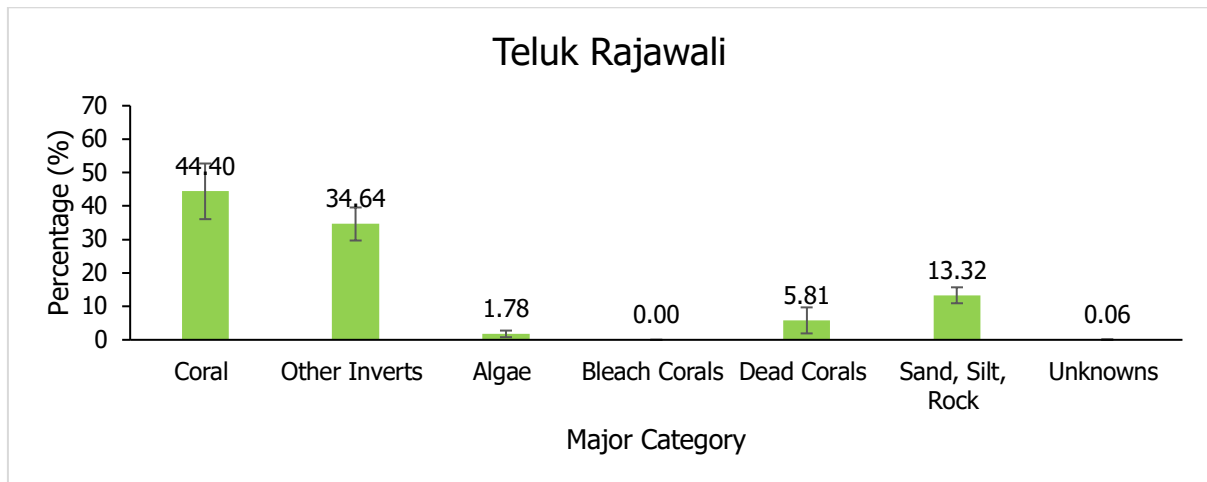


Figure AB: Percentage of benthic cover at Teluk Rajawali.

CHAPTER 3

ASSESSMENT OF SHALLOW CORAL REEF ECOSYSTEM IN TERENGGANU MARINE PARK: CORALLIVORES GASTROPOD, *Drupella* spp. PREVALENCE IN PULAU REDANG

Nursalwa Baharuddin, Afiq Durrani Mohd Fahmi,
Siti Nur Hakimah Zainuddin and Izwandy Idris

Apart from global warming and anthropogenic threats, corals also facing from within the ecosystem itself. Several species are known to predate coral, among others crown of thorn (CoT) and gastropods. Coral predation by CoT is well documented and studied, yet information on predation from gastropods, notably from genus *Drupella*, is still minimal.

A study on *Drupella* prevalence in the coral reef at Pulau Redang was done in 2016 as part of a climate change study. The current research will compare the 2016 data and added new research on the bacterial community associated with the snails. Moreover, recent data of corallivorous gastropods in other marine park islands served as a baseline for future study and monitoring.

3.2 METHODOLOGY

3.2.1 *Drupella* spp. field work and collection

Drupella spp. were collected in selected reefs around the Pulau Redang representing the north, south, east and west. Five different sites were selected for this study which are Chagar Hutang (CH-north), Pulau Kerengga Besar (KB-south east), Mak Simpan (MS-West), Pulau Lima (PL-east), and Pulau Terumbu Kili (TK-South) (Figure 3.1). Sampling was conducted on 16th and 18 July 2020.

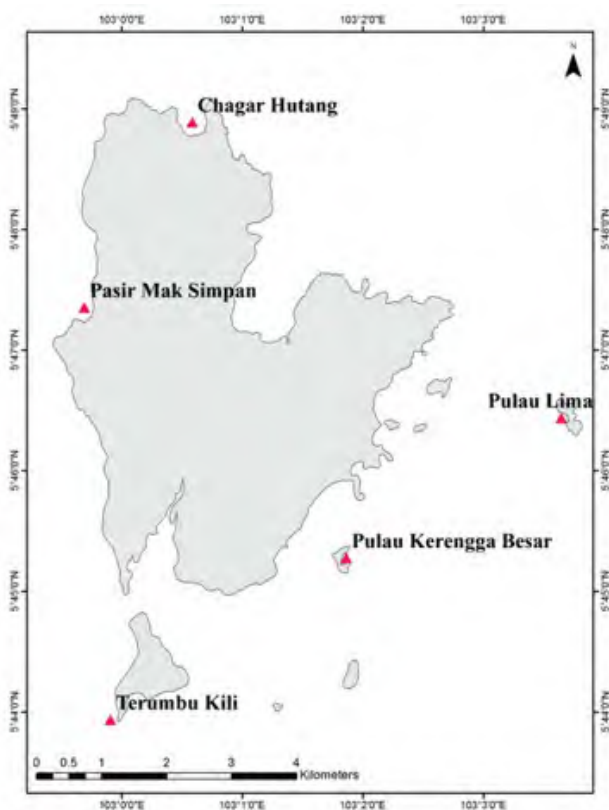


Figure 3.1. Sampling sites of Pulau Redang which are Chagar Hutang (CH-north), Pasir Mak Simpan (MS-west), Pulau Lima (PL-east), Pulau Kerengga Besar (KB-south east) and Terumbu Kili (TK-south).

A transect line of 50 m x 10 m coral area was surveyed by scuba divers at each sampling sites. Transect was laid out between 5-12 meters deep at all sampling sites. A quadrat of 0.625 m² was laid out at each 10 m. *Drupella* spp. were collected at branching (i.e. *Acropora*) and foliose (i.e. *Montipora*) based on study by McClanahan (1997). Photographs were taken at each quadrat to record presence/absence of *Drupella* spp. as well as type of corals. *Drupella* spp. were collected from the quadrat areas by using large forceps and kept in labelled plastic bags. Collected gastropods were kept in a cooled ice chest and transferred to the freezer (4°C) for further analysis.

3.2.2 Laboratory analysis

Shell morphometric including shell's length (mm), shell width (mm), aperture length (mm) and aperture width (mm) were measured using an electronic vernier caliper. *Drupella* spp. were also sorted into three size classes categories which are adult (30-40mm), sub-adult/ juvenile (20-30mm) and recruit (0-20 mm) following Forder (1992) and recorded.

Wet weight of each gastropod was determined by placing it on a piece of pre-weighted tin foil, large enough to enclose a single gastropod, and weighed using an electronic balance. Then all samples were dried in the oven at 65°C for about five days to determine dry weight. The dry weight was recorded on day 3, 4 and 5 and lastly were averaged to determine dry weight. Then aluminium foil was removed, and each individual gastropod was placed in a crucible jar. Afterwards, they were transferred into an ashing oven per session and were combusted at 450°C for four hours. Crucible jars with gastropod were removed from the ash oven using a thong and left to cool. Once cool, all gastropods were removed from crucible jars and shells were tapped to remove ash (flesh). Ash-free dry weight (g) of individual gastropod was recorded using a balance to three decimal points. Condition Index (CI) is calculated as dry flesh weight (g) divided by dry shell weight (g).

For microbiological analysis, 3 randomly selected *Drupella* spp. from each site were surface sterilised by wiping outer shells with 70% ethanol solution and removed aseptically from the animals. *Drupella* spp. were washed with sterile seawater before placed on agar plates to isolate surface bacterial community. They were then crushed in a sterile Petri dish in 1X phosphate-buffered saline solution and streaked onto agar plates for the isolation of the internal microflora of *Drupella* spp. ONR7a agar plates were used as minimal media agar, while marine agar were used for nutrient enriched media agar to isolate colonies of interesting morphological traits and metabolic potential. Further testing on isolated bacterial colonies will be carried out using high-throughput assays to determine enzymatic potential including hydrocarbon degradation potential.

3.3 RESULTS

Pulau Redang

A total of 178 snails representing two subclasses, Caenogastropoda and Vetigastropoda, were recorded within the live coral colonies of Pulau Redang. The species are *Astraliu rhodostomum*, *Drupella rugosa*, *Morula spinosa*, *Tenguella marginalba* and *Drupa ricinus* (Figure 3.1). *Drupella rugosa* was the most abundant individuals (112; 63.28%), followed by *M. spinosa* (12; 6.78%), *T. marginalba* (43; 24.29%) and lastly, *A. rhodostomum* (1; 5.65%) (Figure 3.2).

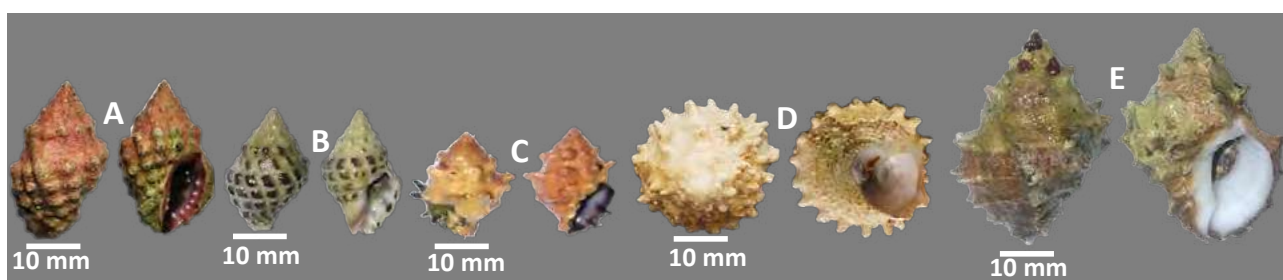


Figure 3.1. Family Muricidae and Turbinidae (Subclass Caenogastropoda and Vetigastropoda). (A) *Morula spinosa* (H. Adams & A. Adams, 1853) dorsal and apertural view; (B) *Tenguella marginalba* (Blainville, 1832) dorsal and apertural view; (C) *Astraliu rhodostomum* (H. Adams & A. Adams, 1853) dorsal and apertural view; (D) *Drupella rugosa* (Born, 1778) and (E) *Drupa ricinus* (Linnæus, 1758). All species were photographed in dorsal and apertural view. Scale: 10 mm.

The highest species availability represented by Muricidae, which are 112 (63%) of *D. rugosa*, 12 (7%) *M. spinosa* and 43 (24%) *T. marginalba*. Muricidae family can be found at all sites except Chagar Hutang and Mak Simpan. The highest abundance of gastropods was *D. rugosa*, whilst the least was only ten *Astraliu rhodostomum* (6%) at Pulau Lima and one *D. rugosa* (0.6%) at Pulau Kerengga (Table 3.1). None of the corallivorous gastropods can be found in Chagar Hutang and Mak Simpan.

Table 3.1. The abundance (individuals) and total species of marine gastropods found in sampling sites at Pulau Redang.* _ indicates the absence of species

PULAU REDANG								
Subclass	Family	Species	Pulau Kerengga	Pulau Lima	Terumbu Kili	Chagar Hutang	Mak Simpan	Total
Vetigastropoda	Turbinidae	<i>Astraliu rhodostomum</i>	0	10	0	0	0	10
		<i>Drupella rugosa</i>	41	14	57	0	0	112
		<i>Morula spinosa</i>	1	5	6	0	0	12
Caenogastropoda	Muricidae	<i>Tengguella marginalba</i>	9	3	31	0	0	43
		<i>Drupa ricinus</i>	1	0	0	0	0	1
Total Individuals			178					
Total species			5					

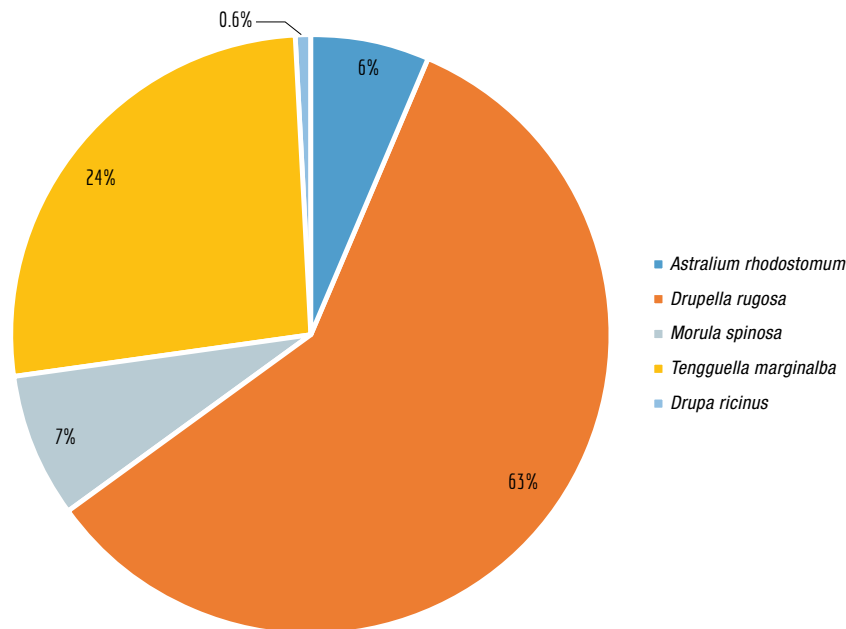


Figure 3.2. The percentage abundance (%) of corallivorous gastropods species found in Pulau Redang

The longest and widest shells were *A. rhodostomum* (28.49 mm and 25.63 mm) and *D. rugosa* (28 mm and 15.09 mm). *Morula spinosa* has the lowest shell length (15.15 mm) than *T. marginalba* (17.09 mm). The heaviest weight (wet and dry weight) also belongs to *A. rhodostomum* (10.11g and 9.23g) and *D. rugosa* (3.81g and 3.71g). In contrast, *M. spinosa* has the lightest weight (1.03g and 0.93g) compared to other gastropod species. All individuals of gastropods analysed with a similar pattern of condition index (<2.00) (Table 3.2).

Table 3.2. Shell morphometrics: shell length (mm), shell width (mm), wet weight (g), dry weight (g) and condition index (CI) of marine gastropods following species and sample size (n) at Pulau Redang. Mean with standard deviation, s.d. (mm).

PULAU REDANG					
Species	Shell		Weight		Condition Index
	Length \pm s.d. (n)	Width \pm s.d. (n)	Wet weight \pm s.d. (n)	Dry weight \pm s.d. (n)	
<i>Astraliu rhodostomum</i> (Lamarck, 1822)	28.49 \pm 7.06(10)	25.63 \pm 5.21(10)	10.11 \pm 6.66(10)	9.23 \pm 6.14(10)	1.10 \pm 0.06(10)
<i>Drupella rugosa</i> (Born, 1778)	28.00 \pm 2.25(81)	15.09 \pm 1.31(81)	3.81 \pm 0.84(81)	3.71 \pm 0.73(81)	1.12 \pm 0.19(18)
<i>Morula spinosa</i> (H. Adams & A. Adams, 1853)	15.15 \pm 4.14(12)	10.99 \pm 3.64(12)	1.03 \pm 0.61(12)	0.93 \pm 0.56(12)	1.07 \pm 0.03(12)
<i>Tengguella marginalba</i> (Blainville, 1832)	17.09 \pm 6.59(43)	9.80 \pm 3.77(43)	1.12 \pm 1.22(43)	1.08 \pm 1.17(43)	1.10 \pm 0.06(43)

Pulau Perhentian

A total of 234 corallivorous gastropods were collected from all sites in Pulau Perhentian. The corallivorous gastropods consist of five species, including *Drupella cornus*, *D. rugosa*, *M. spinosa*, *T. marginalba* and *Cerithium columna* (Figure 3.3).



Figure 3.3. Corallivorous gastropods in Pulau Perhentian. (A) *Morula spinosa* (H. Adams & A. Adams, 1853); (B) *Tenguella marginalba* (Blainville, 1832); (C) *Cerithium columna* (G.B. Sowerby I, 1834); (D) *Drupella rugosa* (Born, 1778); and (E) *Drupella cornus* (Röding, 1798). All species were photographed in dorsal and apertural view. Scale: 10 mm.

Amongst of all those five species of gastropods found in Pulau Perhentian, *D. rugosa* recorded the highest number of individuals with 164 (70.09%) individuals followed by *T. marginalba* with 42 (17.95%) individuals and *M. spinosa* with 23 (9.83%) individuals (Figure 3.4). The lowest total number of individuals was *C. columna*, with only one individual. *Drupella cornus* and *C. columna* had the least with four (1.71%) and one (0.43%) individual, respectively (Table 3.3). There are no corallivorous gastropods that can be found at S11 (Coral Bay) in Pulau Perhentian.

Table 3.3. The abundance (individuals) and total species of corallivorous gastropods in Pulau Perhentian; S1, S2, S3 (Pulau Rawa North), S4 (Pulau Rawa South), S5 (Terumbu Tiga), S6 (Perhentian Besar South), S7 (Tanjung Basi), S8 (D' Lagoon), S9 (Beacon), S10 (Tg. Nisam), S11 (Coral Bay), S12 (Pulau Rawa South) and S13 (Pinang Seribu).

PULAU PERHENTIAN																Σ ind.
Subclass	Family	Species	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	
Caenogastropoda	Cerithiidae	<i>Cerithium columna</i>	0	0	0	1	0	0	0	0	0	0	0	0	0	1
		<i>Drupella cornus</i>	0	0	2	1	0	0	0	0	0	0	0	0	1	4
		<i>Drupella rugosa</i>	0	10	3	13	7	26	13	7	5	3	0	68	9	164
	Muricidae	<i>Morula spinosa</i>	1	0	1	0	0	6	6	2	1	2	0	3	1	23
		<i>Tenguella marginalba</i>	0	0	1	4	5	3	4	7	9	1	0	6	2	42
Total of individuals (s)										234						
Total species										5						

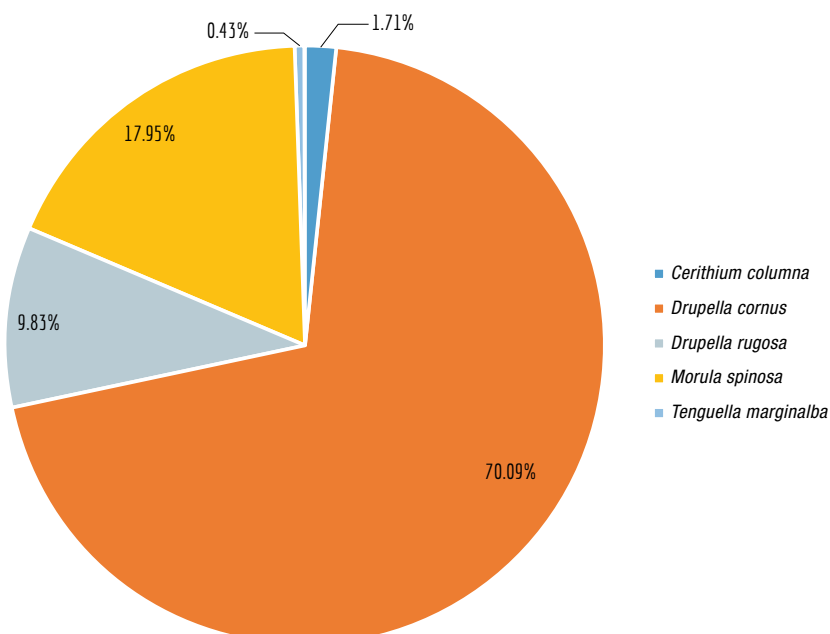


Figure 3.4. The percentage abundance (%) of corallivorous gastropods found at Pulau Perhentian.

Drupella rugosa and *C. columna* have the largest in term of shell length (25.40 mm and 21.29 mm), whilst *D. cornus* and *T. marginalba* have bigger values for aperture length (15.97 mm and 12.60 mm) compared to *M. spinosa* (11.39 mm). All gastropod species have shown almost similar wet weight (g), dry weight (g) and condition index (CI) (Table 3.4).

Table 3.4. Shell morphometrics: shell length (mm), shell width (mm), wet weight (g), dry weight (g) and condition index (CI) of marine gastropods following species and sample size (n) at Pulau Redang. Mean with standard deviation, s.d. (mm).

Species	PULAU REDANG				
	Shell		Weight		Condition Index
	Length \pm s.d. (n)	Width \pm s.d. (n)	Wet weight \pm s.d. (n)	Dry weight \pm s.d. (n)	
<i>Cerithium columna</i> (G.B. Sowerby I, 1834)	21.29(1)	11.00(1)	1.30(1)	1.29(1)	1.09(1)
<i>Drupella cornus</i> (Röding, 1798)	20.55 \pm 10.23(4)	15.97 \pm 6.32(4)	3.33 \pm 3.84(4)	2.65 \pm 2.49(4)	1.07 \pm 0.04(4)
<i>Drupella rugosa</i> (Born, 1778)	25.40 \pm 2.23(140)	13.89 \pm 1.62(140)	3.53 \pm 0.87(140)	2.74 \pm 0.71(140)	1.09 \pm 0.08(140)
<i>Morula spinosa</i> (H.Adams & A.Adams, 1853)	17.09 \pm 3.30(23)	11.39 \pm 2.46(23)	1.11 \pm 0.58(23)	1.16 \pm 0.63(23)	1.11 \pm 0.17(23)
<i>Tenguella marginalba</i> (Blainville, 1832)	20.70 \pm 4.88(42)	12.60 \pm 2.87(42)	1.27 \pm 0.92(42)	1.21 \pm 0.91(42)	1.14 \pm 0.16(42)

Pulau Kapas

A total of 56 gastropods were collected in the coral reef area at Pulau Kapas. The snails consist of *D. rugosa*, *T. marginalba* and *M. spinosa* (Figure 3.5). *Drupella rugosa* was the most abundant species, followed by *T. marginalba* and *M. spinosa*, respectively (Table 3.5).

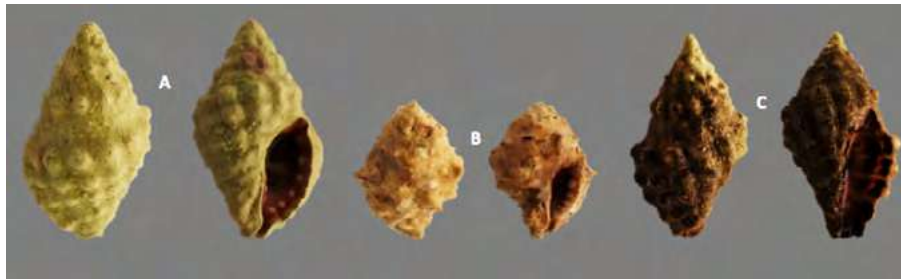


Figure 3.5. Coralivorous gastropods at Pulau Kapas. (A) *Morula spinosa* (H. Adams & A. Adams, 1853); (B) *Tenguella marginalba* (Blainville, 1832); and (C) *Drupella rugosa* (Born, 1778). All species are in dorsal and apertural view. Scale: 10 mm.

Table 3.5. The abundance (individuals) and total species of marine gastropods (Caenogastropoda, Muricidae) found at Pulau Kapas.*_ indicates the absence of species

PULAU REDANG							Σ ind.
Subclass	Family	Species	Teluk Jawa	Berakit	Berakit	Bukit Singa	
Caenogastropoda	Muricidae	<i>Drupella rugosa</i>	1	3	34	0	38
		<i>Morula spinosa</i>	4	0	0	0	4
		<i>Tengguella marginalba</i>	2	10	2	0	14
Total Individuals (s)					56		
Total species					3		

Drupella rugosa recorded the highest number of individuals with 38 (67.86%) of individuals from three sites while *T. marginalba* and *M. spinosa* had the least with 14 (25%) and four (7%) individuals, respectively. *Morula spinosa* only can be found in Teluk Jawa (Table 3.5). None of the corallivorous gastropods can be found in the reef at Bukit Singa.

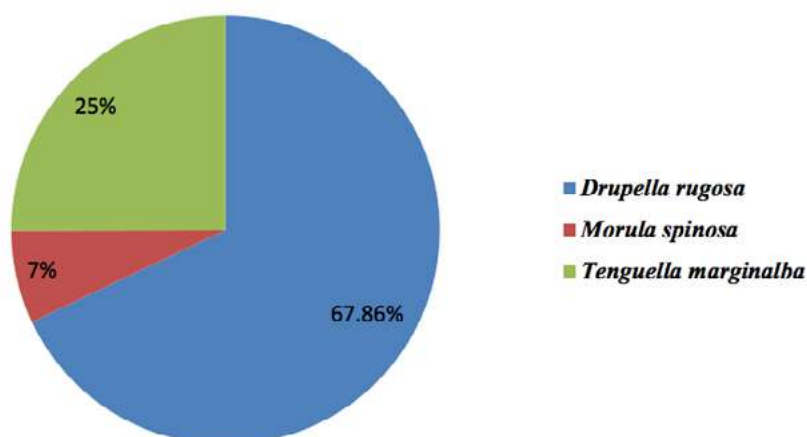


Figure 3.6. The percentage of corallivorous gastropods species (%) found in Pulau Kapas

Drupella rugosa has the largest shell length and shell width with 25.93 mm and 13.96 mm, followed by *T. marginalba* (23.79 mm and 11.25 mm) and *M. spinosa* (20.54 mm and 11.21 mm). Additionally, *D. rugosa* recorded the highest wet weight and dry weight (3.39 g and 2.78g) compared to other species, while *T. marginalba* has the lightest wet and dry weight (1.99g and 1.70g). The condition index (CI) for all species almost shown a similar value with; *D. rugosa* (1.09), *T. marginalba* (1.01) and *M. spinosa* (1.06) (Table 3.6).

Table 3.6. Shell morphometrics: shell length (mm), shell width (mm), wet weight (g), dry weight (g) and condition index (CI) of corallivorous gastropods following species and sample size (n) at Pulau Kapas. Mean with standard deviation, s.d. (mm).

Species	Shell		Weight		Condition Index
	Length \pm s.d. (n)	Width \pm s.d. (n)	Wet weight \pm s.d. (n)	Dry weight \pm s.d. (n)	
<i>Drupella rugosa</i> (Born, 1778)	25.93 \pm 1.93 (38)	13.96 \pm 1.02 (38)	3.39 \pm 0.68 (38)	2.78 \pm 0.60 (38)	1.09 \pm 0.19 (38)
<i>Morula spinosa</i> (H. Adams & A. Adams, 1853)	20.54 \pm 2.23 (4)	11.21 \pm 1.41 (4)	1.97 \pm 0.65 (4)	1.97 \pm 0.74 (4)	1.06 \pm 0.01 (4)
<i>Tenguella marginalba</i> (Blainville, 1832)	23.79 \pm 5.97 (14)	11.25 \pm 2.27 (14)	1.99 \pm 1.03 (14)	1.70 \pm 0.91 (14)	1.01 \pm 0.23 (14)

Pulau Tenggol

Our study found five species of gastropods from two families (Muricidae and Cerithiidae) among the coral colonies in Pulau Tenggol. *Drupella rugosa*, *T. marginalba*, *C. violacea* and *D. cornus* belong to Muricidae while *C. coralium* from the Cerithiidae family. The most dominant corallivorous species in Pulau Tenggol was *Drupella rugosa* (Figure 3.7).



Figure 3.7. Corallivorous gastropods at Pulau Tenggol. (A) *Tenguella marginalba* (Blainville, 1832), (B) *Coralliophila violacea* (Kiener, 1836), (C) *Drupella rugosa* (Born, 1778), (D) *Drupella cornus* (Röding, 1798); (E) *Cerithium coralium* (Kiener, 1841). All species photographed with dorsal and apertural view. Scale: 10 mm.

Amongst all 53 individuals, 35 individuals of *D. rugosa* were recorded at all sites, followed by eight *Drupella cornus* (15%), five *Coralliophila violacea* (9.4%), *Tenguella marginalba* (7.55%) and only one *Cerithium coralium* from Cerithiidae with the least number of individuals (1.9%). *Cerithium coralium* only can be found in Teluk Rajawali (Figure 8 and Table 3.7).

Table 3.7. The abundance (individuals) and total species of marine gastropods (Caenogastropoda, Muricidae) found at all sites in Pulau Tenggol.*_ indicates the absence of species.

Subclass	Family	Species	PULAU TENGGOL					Σ ind.
			Teluk Rajawali	Teluk Rajawali 2	Sri Nakhota	Lost World	Turtle point	
Caenogastropoda	Muricidae	<i>Drupella rugosa</i>	0	15	2	2	16	35
		<i>Tenguella marginalba</i>	0	4	0	0	0	4
		<i>Coralliophila violacea</i>	2	3	0	0	0	5
		<i>Drupella cornus</i>	0	6	2	0	0	8
	Cerithiidae	<i>Cerithium coralium</i>	1	0	0	0	0	1
Total of individuals (s)			53					
Total species			5					

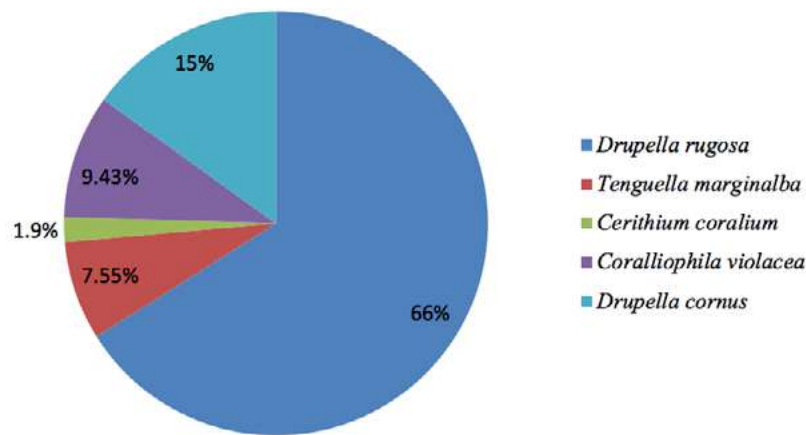


Figure 3.8. The percentage abundance (%) of corallivorous gastropods found in Pulau Tenggol

Generally, *Cerithium coralium* (44.47 mm) has the highest shell length, followed by *Drupella rugosa* (31.55 mm), *Drupella cornus* (31.44 mm) and *Tenguella marginalba* (29.87 mm). *Coralliophila violacea* recorded the shortest shell length (22.80 mm) compared to other species. In contrast, species of *Cerithium coralium* had wider shells (14.89 mm) than species from Muricidae; *Tenguella marginalba* (14.89 mm) and *Drupella cornus* (14.82 mm). *Tenguella marginalba* was the lightest wet and dry weight (3.63 g and 2.94 g) compared to *Cerithium coralium* (10.69 g and 10.28 g). Moreover, condition index (dry flesh weight to dry shell weight ratio) remained below 2.0 were under 'thin' categorised of fatness (Table 3.8).

Table 3.8. Shell morphometrics: shell length (mm), shell width (mm), wet weight (g), dry weight (g) and condition index (CI) of marine gastropods following species and sample size (n) at Pulau Tenggol. Mean with standard deviation, s.d. (mm).

Species	Shell		Weight		Condition Index
	Length \pm s.d. (n)	Width \pm s.d. (n)	Wet Weight \pm s.d.(n)	Dry Weight s.d. (n)	
<i>Drupella rugosa</i> (Bom, 1778)	31.55 \pm 3.27 (35)	16.18 \pm 1.44 (35)	5.73 \pm 1.86 (35)	4.97 \pm 1.76 (35)	1.06 \pm 0.06 (35)
<i>Tenguella marginalba</i> (Blainville, 1832)	29.87 \pm 5.34 (4)	14.89 \pm 2.75 (4)	3.63 \pm 1.66 (4)	2.94 \pm 1.35 (4)	0.96 \pm 0.25 (4)
<i>Coralliophila violacea</i> (Kiener, 1836)	22.80 \pm 6.18 (5)	17.09 \pm 5.24 (5)	5.29 \pm 3.57 (5)	4.79 \pm 3.06 (5)	1.73 \pm 1.44 (5)
<i>Drupella cornus</i> (Röding, 1798)	31.44 \pm 4.54 (8)	14.82 \pm 1.67 (8)	5.11 \pm 1.67 (8)	4.69 \pm 1.53 (8)	1.06 \pm 0.01 (8)
<i>Cerithium coralium</i> (Kiener, 1841)	44.47 (1)	16.22 (1)	10.69 (1)	10.28 (1)	1.04 (1)

3.4 DISCUSSION

Drupella rugosa was the highest abundance of corallivorous species compared to other species on all islands. The species' behaviour was described as complex because its density changes according to the relative abundance of each coral taxon (Morton and Blackmore, 2009). It feeds on scleractinian corals as obligate corallivores (Morton et al., 2002; Rotjan & Lewis, 2008). The large abundance of *D. rugosa* most frequently associated with the dominant coral species, *Acropora* spp. (Bruckner et al., 2017). *Acropora* spp. has greater surface area, more tissue and a higher protein and energy content than other coral families that attracted corallivorous gastropods (Keesing, 1990). This species revealed a dominant proportion of adults compared to juveniles and recruits at all islands. Adults may be considered as better competitors dominating the resources such as corals (Nicholson, 1954). In contrast, the previous tropical cyclone, Pabuk, that hit these islands in December 2019 has caused severe destruction to many coral reef ecosystems. Hence, it was expected that many juveniles died whilst recruits were expected to drift, given many gastropods species has planktonic larvae or veliger. Their inability to settle at stable corals caused their low population recorded during this expedition.

Muricidae dominated the second most abundant species in all islands; *T. marginalba* and *M. spinosa*. Major influences on *T. marginalba* distribution and abundance include emersion (Moran, 1985b), wave exposure (Meyer & O'Gower 1963; Moran 1985b), competitor abundance (Moran, 1985b) and availability of suitable prey species (Fairweather, 1988). *Tenguella marginalba* is known to inhabit a wide distribution of coastal and marine habitats (Radwin & D'Atillio, 1976). This species has a slender body shape that gives protection from the rough conditions created by waves. Moreover, they have been found to avoid areas with strong wave exposure (Mayer and O'Gower, 1963); instead, favouring the edges of pools (O'Gower and Meyer, 1971) and crevices (Moran, 1985b; Coulson et al., 2011). In the meantime, *M. spinosa* also known as an opportunistic coral-feeding species (Yokochi, 2004). A study by Turner (1994) revealed that *M. spinosa* has the ability to degrade coral reefs on a large scale.

However, the least abundance of several species in all islands, such as *C. corallium* in Pulau Tenggol, *C. columna* in Pulau Perhentian and *D. ricinus* in Pulau Redang, is probably caused by the haphazard arrangement of coral branches: which hiding the snails and making the collection difficult. Nevertheless, studies done by researchers demonstrated that *D. rugosa* feed on *Acropora* spp. (Taylor, 1976; Taylor, 1978a). This is despite claims that they are herbivorous (Taylor, 1983).

The length, width, wet weight, dry weight and condition index for all species are almost constant, indicating the population of these species are not under stress. This could be due to individuals came from the same population. In addition, high dietary plasticity and able to include a variety of corals species allowed their stable growth (Shafir, 2008). Moreover, increment in shell length can also influence increment of other shell morphometrics (Okumus & Stirling, 1998). The increase of wet weight and dry weight probably due to gonadal growth and reproductive cycle supported by the availability of food and nutrients (Gabbot, 1975), while the lower value of body weight (wet and dry weight) probably due to spawning or starvation (Palmer, 1982). The condition index (CI) of corallivorous gastropod that recorded <2.00 indicated as 'thin' of fatness probably due to gonad in resting state (Rahim et al. 2012). Higher condition index (CI) can be reflected in the higher concentration of nutrients in molluscs bodies (Mercaldo-Silva, 2005).

Bacterial community associated with *Drupella* sp.

In addition to the assessment of *Drupella* sp. distribution and abundance, qualitative assessment of bacterial community associated with *Drupella* sp. was carried out to provide a baseline study of biodiversity of bacteria related to coralivorous *Drupella* sp.. Host-associated bacteria influence ecological processes in addition to immunological and evolutionary processes with the added potential for biotechnological application. Microbial community structure and function determine host fitness and resilience to variations in environmental factors. In this study, we isolated the external (surface) and internal microbiota (gut) of *Drupella* sp. using a culture-based approach, i.e. nutrient-rich media (Figure 3.9) and nutrient-limited agar (Figure 3.10) agar.



Figure 3.9. Colonies isolated from *Drupella* sp. growing in rich media (Marine Agar)

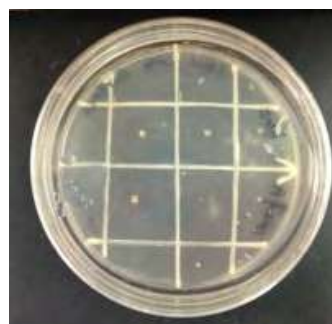


Figure 3.10. Colonies isolated from *Drupella* sp. growing in nutrient-limited media (ONR7a)

Diversity of bacterial colonies successfully isolated from *Drupella* sp. from Pulau Kapas, Pulau Tenggol, and Pulau Perhentian (Table 3.9) based on morphological differences provides preliminary insight into the biotechnological potential of bacteria associated with *Drupella* sp. Unfortunately, agar plates for specimens from Pulau Redang were contaminated; thus, results are not available. These bacterial associations can be further exploited for various industrial applications, much like other snail microbiome-derived bacteria for biomass degradation, biofuel production, and wine, paper or laundry detergents (Dar, Pawar and Pandit, 2017).

Table 3.9. Morphology of bacterial colonies isolated from gut and surface of *Drupella* sp. sampled from Pulau Kapas, Pulau Tenggol, and Pulau Perhentian.

LOCATION	SOURCE	MORPHOLOGY			COLOUR
		Form	Elevation	Margin	
Pulau Kapas	Gut	Irregular	Raised	Undulate	Opaque white
	Gut	Irregular	Umbonate	Undulate	Translucent orange
	Gut	Irregular	Umbonate	Undulate	Translucent peach
	Gut	Irregular	Raised	Undulate	Opaque yellow
	Surface	Irregular	Flat	Undulate	Opaque white
	Surface	Circular	Raised	Entire	Opaque orange
	Surface	Circular	Raised	Entire	Opaque white
Pulau Tenggol	Gut	Circular	Raised	Entire	Opaque yellow
	Gut	Circular	Raised	Undulate	Pale orange
	Gut	Circular	Raised	Undulate	Translucent white
Pulau Perhentian	Surface	Circular	Crateriform	Entire	Opaque yellow
	Surface	Circular	Umbonate	Entire	Pale orange
	Surface	Irregular	Flat	Undulate	White
	Surface	Circular	Flat	Entire	White
	Surface	Circular	Flat	Entire	Pale orange
	Surface	Irregular	Raised	Undulate	Pale orange
	Surface	Circular	Raised	Entire	Pale orange
	Surface	Circular	Raised	Entire	Yellow
	Surface	Circular	Raised	Entire	Translucent white
	Surface	Circular	Raised	Entire	Opaque white
	Gut	Circular	Raised	Entire	Opaque white
	Gut	Irregular	Raised	Entire	Pale orange

Observation of colonies growing in enriched media revealed antagonistic interaction between the colonies. Figure 3.11 shows inhibition of growth of a spreader type colony from colonising the surface of the nutrient-enriched agar by the bacterial colony circled in red. Antimicrobial activity showcased by the colony circled in red can be further assessed for its novelty and potentially exploited in the pharmaceutical industry. Other interesting characteristics shown from bacterial isolates include agarose degradation and swarming motility (Figure 3.12). Swarming motility is a characteristic of colonies capable of producing surfactants and is a survival advantage in a competitive environment. Swarmers may give an advantage to the host by limiting other bacterial associates that may be pathogenic or disease carriers. While reports have shown *Drupella* can transfer diseases such as black band disease and brown band disease on corals (Nicolet et al., 2018), we have not identified the spread of vector-borne diseases from our observation.



Fig 3.11. Colony displaying antimicrobial activity circled in red showing zone of inhibition, compared to colony incapable of producing antimicrobials circled in green showing no zone of inhibition.



Figure 3.12. Colonies displaying swarming motility compared to control colony (yellow colony).

Bacterial colonies isolated from marine agar were tested for hydrocarbon-degrading potential using ONR7a agar surface enriched with n-Tetradecane. No colonies isolated from the gut or surface of *Drupella* sp. were found growing on n-Tetradecane enriched ONR7a agar. Therefore, it can be concluded that culture-dependent bacterial colonies isolated from *Drupella* sp. were not capable of degrading tetradecane, a saturated aliphatic hydrocarbon compound present in plant metabolites.

Prospects for microbiological assessment *Drupella*-associated bacterial community

Prospects of this study include expanding enzymatic tests of culturable bacteria against coral-associated diseases such as brown band disease. In a previous study carried out by Nicolet et al. (2013) in the Great Barrier Reef, *Drupella* sp. were identified as a potential vector for the spreading of brown band disease in corals. Brown band disease was not observed during our survey and collection of *Drupella* samples. Therefore we hypothesise that the naturally associated bacteria isolated from *Drupella* collected at our site has antimicrobial activity that could prevent the prevalence or severity of future brown band infection. Characterising *Drupella*-associated bacterial community using culture-independent methods such as high-throughput sequencing would provide tremendous improvement in detecting diversity and abundance of our sample collection. This will be vital in understanding the implications of a changing environment on disease transmission via predation. Consequently, metabolic diversity of *Drupella*-associated bacteria can be further characterised using metagenomic analysis that could greatly benefit the understanding of interaction within the bacterial community and the relationships between the host and its bacterial community.

REFERENCES

- Bruckner, A. W., Coward, G., Bimson, K., & Rattanawongwan, T. (2017). Predation by feeding aggregations of *Drupella* spp. inhibits the recovery of reefs damaged by a mass bleaching event. *Coral Reefs*, 36(4), 1181-1187.
- Coulson, L. A., Perrin, C., Roberts, D. G., Minchinton, T. E., & Ayre, D. J. (2011). Can limited dispersal or biotic interaction explain the declining abundance of the whelk, *Morula marginalba* at the edge of its range?. *Biological Journal of the Linnean Society*, 103(4), 849-862.
- Dar, M. A., Pawar, K. D. and Pandit, R. S. (2017) 'Gut Microbiome Analysis of Snails: A Biotechnological Approach', in *Organismal and Molecular Malacology*. InTech. doi: 10.5772/68133.
- Fairweather, P. G. (1988). Movements of intertidal whelks (*Morula marginalba* and *Thais orbita*) in relation to availability of prey and shelter. *Marine Biology*, 100(1), 63-68.
- Gabbot, P. A. (1975). Storage cycles in marine bivalve molluscs: A hypothesis concerning the relationship between glycogen metabolism and gametogenesis, in: In *Proceeding of the 9th European Marine Biology Symposium*. Aberdeen University Press. 191-211 pp.
- Gold, Z., & Palumbi, S. R. (n.d.). *Long-term growth rates and effects of bleaching in Acropora hyacinthus*. <https://doi.org/10.1007/s00338-018-1656-3>
- Keesing, J. K. (1990). Feeding biology of the crown-of-thorns starfish, *Acanthaster planci* (Linnaeus). Ph.D. thesis, James Cook University of North Queensland, 197 pp.
- Mercado-Silva, N. (2005). Condition index of the eastern oyster, *Crassostrea virginica* (Gmelin, 1791) in Sapelo Island Georgia—effects of site, position on bed and pea crab parasitism. *Journal of Shellfish Research*, 24(1), 121-126.
- Meyer, G. R., & O'Gower, A. K. (1963). The ecology of six species of littoral gastropods. I. Associations between species and associations with wave action. *Marine and Freshwater Research*, 14(2), 176-193.
- Moran, M. J. (1985). Distribution and dispersion of the predatory intertidal gastropod, *Morula marginalba*. *Marine ecology progress series*. Oldendorf, 22(1), 41-52.
- Morton B, Blackmore G, Kwok CT (2002). Corallivory and prey choice by *Drupella rugosa* (Gastropoda: Muricidae) in Hong Kong. *Journal Molluscan Study*, 68:217-223.
- Morton, B., & Blackmore, G. (2009). Seasonal variations in the density of and corallivory by *Drupella rugosa* and *Cronia margaritcola* (Caenogastropoda: Muricidae) from the coastal waters of Hong Kong: 'plagues' or 'aggregations'?. Marine Biological Association of the United Kingdom. *Journal of the Marine Biological Association of the United Kingdom*, 89(1), 147.

- Nicholson, A., (1954). An outline of the dynamics of animal populations. *Australian Journal of Zoology*, 2: 9–65.
- Nicolet, K. J. et al. (2013) 'The corallivorous invertebrate *Drupella* aids in transmission of brown band disease on the Great Barrier Reef', *Coral Reefs*. Springer Verlag, 32(2), pp. 585–595. doi: 10.1007/s00338-013-1010-8.
- O'Gower, A. K., & Meyer, G. R. (1971). The ecology of six species of littoral gastropods. III. Diurnal and seasonal variations in densities and patterns of distribution in three environments. *Marine and Freshwater Research*, 22(1), 35–40.
- Okumuş, İ., & Stirling, H. P. (1998). Seasonal variations in the meat weight, condition index and biochemical composition of mussels (*Mytilus edulis* L.) in suspended culture in two Scottish sea lochs. *Aquaculture*, 159(34), 249–261.
- Palmer, A. R. (1982). Growth in marine gastropods. A non-destructive technique for independently measuring shell and body weight. *Malacologia*, 23(1), 63–74.
- Radwin, G. E., & d'Attilio, A. (1976). *Murex shells of the world: an illustrated guide to the Muricidae*. Stanford University Press.
- Rahim, A. A., Idris, M. H., Kamal, A. H. M., Wong, S. K., & Arshad, A. (2012). Analysis of condition index in *Polymesoda expansa* (Mousson 1849). *Pakistan Journal of Biological Sciences*, 15(13), 629–634.
- Rotjan, R. D., & Lewis, S. M. (2008). Impact of coral predators on tropical reefs. *Marine ecology progress series*, 367, 73–91.
- Shafir, S., Gur, O., & Rinkevich, B. (2008). A *Drupella cornus* outbreak in the northern Gulf of Eilat and changes in coral prey. *Coral Reefs*, 27(2), 379.
- Taylor, J. D. (1976). Habitats, abundance and diets of muricacean gastropods at Aldabra Atoll. *Zoological Journal of the Linnean Society*, 59(2), 155–193.
- Taylor, J. D. (1978). Habitats and diet of predatory gastropods at Addu Atoll, Maldives. *Journal of experimental marine Biology and Ecology*, 31(1), 83–103.
- Taylor, J. D. (1983). The food of coral-reef *Drupa* (Gastropoda). *Zoological Journal of the Linnean Society*, 78(4), 299–316.
- Turner, S. J. (1994). Spatial variability in the abundance of the corallivorous gastropod, *Drupella cornus*. *Coral Reefs*, 13(1), 41–48.
- Yokochi, H. (2004). Predation damage to corals. *Coral Reefs of Japan*. Tokyo: Ministry of the Environment, 49–55.

CHAPTER 4

ASSESSMENT OF SHALLOW CORAL REEF ECOSYSTEM IN TERENGGANU MARINE PARK: RUBBLE CRYPTOFAUNA DIVERSITY

Izwandy Idris, Tulio F. Villalobos Guerrero, Isabel C. Molina Acevedo and Fatin Sharmimi Muhamad

4.1 INTRODUCTION

Reef organisms are mostly associated with corals (cnidarians), fishes, and other macroinvertebrates such as giant clam and snails (molluscs), sea cucumber and starfish (echinoderms), sponges (porifera) and tunicates (chordates). These organisms can be seen live on the surface of corals or substrates. However, many small size organisms are living within or underneath the coral rubbles which usually unknown by divers. Coral rubbles are mainly made from fragments of dead corals and lying on the reef flow. Overtime, these rubbles are becoming a cryptic microhabitat for various organisms because of holes and pores created by then the living coral or other boring organisms.

Studies on rubble cryptofauna (also known as coelobites) have been done in several reefs around the world (for example Biondi et al., 2020; Gischler & Ginsburg, 1996; González-Gómez et al., 2018) and found high diversity of organisms. However, study on the similar aspect in Malaysia's coral reef ecosystem is lacking. Hence, this study is intended to reveal the diversity of cryptofauna in Terengganu Marine Park for the first time. Additionally, we are trying to determine the effects of tourism pressure through the coelobite community composition in diving and snorkelling spots in Terengganu Marine Park.

4.2 METHODOLOGY

Samplings were done in four islands in Terengganu Marine Park including Pulau Redang, Pulau Perhentian, Pulau Kapas and Pulau Tenggol. At each island, several dive sites were chosen based on the accessibility and the sites are popular sites among visitors.

Coral rubbles were collected either by snorkelling or SCUBA diving. At each site, three replicates of coral rubbles about the size of football were collected and kept in the plastic bag. The rubbles were kept submerged in the seawater and plastic bag to prevent any organisms to escape or died because of dehydration or high temperature.

Rubbles were then weighed to determine their volume. Then, all rubbles will be breaking off using combination of hammer and chisel to remove any fauna that live in the rubbles. The breaking process were carefully done to avoid damaging organisms.

Collected organisms were then sorted in according to possible phylum and then photographed before fixed in 95% ethanol. All specimens are now deposited at the South China Sea Repository and Reference Centre (RRC) with assigned catalogue numbers.

Number of individuals per taxa and density are the primary data that will be collected from identified specimens. Subsequently, ecological indices (richness, diversity, evenness) will be calculated followed by more in-depth analysis (statistical test such as multivariate) to detect distribution pattern between sampling sites and islands.

4.3 RESULTS

Most of the specimens were only able to identify until class level. The identification process to the lowest possible taxa is still ongoing. However, it will be focusing only on specific taxa because of the limitation of staff, equipment and working hours in the laboratory due to the pandemic.

The average abundance of cryptofauna in all major Terengganu Marine Park islands (Pulau Perhentian, Pulau Redang, Pulau Kapas and Pulau Tenggol) and reference site (Pulau Bidong) are shown in Figure 4.1. In general, Polychaeta was the most abundant invertebrate in marine parks (56%), followed by Malacostraca (17%), Ophiuroidea (9%), Bivalvia (7%) and Gastropoda (6%). Other classes have a very small abundance (<1%) (Figure 4.1A). However, in the reference site (Pulau Bidong), Malacostraca was the dominant class (31%), then followed by Polychaeta (24%), Bivalvia (15%), Gastropoda (11%), Ophiuroidea (11%) and Others (Cnidarian, Sipuncula, Platyhelminthes, Fish; 7%), other classes have very minimal abundance (<1%) (Figure 4.1B).

In terms of average density (ind/cm³), the northernmost of the Marine Park islands, Pulau Perhentian has the highest density; the trend shows a gradual decrease as it moves south with the lowest density recorded in Pulau Tenggol (Figure 4.2A). The diversity index value (H) and evenness (J) show a different pattern (Figure 4.2B). The highest diversity and evenness among the four Marine Park islands were recorded from Pulau Kapas, while the lowest diversity and evenness were recorded from Pulau Redang. Interestingly, Pulau Bidong (reference site) exhibited the highest diversity and evenness compared to the Marine Park islands. Figure 4.3 shows some of the cryptofauna found within the coral rubble cavity in the Terengganu Marine Park islands.

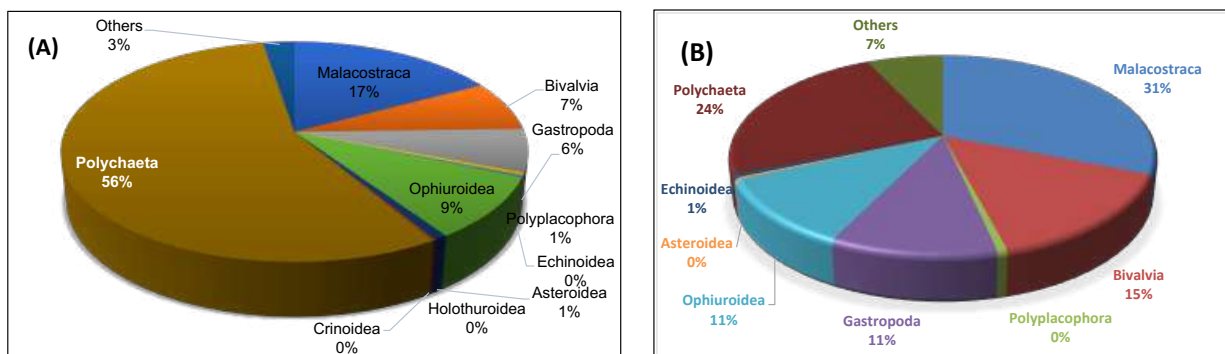


Figure 4.1. Abundance of cryptofauna in coral rubbles at Terengganu Marine Park islands. A: Average abundance (%) from Pulau Perhentian, Pulau Redang, Pulau Kapas and Pulau Tenggol; B: Average abundance (%) of cryptofauna from Pulau Bidong (reference site).

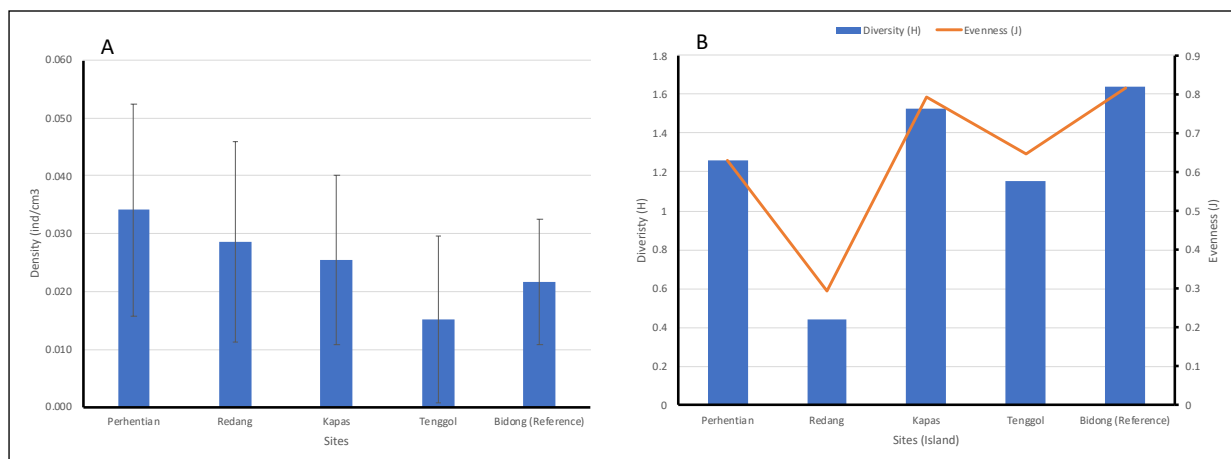


Figure 4.2. Cryptofauna in Terengganu Marine Park islands. A: Average density (ind/cm³), and B: Diversity (H) and Evenness (J) value.



Figure 4.3. Examples of coral rubble cryptofauna found at Terengganu Marine Park islands. Identifications are on the class level. A: Malacostraca, B: Bivalvia, C: Echinoidea, D: Ophiuroidea, E: Polyplacophora, F: Asteroidea, G: Polychaeta, H: Gastropoda, and I: Sipuncula (categorised as Others).

Pulau Perhentian

The abundance of cryptofauna in Pulau Perhentian is shown in Figure 4.4. The most abundant epibionts (%) was Polychaeta (46%), followed by Ophiuroidea (21%), Malacostraca (11%), Bivalvia (10%) and Gastropoda (9%), other classes showed abundance less than 1%. The diversity (H), evenness (J) density (ind/cm³) of epibionts in coral rubble at Pulau Perhentian are shown in Figure 4.5. The highest diversity was recorded from the site 'Beacon/Lighthouse' (1.54), followed by Pulau Rawa South (1.52). Meanwhile, the lowest diversity was recorded from site 'D'Lagoon' (0.72). Simultaneously, the evenness values following the same pattern as the diversity. The highest evenness value recorded was also at the 'Beacon/Lighthouse' site (0.79), while the lowest evenness value was recorded at Tanjung Basi (0.37) (Figure 4.5A).

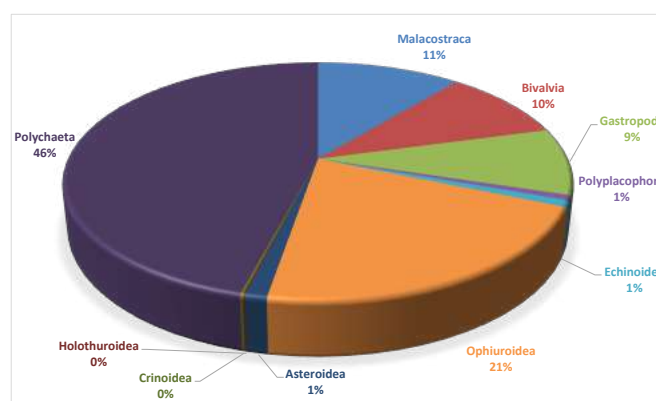


Figure 4.4. Abundance (%) of coral rubble cryptofauna in Pulau Perhentian.

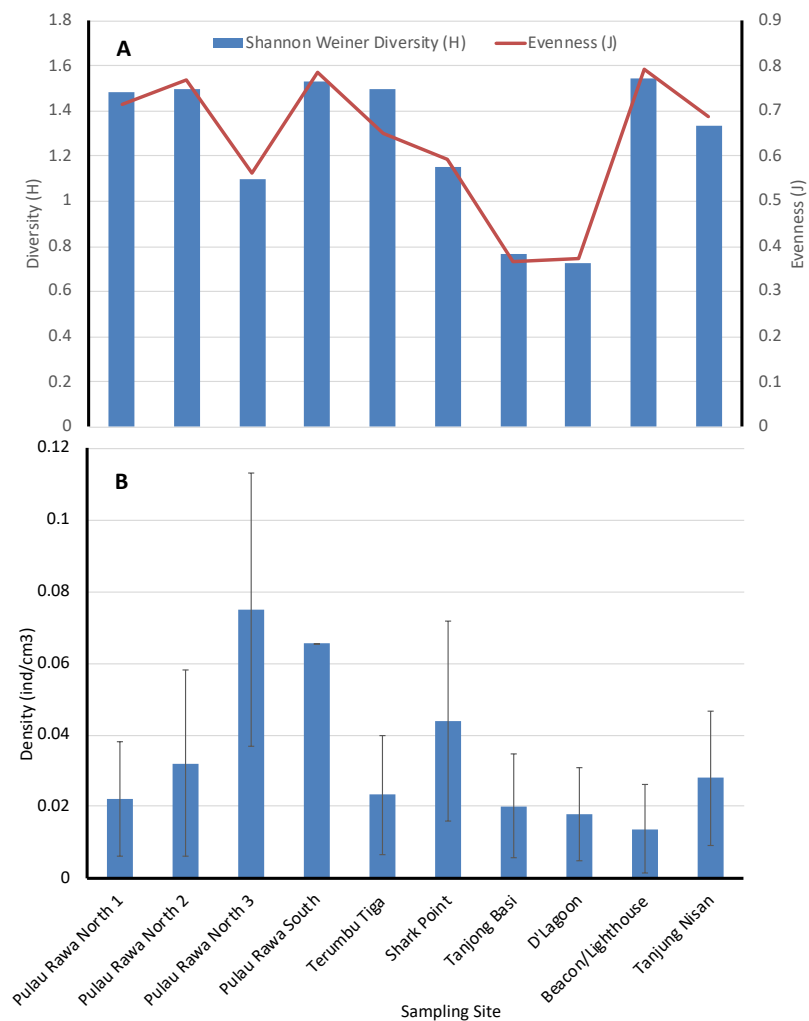


Figure 4.5. Ecological data of coral rubble cryptofauna at Pulau Perhentian. A: Diversity (H) and Evenness (J), B. Density (ind/cm³).

The density of cryptofauna in Pulau Perhentian is shown in Figure 4.5B. The highest density was recorded from Pulau Rawa North 3 (0.075 ± 0.038 ind/cm³). Interestingly, the lowest density recorded was from the Beacon/Lighthouse site (0.014 ± 0.012 ind/cm³).

Pulau Redang

The abundance (%) of cryptofauna in Pulau Redang is shown in Figure 4.6. The most dominant component of the benthic organism is Polychaeta (82%), followed by Malacostraca (8%), Ophiuroidea (4%), Others (4%) and Bivalvia (2%). Other classes were less than 1%.

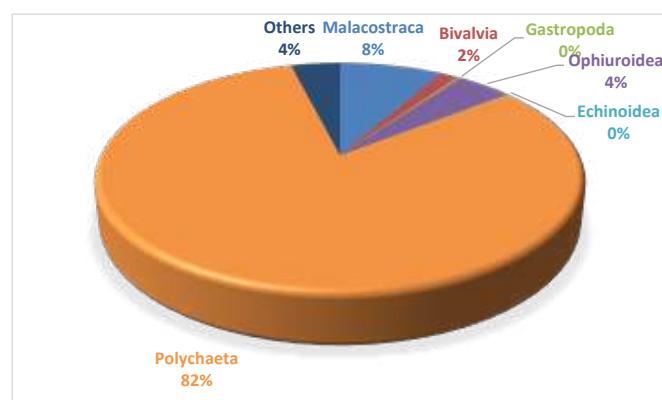


Figure 4.6. Abundance (%) of coral rubble cryptofauna in Pulau Redang.

The diversity (H), evenness (J) and density of cryptofauna in Pulau Redang are shown in Figure 4.6. The highest diversity was recorded at Pulau Kerengga (1.08), while the lowest diversity index value was at Chagar Hutang (0.16) (Figure 4.7A). The evenness pattern is similar to the diversity index. The most evenly distributed site was Pulau Kerengga; however, the less even site was Terumbu Kili (0.14) (Figure 4.7A). Moreover, the density of cryptofauna at Pulau Redang was in a different pattern than the ecological indices. The highest density was recorded in Terumbu Kili (0.05 ± 0.02 ind/cm³), while the lowest was recorded in Chagar Hutang (0.01 ± 0.01 ind/cm³) (Figure 4.7B).

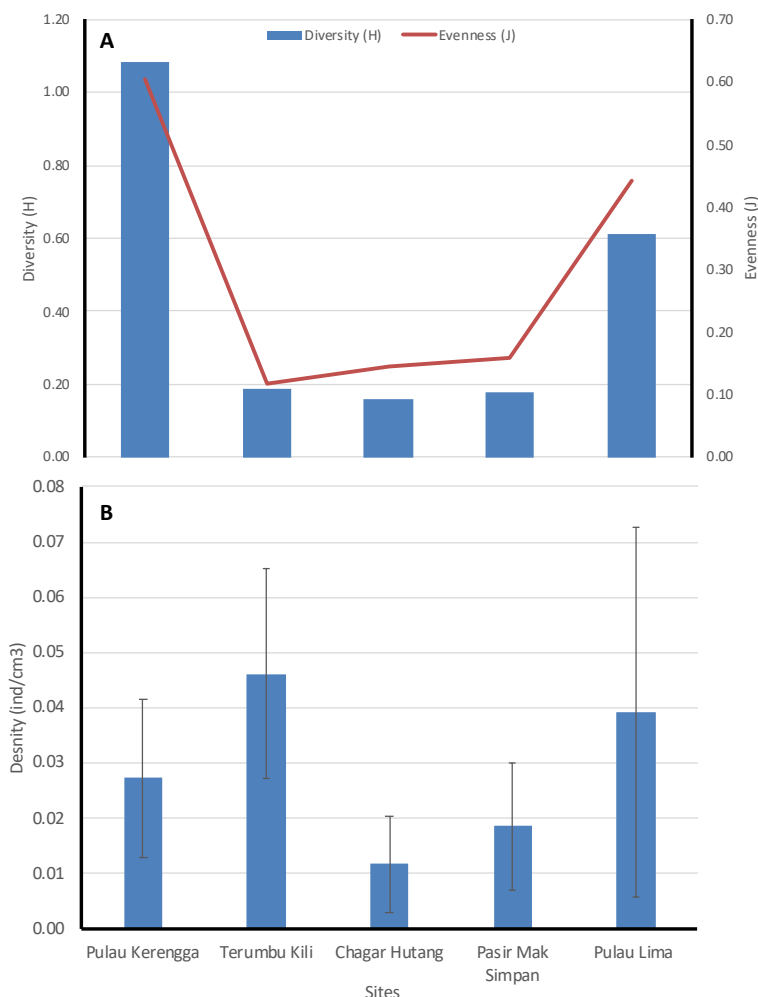


Figure 4.7. Coral rubble cryptofauna in Pulau Redang, Terengganu. A: Diversity (H) and Evenness (J), B: Density (ind/cm³).

Pulau Kapas

The abundance of coral rubble cryptofauna in Pulau Kapas is shown in Figure 4.8. The most abundant taxa were Malacostraca (37%), followed by Polychaeta (35%). Several classes have a small abundance (<1%), including Holothuroidea, Polyplacophora and Echinoidea.

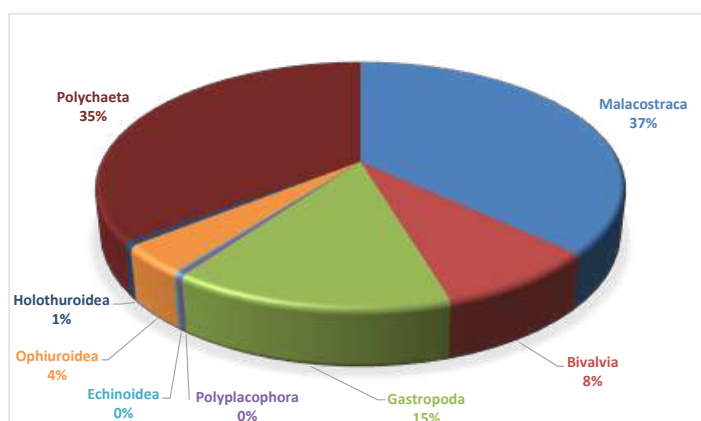


Figure 4.8. Abundance (%) of coral rubble cryptofauna in Pulau Kapas.

The ecological indices (diversity and evenness) and density of coral rubble cryptofauna in Pulau Kapas are shown in Figure 4.9. The highest diversity was found at the 'Southern Tip' site (1.67), while the lowest diversity was recorded at the Bukit Singa site (1.32). However, the number of individuals per taxa was mostly even at site Pulau Kapas (0.86), whereas Bukit Singa has the lowest evenness value (0.74) (Figure 4.9A). The highest density was recorded at the Southern Tip (0.039 ± 0.02 ind/cm³), whereas Berakit (0.014 ± 0.011 ind/cm³) has the lowest cryptofauna density among the sampling site (Figure 4.9B).

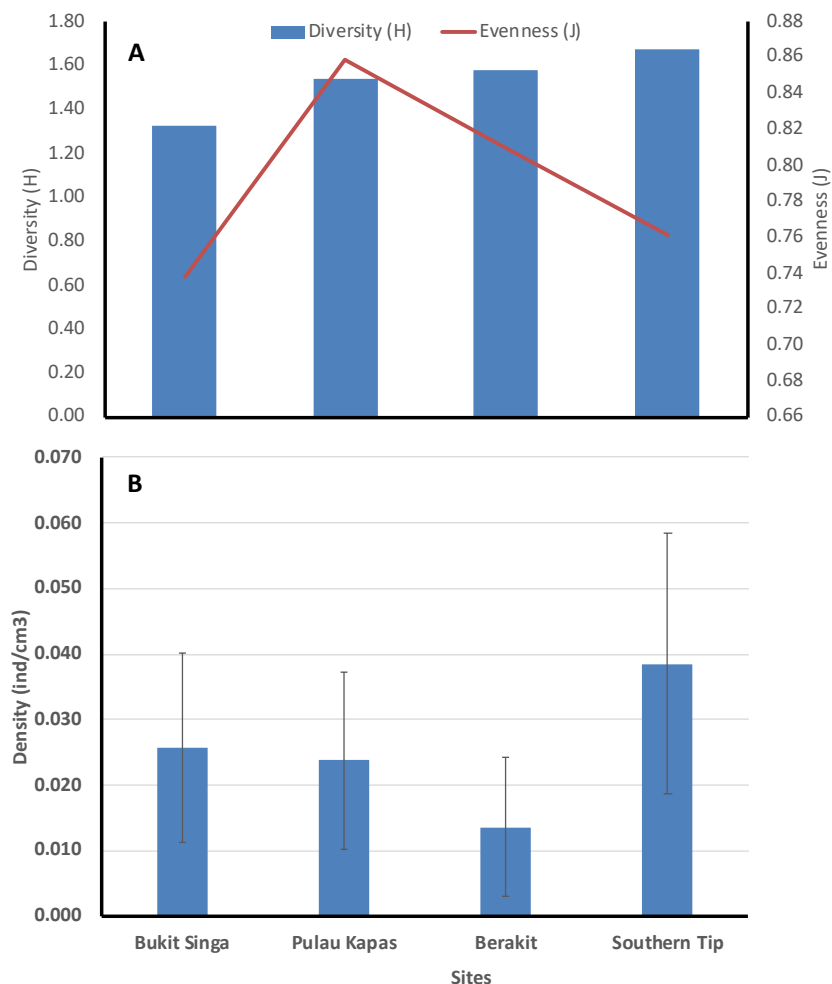


Figure 4.9. Coral rubble cryptofauna in Pulau Kapas. A: Diversity (H) and Evenness (J), B: Density (ind/cm³).

Pulau Tenggol

The abundance of coral rubble cryptofauna at Pulau Tenggol is shown in Figure 4.10. The most abundant cryptofauna was Polychaeta (61%), followed by Malacostraca (12%) and Bivalvia (10%), Ophiuroidea (7%) and Others (6%). Other classes of cryptofauna show an abundance of less than 2% each.

The diversity (H), evenness (J) and density are shown in Figure 4.11. The pattern for both diversity and evenness of cryptofauna at Pulau Tenggol were almost similar (Figure 4.11A). The highest diversity was recorded at Tukun Rajawali 2 (1.4), while the lowest diversity was recorded at two sites, namely Turtle Point and Lostword, with the H value was 0.9 each. The highest evenness was recorded at Tukun Rajawali 2, while the lowest was recorded from Turtle Point. However, the density of cryptofauna showed a different pattern compared to diversity and evenness (Figure 4.11B). The highest density was recorded from Turtle Point (0.37 ± 0.35 ind/cm³) followed by Tukun Rajawali (0.018 ± 0.022 ind/cm³). The lowest density was recorded at two sites, namely Lostworld (0.006 ± 0.006 ind/cm³) and Sri Nakhoda (0.006 ± 0.008 ind/cm³).

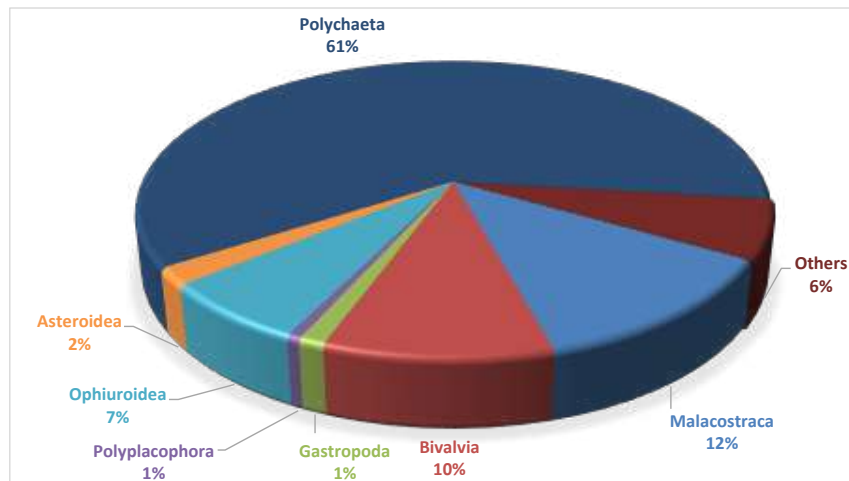


Figure 4.10. Abundance (%) of coral rubble cryptofauna at Pulau Tenggol, Terengganu. 'Others' refers to a combination of Cnidaria, Platyhelminthes, Spongia, and Sipuncula.

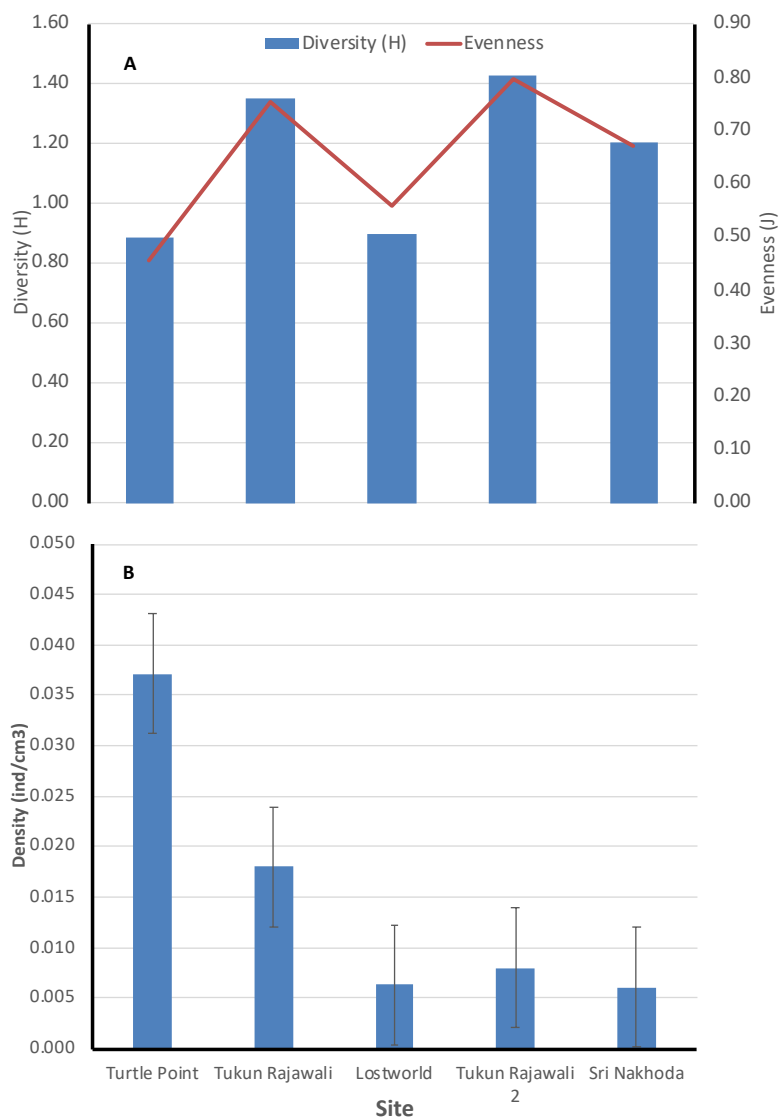


Figure 4.11. Coral rubble cryptofauna at Pulau Tenggol, Terengganu. A: Diversity (H) and evenness (J), B: Density (ind/cm³)

4.3 DISCUSSION

Based on the results, the cryptofauna diversity in the coral rubble of Terengganu Marine Park islands is dominated by two classes, including Malacostraca and Polychaeta. However, three out of four Marine Park islands were dominated by Polychaeta, while for Pulau Kapas, the abundance of Polychaeta and Malacostraca were almost similar. Several species within Polychaeta and Malacostraca are used as a bioindicator to detect an environmental disturbance in coral reef areas (Dean, 2008, Ulfah et al., 2021). Thus, a high abundance of polychaetes and malacostracans may indicate the areas are in stress. All sampling sites in Pulau Perhentian, Pulau Redang, Pulau Kapas and Pulau Tenggol are major tourist locations for water activities, including snorkelling and scuba diving. Although sampling activities were conducted almost a year after the islands were closed because of the movement control order in combating COVID-19, it is a belief that the changes in cryptofauna composition require more time to recover. The slow recovery process is due to the slow growth rates of coral (Gold and Palumbi, 2018). Pulau Bidong, used as a reference site, shows the highest diversity and evenness compared to the four Terengganu Marine Parks islands. Pulau Bidong is not gazetted as a marine park; thus, no intensive tourism activities were conducted. No resort is built on Pulau Bidong except for a research station owned by the Universiti Malaysia Terengganu. Occasionally, tourists from Pulau Redang or the mainland visited Pulau Bidong for snorkelling and SCUBA diving. The absence of a resort on the island probably the main factor of low recreational activities, subsequently causing less stress to the coral reef area.

On the other hand, the sampling sites chosen for Pulau Kapas are only suitable for experienced divers because of the strong current, which hinders snorkelling and swimming activities. This is probably why the diversity and evenness of cryptofauna at Pulau Kapas were the highest among the four Marine Park islands.

Identification of coral rubble cryptofauna is still ongoing and will take a longer time than expected. This is due to the restriction from the Movement Control Order. Nevertheless, many of the organisms collected during this study are either new record for Malaysia or new species to science.

REFERENCES

- Biondi, P., Masucci, G. D., & Reimer, J. D. (2020). Coral cover and rubble cryptofauna abundance and diversity at outplanted reefs in Okinawa, Japan. *PeerJ*, 8:e9185
- Dean, H. K. (2008). The use of polychaetes (Annelida) as indicator species of marine pollution: a review. *Rev.Biol. Trop*, 56(4), 11–38.
- Gold, Z., Palumbi, S. R. (2018). Long-term growth rates and effects of bleaching in *Acropora hyacinthus*. *Coral Reefs* 37, 267–277 .
- González-Gómez, R., Briones-Fourzán, P., Álvarez-Filip, L., & Lozano-Álvarez, E. (2018). Diversity and abundance of conspicuous macrocrustaceans on coral reefs differing in level of degradation. *PeerJ* 6:e4922
- Gischler, E., & Ginsburg, R. N. (1996). Cavity dweller (Coelobites) under coral rubble in southern Belize. *Bulletin of Marine Science*, 58(2), 570-589
- Ulfah, M., Fadhlurrahman, Devira, C. N., Kurnianda, V., Nurfadillah, N., Mellisa, S., Sembiring, A., Kurniasih, E. M., Ambariyanto, Meyer, C., & Muiari. (2021). Identification of Caridae Cryptic organism (Crustacea) on the Pocillopora dead coral in Sabang, Aceh. *IOP Conference Series: Earth and Environmental Science*, 674(1), 012008. <https://doi.org/10.1088/1755-1315/674/1/012008>

CHAPTER 5

NOTES ON THE POTENTIAL OF STABLE ISOTOPE ANALYSIS $\Delta^{13}\text{C}$ AND $\Delta^{15}\text{N}$ TO CONSTRUCT THE FOOD WEBS OF CORAL REEF ECOSYSTEM OF MALAYSIA

Maizah Mohd Abdullah and Zalina Bashir Ali

5.1 BACKGROUND

Stable isotope analysis (SIA) is a vital tool in the reconstruction of animal diets (Middelburg, 2014). In dietary studies, SIA is based on the principle that the stable isotope values of prey are transformed to the tissues of consumers in a predictable manner (Shiffman et al., 2012; Caut et al., 2013), which can be best represented by the concept of “you are what you eat” (DeNiro and Epstein, 1976). SIA can provide long-term dietary information about marine consumers, which cannot be achieved by the analysis of gut contents. Additionally, SIA can elucidate the position and role of marine producers in the food web. Marine food webs are strongly influenced by the composition and abundance of species in a certain habitat. The importance of trophic groups which form the food web differs between locations and changes with time (Glynn, 2004). Therefore, while an understanding of the trophic makeup of coral reef habitats in the South China Sea is crucial, conclusions cannot be generalized across vast reef habitats. The current study compares between the food webs at several coral reefs in the Pulau Redang to provide a brief insight into their variations within a relatively small geographic range.

In dietary studies, SIA offers many advantages over the traditional approach of analysing an animal's stomach contents to identify its prey. Although stomach contents can provide information on the exact species ingested by a shark, they can only provide a snapshot of its current diet. Therefore, in order to reasonably represent the typical diet of an entire population of sharks, many sharks must be subjected to intrusive stomach flushing, forced regurgitation or even euthanasia (Matich et al., 2010). With shark populations dwindling globally, this is a current concern in shark research (Heupel & Simpfendorfer, 2010; Hammerschlag & Sulikowski, 2011).

The analysis of stable isotopes hence provides a more ethical and conservation-friendly alternative for dietary studies involving vulnerable elasmobranch populations. SIA can be performed on tissue samples which are easily extracted without harming the individual, such as fin, dermis, or blood. Only small samples are required to produce reliable results – these can be as little as 0.5 – 1.0 mg in dry weight. This enables biologists to sample large numbers of specimens and specimens that are endangered or found within marine protected areas or no-take zones, without causing long-term harm to the population, making it the better option for dietary studies in marine protected areas.

5.2 SAMPLING OF TELEOSTS AND OTHER FOOD WEB COMPONENTS

The food web components such as invertebrates and algae should be caught and collected by hands by snorkelling and SCUBA diving. Fishes for the representative feeding groups (carnivorous, herbivorous, omnivorous) should be caught using fishing rod. All samples should be kept on ice before transported to the laboratory. All samples will be identified, and the sizes will be measured. Tissue samples from the organisms will be extracted from the caught samples for stable isotope analysis.

For specific target species such as blacktip reef sharks to represent the apex predator of near shore coral reef habitat, angling method is appropriate. Blacktip reef sharks, *Carcharhinus melanopterus*, could be angled from the shore using a suitable fishing rod fitted with a fishing reel. After a specimen's morphological data was recorded, fin and blood samples could be obtained for stable isotope analysis, and the sharks will be released back into the ocean. A fin clipping of approximately 1 cm² should be taken from the base of the dorsal fin using a pair of dissecting scissors. The fin clippings should immediately transferred into a 5 ml plastic vial containing 5 ml of 70% ethanol.

5.3 SAMPLE PREPARATION AND STABLE ISOTOPE ANALYSIS

In the laboratory, samples should be rinsed with distilled water and dried in an oven at 60°C for 48 h, or until completely dry. Dry samples should be homogenized into a fine powder using a pestle and mortar. The pulverized samples should be subsequently transferred into 2 ml sterile plastic and kept in sealed Ziploc® bags containing silica gel desiccants. All samples could be sent to the Department of Chemistry Malaysia (DCM) for analysis. Approximately 1.5 mg of powdered tissue from each sample will be combusted at 1000°C using a SerCon ANCA GSL elemental analyser interfaced via continuous flow to a SerCon GEO20-20 isotope-ratio mass spectrometer. Stable isotope abundances will be measured in triplicates for each sample by comparing the ratio of the two most abundant isotopes (e.g. ¹³C/¹²C and ¹⁵N/¹⁴N) in the sample to the international standard. Standards used for carbon and nitrogen are the secondary standards referenced to a relative known international standard, Vienna Pee Dee Belemnite and atmospheric nitrogen (air), respectively.

5.4 RESULTS INTERPRETATION

In general, animals with enriched $\delta^{13}\text{C}$ values, ranging between circa -19.0 ‰ and -16.0 ‰ indicates that the animals relied fully on coastal marine food resources such as marine plankton and algae (Thimdee et al. 2004; Zulkifli et al. 2014). Animals fed on the widest range of food resources are forming a distinct cluster on the dual isotopes plot and shows the most negative values of $\delta^{13}\text{C}$.

CHAPTER 6

CORAL REEFS HEALTH: VIEW FROM BENTHIC AND FISH POPULATIONS

Jen Nie Lee, Meii Mohamad Norizam and Yusri Yusuf

6.1 INTRODUCTION

The coral reefs are filled with a variety of plants and animals where scleractinian coral are one of the most important components. The abundance and diversity of coral reef communities is different in those areas. There are areas that are more vulnerable to developmental stress but do not show a change in the health of coral reefs. The health level of coral reefs is usually measured by the cover of hard coral. Coral health index index / score commonly used in the Asian region (Chou et al. 1994) is based on the percentage of live coral percentages (hard and soft coral). Nevertheless, the determination of the percentage of live coral cover is unclear to the health status of the coral reef ecosystem. Some agencies and other countries have the concept of determining the health of coral reef ecosystems and different indicator species based on the skill level and data retrieval techniques of some components.

Covid-19 outbreak in Malaysia in the early 2020 causes Movement Control Order (MCO) in mid-March 2020 which require all business to stop operating except essential services (Tang 2020, Ong et al. 2021). The stringent lockdown was enforced just right after the monsoonal cycle that closes most islands (including Pulau Redang) from November to February each year. This event generally gives positive input to the coral reefs with less anthropogenic impacts such as limited boating activity and water activities such as snorkelling and diving. Thus, this study aim to determine the changes of coral reef health and benthic composition difference before and post-COVID-19 in comparison to previous report (Lee et al. 2020) at the same sites.

6.2 METHODOLOGY

The selected reefs were identified to monitor and collect coral reef information surrounding Pulau Redang with locations from Chagar Hutang (CH), Terumbu Kili (TK), Pulau Lima (PL), Pulau Kerengga Besar (KR) and Pasir Mak Simpan (MS) (Figure 6.1). Reef assessment was conducted using 50 m transect line, starting with fish identification and total number of each species. Then, the survey of benthic communities using Code from ROLL-2 (Table 6.1; Lee et al. 2019) with 19 categories. At the same time, photo quadrat images of 0.5 x 0.5m were taken along the transect line for further analyses.

Table 6.1: Benthic categories according to ROLL-2b

HC	Karang keras (termasuk semua jenis selain daripada BA&BN) Hard coral (includes all types other than BA&BN)
BA	Karang Acropora bercabang / Branching Acropora
BN	Karang bercabang tapi bukan Acropora / Branching non-Acropora
SC	Karang lembut / Soft coral
ZO	Zoanthids
RKC	Karang baru mati / Recently killed coral
DC	Karang mati / Dead coral
DCA	Karang mati diliputi alga / Dead coral with algae
NIA	Alga penunjuk nutrien / Nutrient indicator algae: Filamen hijau / Filamentous Green - (e.g. Cladophora, Chaetomorpha) Filamen hijau-biru / Filamentous Blue-Green - (e.g. Lyngbya) Helaian hijau / Foliose / Sheet Green - (e.g. Ulva, Enteromorpha, Caulerpa)
AL	Alga lain / Other algae
CCA	Alga kekarang krustos / Crustose coralline algae
CA	Alga berkapur / Calcified alga
SG	Rumput laut / Seagrass: Halophila HA/NHA
SP	Span / Sponge
RC	Batu / Rock > 15cm
RB	Piung / Rubble < 15cm
SD	Pasir / Sand
SI	Selut/Slit/Clay
OT	Lain-lain/Other

The community of coral reef fishes will be monitored using the belt transect (English et al. 1997), to determine the changes in the reef fishes community. Total number of individuals for each coral reef fish will be identified and recorded along the belt transect of 5m x 50m (250m² area). For unidentified species, photographs will be taken, using underwater cameras for later identification, using established field guides such as Allen & Erdmann (2012) and Matsunuma et al., (2011).

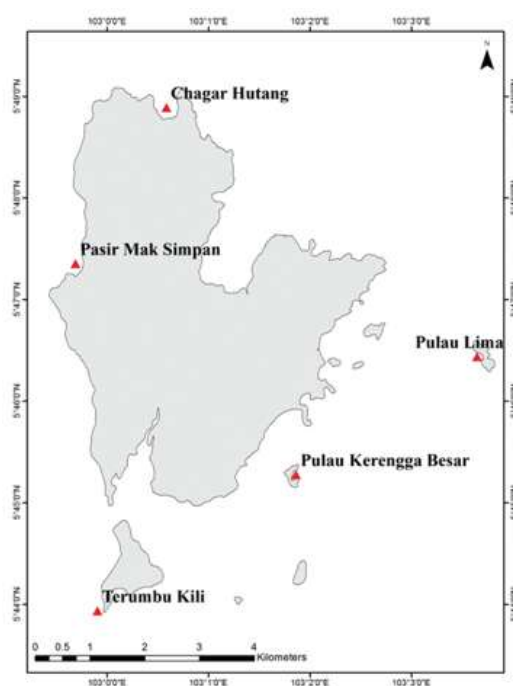


Figure 6.1: Map of study area around Pulau Redang (Lee et al. 2020)

6.3 RESULTS AND DISCUSSION

6.3.1 Benthic composition

Benthic composition (Figure 6.2) using live coral cover were determine with comparative to previous finding in 2016 at the same sites showed that some sites increased or decreased of live coral cover (Fig 6.3). Statistical comparison (Welch Two sample t-test) showed no significant differences of the live coral or algae cover from 2016 to 2020 (Fig 6.4). Even though major decline of live coral cover at Mak Simpan was directly as an outcome of Pabuk event that hit the area in early 2019, it was not significantly different. Same analyses for algae cover as it was hypothesised that less human disturbance during COVID-19 will increase the fish grazing activity and reduces the algae cover. Obvious reduction of branching *Acropora/Pocillipora* was clearly observed in photo quadrat and other photo records as in table below. There are possibilities of same effects at Terumbu Kili and other locations too. However, increase of live coral cover can be influence by many other factors.

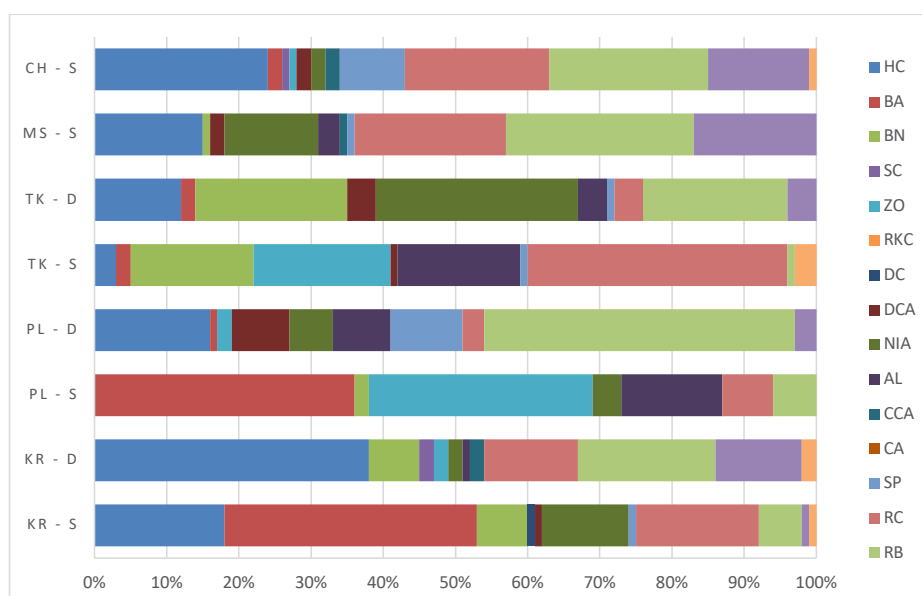


Figure 6.2: Benthic composition recorded at all sampling sites using ROLL-2 method at Pulau Redang in 2020.

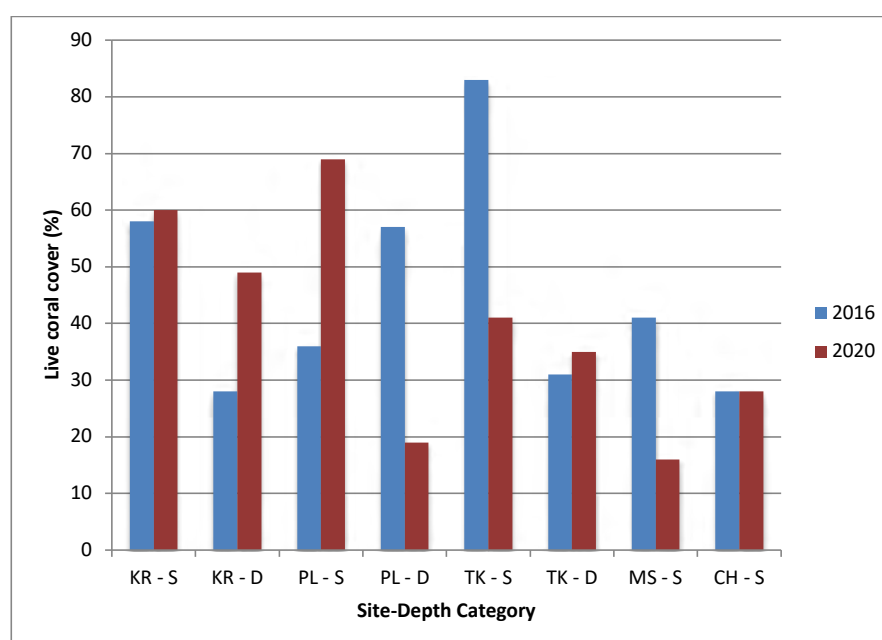


Figure 6.3: The differences of live coral cover in each site from the same sampling location.

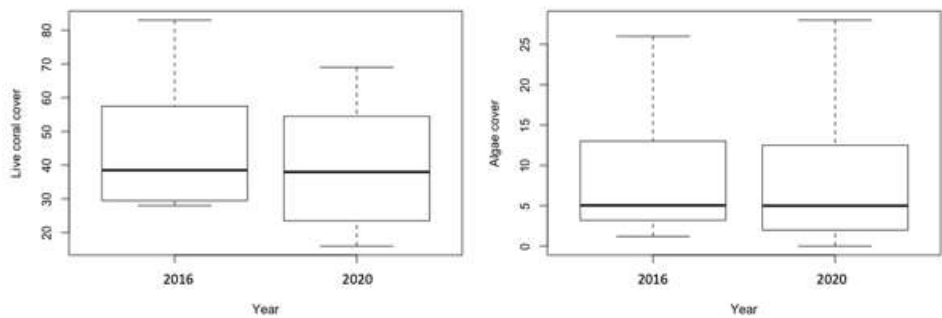




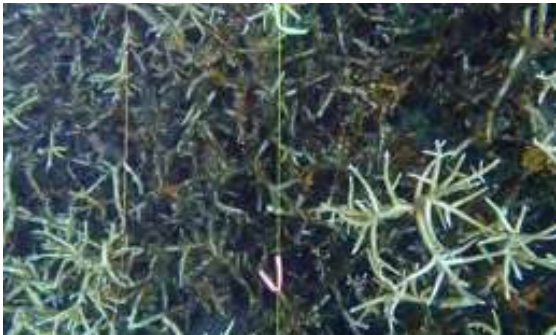

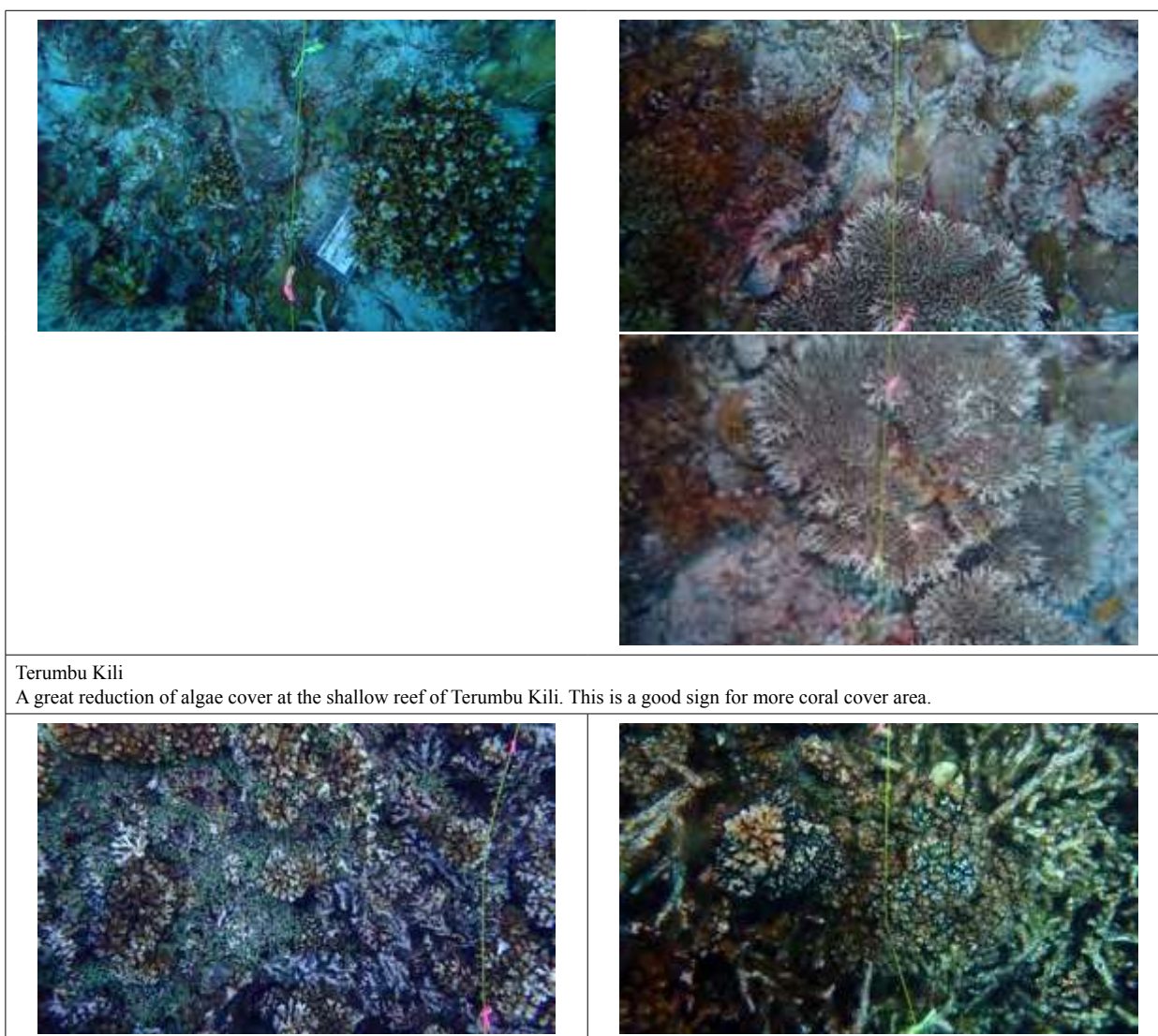


Figure 6.4: No significant differences of live coral and algae cover from the same sites surveyed in 2016 and 2020

Photos comparison

2016	2020
Mak Simpan: Same area at Mak Simpan during 2016 (left) and after Pabuk Storm in 2019 (right). Massive corals are still standing, tilted or overturned. Most branching corals were broken and killed.	
	
Pulau Kerangga: Same giant clams are health at the same site.	
	
Pulau Lima: Pulau Lima shallow reefs are mainly dominated with branching Acropora. Reduce of algae cover in 2020 shows a good sign of less anthropogenic influence; and the site usually showed pale colour coral.	
	
Pulau Lima: Same area was recorded in 2016 and 2020. Pocillopora colonies enlarged and a new colony of table Acropora which is about 0.5m diameter.	



Terumbu Kili

A great reduction of algae cover at the shallow reef of Terumbu Kili. This is a good sign for more coral cover area.

Meanwhile, this survey also collect *in-situ* data of coral reef health using new method developed in 2019 (Lee et al. 2019). Pulau Kerengga shows higher branching *Acropora* at shallow water compared to other hard coral lifeform, which was, massive *Porites*. Pulau Lima recorded high branching *Acopora* at shallow water meanwhile more rubble from broken branching *Acropora* at deeper water, due to COT infection and minor wave action.

6.3.2 Fish composition

A total of 15810 individuals from 102 species of coral reef fishes were observed during the post COVID survey at Pulau Redang. Number of species observed at all sites were lower when compared to previous survey in 2016 with a total average species at all sites were 43.2 ± 7.8 (pre COVID) and 38.3 ± 6.5 species (post COVID) (Table 6.2). From all study sites of pre and post COVID, similar trend of species diversity were observed, with Mak Simpan has the highest number of coral reef fish species and the lowest were observed at Pulau Kerengga Deep (Figures 6.5 and Table 6.2).

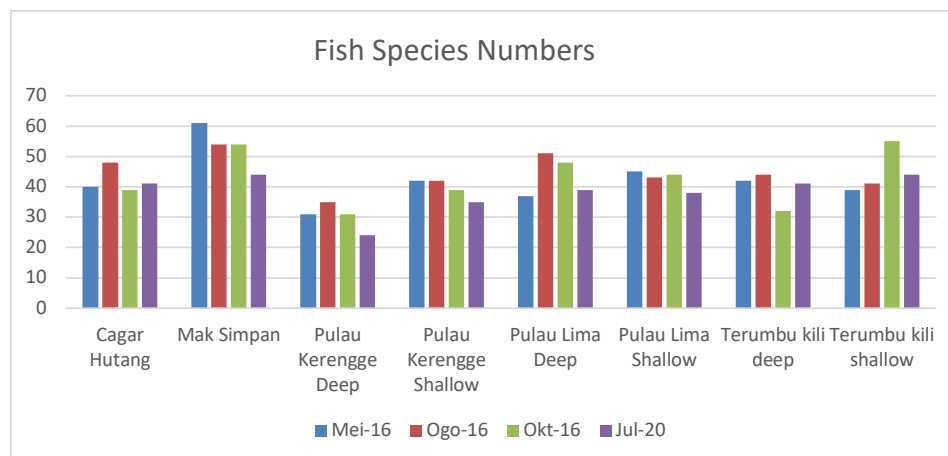


Figure 6.5: Comparison of coral reef fish diversity and sites during pre (2016) and post Covid (Jul 2020).

Table 6.2: Comparison of coral reef fish diversity and sites during pre (2016) and post Covid (Jul 2020).

Number of species	Pre COVID				Post COVID	
	Mei-16	Ogo-16	Okt-16	Means (n=3)	SD	Jul-20
Pulau Lima Deep	37	51	44	44.0	7.0	39
Pulau Lima Shallow	45	43	48	45.3	2.5	38
Cagar Hutang	40	48	39	42.3	4.9	41
Mak Simpan	61	54	54	56.3	4.0	44
Pulau Kerengge Deep	31	35	31	32.3	2.3	24
Pulau Kerengge Shallow	42	42	39	41.0	1.7	35
Terumbu Kili Deep	42	44	32	39.3	6.4	41
Terumbu Kili Shallow	39	41	55	45.0	8.7	44

A total of 15810 individuals of coral reef fishes were observed at all sites during post COVID survey. Individual fishes observed at all sites were lower when compared to previous survey in 2016 with, an average individuals at all sites were 2405.1 ± 4396.2 (pre COVID) compared to 1976.2 ± 1317.58 individuals (post COVID) (Fig 6.8).

Generally, the numbers of individuals observed at sites during post COVID surveys were higher when compared to previous study, with an exception to Pulau Kerengge Deep and Terumbu Kili (Deep and Shallow). Number of individuals at Terumbu Kili were very much influenced by a big school of "kunyit-kunyit" (*Lutjanus lutjanus*), which were observed in the previous study, but were absent during the post COVID survey.

From this study of coral reef fish populations of pre and post COVID at Pulau Redang, we can see a relatively lower species diversity of coral reef fishes at sites in Pulau Redang during post COVID, but the number of fishes observed tend to be higher at most of the sites when compared with pre COVID conditions (Figure 6.6 and Table 6.3).

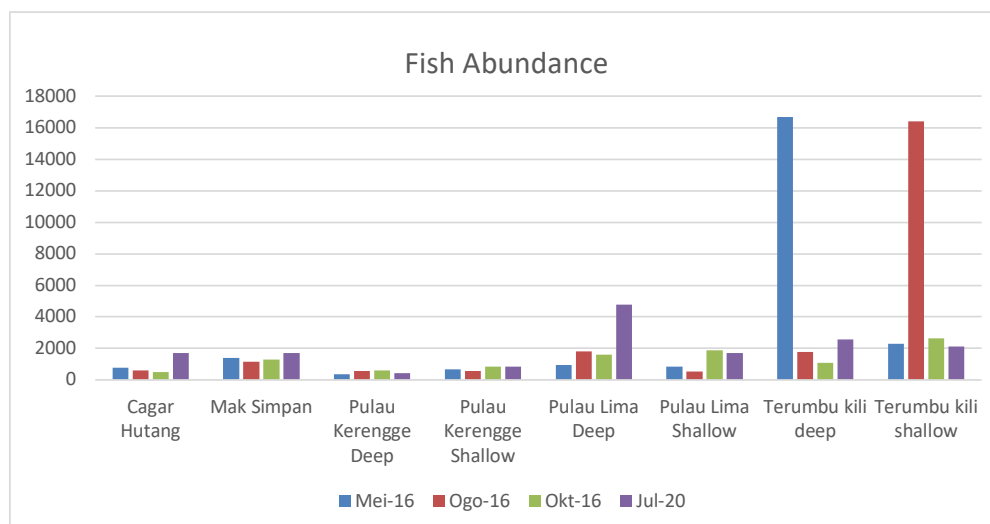


Figure 6.6: Comparison of coral reef fish abundance and sites during pre (2016) and post Covid (Jul 2020).

Table 6.3: Comparison of coral reef fish abundance and sites during pre (2016) and post Covid (Jul 2020).

Number of individuals	Pre COVID					Post COVID
	Mei-16	Ogo-16	Okt-16	Means (n=3)	SD	Jul-20
Pulau Lima Deep	944	1827	1864	1545.0	520.8	4779
Pulau Lima Shallow	836	528	1607	990.3	555.8	1705
Cagar Hutang	761	599	486	615.3	138.2	1692
Mak Simpan	1390	1141	1283	1271.3	124.9	1700
Pulau Kerengge Deep	353	568	599	506.7	134.0	428
Pulau Kerengge Shallow	664	554	857	691.7	153.4	830
Terumbu Kili Deep	16689	1767	1089	6515.0	8817.5	2554
Terumbu Kili Shallow	2276	16392	2649	7105.7	8044.4	2122



Thalassoma lunare and *Cheilinus chlorourus*



Abudefduf vaigiensis



Sargocentrum rubrum



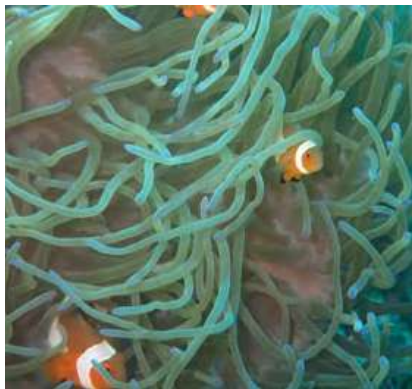
Chaetodon octofasciatus



Sphyraena flavicauda



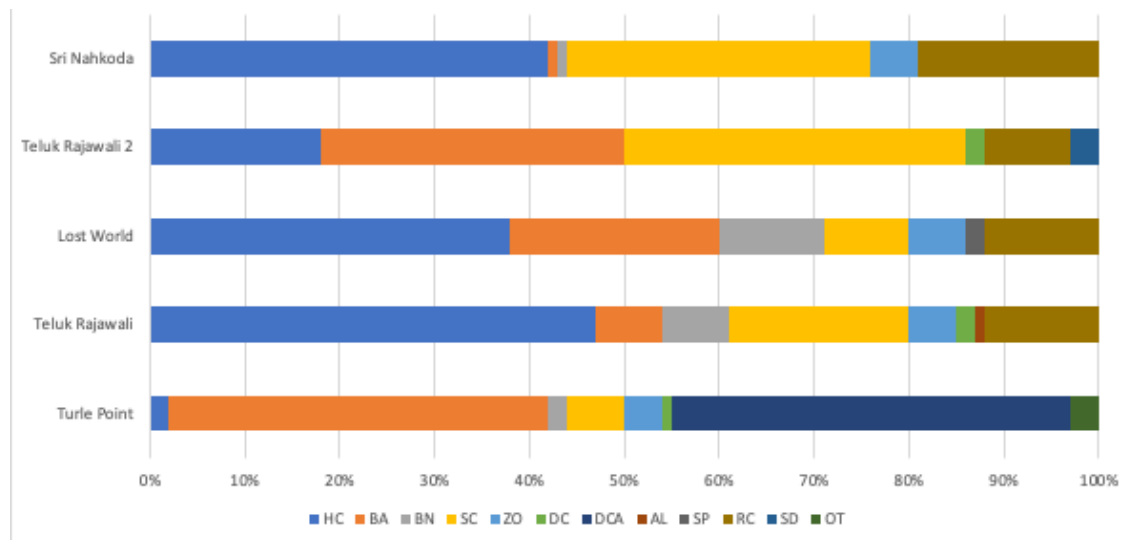
Cephalopis boenak

*Caesio* sp.*Siganus guttatus**Pomacentrus alexanderae**Amphiprion ocellaris**Diproctacanthus xanthurus**Amphiprion perideraion**Labroides dimidiatus**Dascyllus reticulatus**Amphiprion clarkii*

6.4 Pulau Kapas

Apart from Pulau Redang as the main surveyed, the team also went to Pulau Kapas as part of the expedition on the 22-23 September 2020. Survey of benthic composition and fish diversity as describe in the method above. Rapid surveyed at Pulau Kapas discovered a wide range of reefs composition of poor (Southern Tip, 5m) to excellent (Southern Tip, 2m) is a very closed area (Fig 6.x). Each site was unique on its own and coral composition. Silent reef was mainly covered with rocky substrate and only 31% live coral cover. Similar environment at Berakit, however patches of corals were segmented by sandy bottom. Teluk Jawa were dominated Blue coral, (*Octocorallia*, *Heliopora coerulea*). It was one of the locations that had the highest covers of Blue coral apart from Pulau Pinang, Redang (from the experience of surveyor). Meanwhile at Southern Tip (transect were laid at 2 different depths, 2m and 5m), restoration A-frames were noticed during the survey at the reef slope (5m). It was dominated with massive *Porites*. When the team decided to do a rapid survey to shallower water (2m), it was noticeable that the shallower reefs were highly covered with table *Acropora* and branching *Acropora*. The live coral cover at Southern Tip, 2m was 77 % and represented as excellent condition.

6.5 Pulau Tenggol



REFERENCES

- Allen, G.R. and Erdmann, M.V., 2012. Reef fishes of the East Indies. Volumes I-III. University of Hawai'i Press, Tropical Reef Research. Perth, Australia:
- Chou, L. W., Licuanan, W. R., Alino, P., Cheshire, A. C., Loo, M. G., Tanjaitrong, S., o.a. (1994). Status of the coral reefs in the ASEAN region. i C. R. Wilkinson, S. Sudara, & L. M. Chou, *Proc 3rd Asean-Australia Symp on Living Coastal Resources* (ss. -). Townsville: Australia Institute of Marine Science.
- Lee, J.N., Yusri, Y., Md. Nizam, I. & Chan, A.A. (eds) (2020) Climate Change: Coral Reef Communities of Pulau Redang Marine Park, Terengganu. Marine Park and Resource Management Division, Department of Fisheries Malaysia. Ministry of Agriculture and Food Industry. Putrajaya, Malaysia 64pp.
- Lee, J.N., Yusri, Y., Ab. Rahim, G.Y., Lim, A.G., Noorikhwanie, Z., Izarenah, M.R., Md.Nizam, I., Mohamad Anuar, R. (2019). Garis Panduan Sistem Pemantauan Dan Penilaian Tapak Selam, Jabatan Perikanan Malaysia, Kementerian Pertanian dan Industri Asa Tani. 44pp.
- Matsunuma, M., Motomura, H., Matsuura, K., Shazili N. A. M. and Ambak M. A., (eds.). Fishes of Terengganu – east coast of Malay Peninsula, Malaysia. National Museum of Nature and Science, Universiti Malaysia Terengganu and Kagoshima University Museum.
- Ong, M.C., Adiana, G., Roswati, M.A., Kesaven, B., Lee, J.N., Tuan, M.F., T.O., Idham, K., Suvik, A... (2021). Positive and Negative Effects of Covid-19 Pandemic on Aquatic Environment: A Review. *Sains Malaysiana* 5-(4): 1189-1200. doi. org/10.17576/jsm-2021-5004-28
- Tang, K.H.D. (2020). Movement control as an effective measure against Covid-19 spread in Malaysia: an overview. *J Public Health (Berl.): From Theory to Practice*.

CHAPTER 7

TEMPERATURE, SALINITY, AND HYDRODYNAMIC CONDITION IN PULAU REDANG, PULAU PERHENTIAN, PULAU KAPAS AND PULAU TENGGOL DURING POST COVID-19 LOCKDOWN

Nur Hidayah Roseli, Yuzwan Mohamad, Munawwarah Abdul Aziz
and Nurul Maisarah

7.1 INTRODUCTION

The physical oceanography involves the study of physical processes and seawater properties in the ocean. The importance of physical oceanography is to understand the circulation and how it works to change the physical, biological, and chemical properties. Malaysia that located in the southern region of South China Sea is an area with monsoons influences. There is northeast monsoon (Nov – Feb), southwest monsoon (June – September) and monsoon transition month (March – May and October) (Akhir, 2012, Daud & Akhir, 2015; Zhu et al., 2019). Current circulation and seawater properties in Terengganu waters varied relatively with the monsoonal winds. During northeast monsoon, the temperature and salinity in the coastal waters of Terengganu is cooler and less salty. During southwest monsoon season, the temperature and salinity in the coastal waters of Terengganu is warmer and saltier (Akhir & Yong, 2011; Roseli & Akhir, 2014; Roseli et al., 2015). During northeast monsoon, the currents along Terengganu waters were strong and moved northward. Meanwhile, during southwest monsoon, the currents flow southward along Terengganu water (Akhir, 2012; Daud & Akhir, 2015; Tangang et al., 2011; Zainol et al., 2020). Tides in the Terengganu waters are mixed tides with dominant diurnal tides (Daryabor et al., 2016; Roseli et al., 2019). The major daily tidal constituents with greater amplitudes are M_2 (12.4hrs) and K_1 (23.93hrs). The tidal waves propagate from the deep basin into the continental shelf before it splits into the Gulf of Thailand and east coast Peninsular Malaysia. Waves in Terengganu coastal water also varied according to monsoons. Higher (smaller) wave energy values can be observed during the winter (summer) monsoon. Spatially, waves energy flux was higher in the northern part of east coast peninsular Malaysia including Terengganu coastal waters compared to the southern areas. Those waves that were generated from the central and northern South China Sea can penetrate directly due to a long fetch (Mirzae et al., 2014).

The pandemic COVID-19 that induced lockdowns all over the world would affect the environment. It was either have led to significant cooling of the Earth system or increased the heat. The impact of COVID-19 lockdowns is expected to cause measurable changes to the dynamics and thermodynamics of the coastal water. Thus, this study was done to determine the seawater properties and currents circulation during post-COVID-19 lockdown in the islands around Terengganu waters by using in-situ measurement and numerical model simulation. The objective of this study are: 1) To determine the seawater properties in four different islands in Terengganu waters during post COVID-19 lockdown; and 2) To determine the current circulation in four islands off Terengganu water through numerical modelling during post COVID-19 lockdowns.

7.2 METHODOLOGY

In-situ measurement

In-situ data collection were done in four islands, Pulau Redang, Pulau Perhentian, Pulau Kapas and Pulau Tenggol from July until October 2020 (Table 7.1). Total of 71 stations were involved in the data collection.

Table 7.1. Sampling location, sampling time and number of stations

SAMPLING LOCATION	SAMPLING TIME	NO. OF STATIONS
Pulau Redang	21 – 22 July 2020	21
Pulau Perhentian	23 – 25 August 2020	18
Pulau Kapas	24 September 2020	12
Pulau Tenggol	12 October 2020	10

Equipment used to measure temperature and salinity is the conductivity-temperature-depth (CTD castaway). During the first trip in Pulau Redang, the multiparameter was not available, thus only temperature and salinity from CTD are available. In situ currents were measured using Acoustic Doppler and Current Profiler. In Pulau Redang and Perhentian, the ADCP was towed around the island. Global Positioning System (GPS) simultaneously recorded the coordinate of the location. However, during the first sampling in Pulau Redang, there was an error in GPS data which will not be used in the study. The next measurement of currents in Pulau Kapas and Pulau Tenggol, we used the synoptic technique. The ADCP was lowered down at every station for a five minutes period. Due to scarcity in currents field data using the ADCP, the numerical modelling technique is included in the study to understand the variation of circulation around the islands. The coastal modelling was done by using MIKE 21 Hydrodynamic Model FM by DHI software.

Coastal hydrodynamic Modelling

MIKE 21 Hydrodynamic Model FM is used to simulate the current circulation in the four islands. The model inputs including bathymetry, winds, and tides. Bathymetry input was obtained from MIKE C-Map and Nautical Naval Chart. This model used ERA5 hourly winds input from European Centre for Medium-Range Weather Forecasts (ECMWF) that can be retrieved from <https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-singlelevels?tab=overview>. Tidal prediction for three open boundaries were obtained from Tidal Tools in MIKE 21 Toolbox. The model was run for one year; from 1 January until 31 December 2020 with time step of 1460 and time intervals of 6 hours.

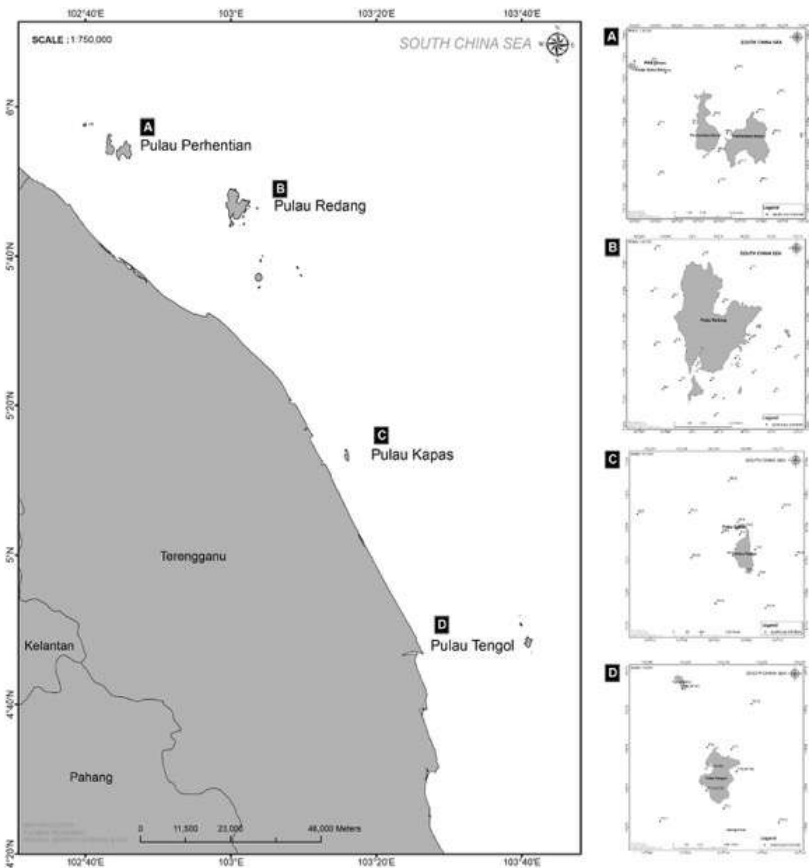


Figure 7.1: Sampling location in Terengganu waters. A is Pulau Perhentian, B is Pulau Redang, C is Pulau Kapas and D is Pulau Tenggol.

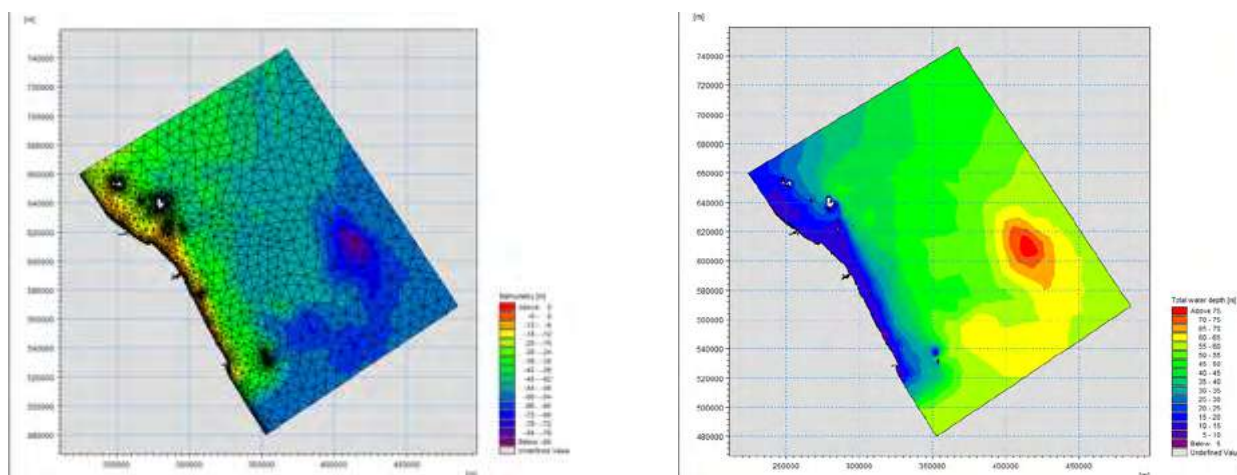


Figure 7.2. Bathymetry generates in a flexible mesh (*left panel*) and total water depth (*right panel*). Bathymetry inputs including, MIKE C-Map and Nautical Naval Chart.

7.3 RESULTS AND DISCUSSION

In-situ observation of temperature and salinity

The temperature and salinity data collected from CTD cast were presented in Table 7.2, Figure 7.3 and Figure 7.4. The highest average temperature was recorded in Pulau Perhentian ($30.09 \pm 0.621^\circ\text{C}$) and the lowest average of temperature was recorded in Pulau Tenggol ($28.83 \pm 0.887^\circ\text{C}$). For salinity, the highest and lowest record was in Pulau Tenggol (32.93 ± 0.323 psu) and Pulau Perhentian (32.87 ± 0.370 psu).

However, the minimum and maximum values in each island showed different characteristics compared to the average values. The maximum temperature values in Pulau Redang, Pulau Perhentian, Pulau Kapas and Pulau Tenggol were 31.39°C , 31.60°C , 30.90°C and 29.67°C respectively. The maximum salinity values in Pulau Redang, Pulau Perhentian, Pulau Kapas and Pulau Tenggol were 33.94 psu, 33.86 psu, 33.61 psu and 34.45 psu respectively. The maximum values of temperature usually indicate the surface temperatures while the maximum values of salinity show the values for bottom salinity.

According to the profiles of potential density anomaly in Figure 7.5, the density in these four islands below pycnocline were mainly influenced by salinity. Meanwhile, the upper pycnocline layer is influenced by thermal stratification. In the coastal islands, salinity plays important role in the variations of density. Fresher and warmer water occupied most of the surface layer while saltier and cooler water occupied the layer below pycnocline. This condition is called stratification.

Stratification layer can be observed through the thermocline, halocline and pycnocline layer where temperature, salinity, and potential density changes rapidly with depth respectively (Figure 7.3, 7.4 and 7.5). Stratification occurs as a result of a density differential between two water layers and can arise as a result of the differences in salinity, temperature, or a combination of both. During southwest monsoon, continuous solar heating and weaker winds caused the warmer and fresher water do not mix with the deeper water column thus enhance the stability of vertical profile. Enhanced stratification due to rapid warming can cause less water exchange between the bottom and the near surface. Limited vertical water exchange is expected to affect many biological processes due to less nutrient supply to the near sea surface especially during prolonged anomalous thermal stress condition.

Table 7.2. Basic statistics of temperature, salinity and potential density from CTD.

	Mean	Std. Dev	Min	Max
<i>Pulau Redang – July 2020</i>				
Temp, $^\circ\text{C}$	29.98	0.666	27.27	31.39
Salinity, psu	32.93	0.323	32.53	33.94
Pot. Density, kg/m^3	20.19	0.4599	19.61	21.83
<i>Pulau Perhentian – August 2020</i>				
Temp, $^\circ\text{C}$	30.09	0.621	27.72	31.60
Salinity, psu	32.87	0.370	32.23	33.86
Pot. Density, kg/m^3	20.11	0.481	19.25	21.64

Pulau Kapas – September 2020

Temp, °C	29.69	0.438	28.72	30.90
Salinity, psu	33.28	0.093	32.91	33.61
Pot. Density, kg/m ³	20.54	0.199	19.87	21.07

Pulau Tenggol – October 2020

Temp, °C	28.83	0.887	25.81	29.67
Salinity, psu	33.29	0.371	32.90	34.45
Pot. Density, kg/m ³	20.84	0.557	20.41	22.68

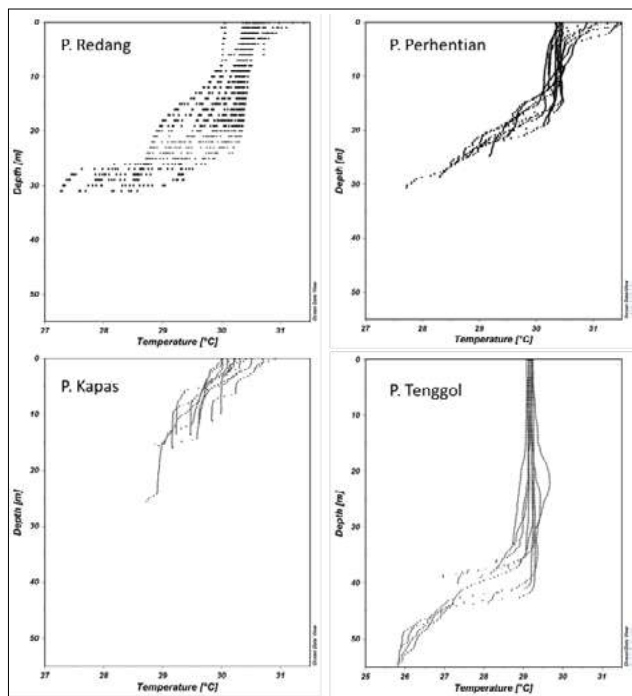


Figure 7.3. Temperature profiles in Pulau Redang, Pulau Perhentian, Pulau Kapas and Pulau Tenggol obtained from CTD.

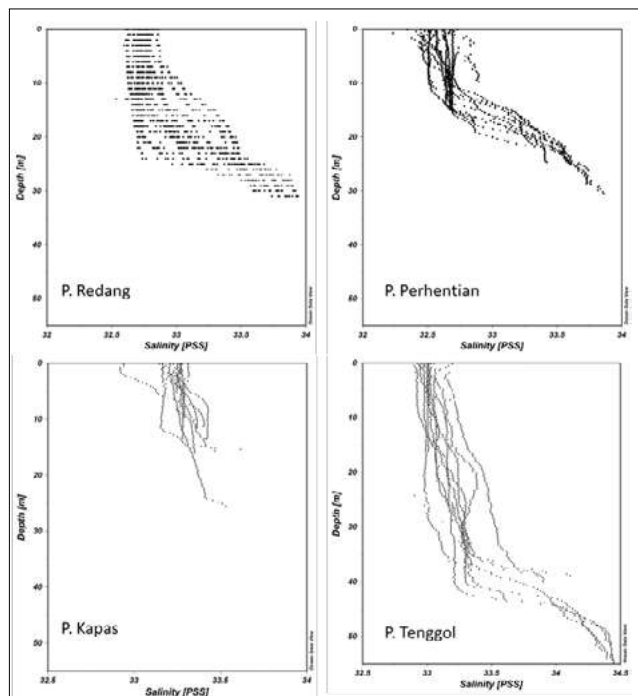


Figure 7.4. Salinity profiles in Pulau Redang, Pulau Perhentian, Pulau Kapas and Pulau Tenggol obtained from CTD.

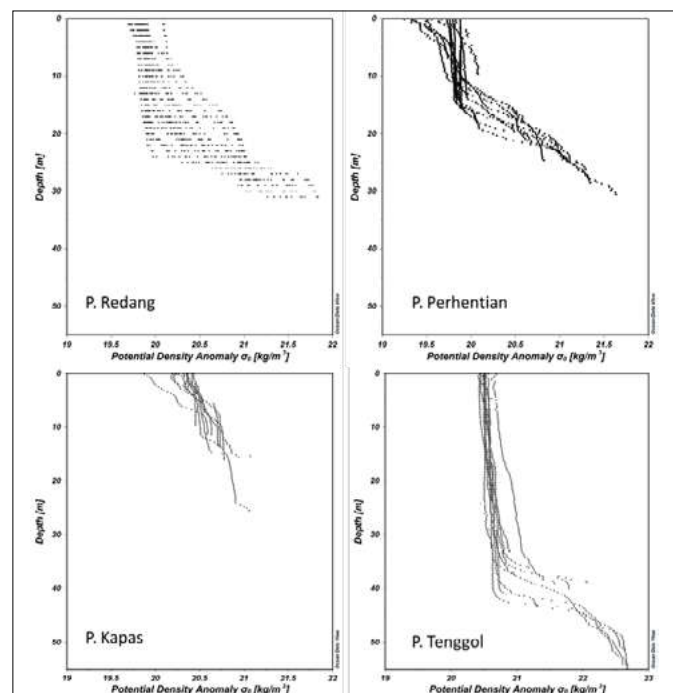


Figure 7.5. Potential density anomaly in Pulau Redang, Pulau Perhentian, Pulau Kapas and Pulau Tenggol obtained from CTD.

Tides

Predicted tide level was plotted from July to October 2020 in line with the sampling dates of the four islands (Pulau Redang, Pulau Perhentian, Pulau Kapas and Pulau Redang) (Figure 7.6).

During the sampling in Pulau redang (21 – 22 July 2020), the tides was spring tides with large tidal range. The maximum water level in this period was 1.12 m and the minimum water level was -1.02 m.

In August at Pulau Perhentian (23 – 25 August 2020), the tides were neap tides with smaller tidal range. The maximum water level was 0.57 m and the minimum water level was -0.47 m.

Sampling time in Pulau Kapas was done during transition between neap tides to spring tides with maximum and minimum water level were 0.77 m and -0.47 m respectively.

During the sampling time in Pulau Tenggol (12 October 2020), the tides was spring tides with slightly high-water level (0.98 m). The minimum water level was -0.68 m. Tidal ranges in Tenggol during the sampling time is smaller than in Redang even though it was done during spring tides.

Table 7.3. Tides condition during the sampling time.

Sampling date	Sampling location	Tides	Maximum water level	Minimum water level
21 – 22 July 2020	Pulau Redang	Spring tides	1.12 m	-1.02 m
23 – 25 August 2020	Pulau Perhentian	Neap tides	0.57 m	-0.47 m
24 September 2020	Pulau Kapas	Neap - Spring tides	0.77 m	-0.76 m
12 October 2020	Pulau Tenggol	Spring tides	0.98 m	-0.68 m

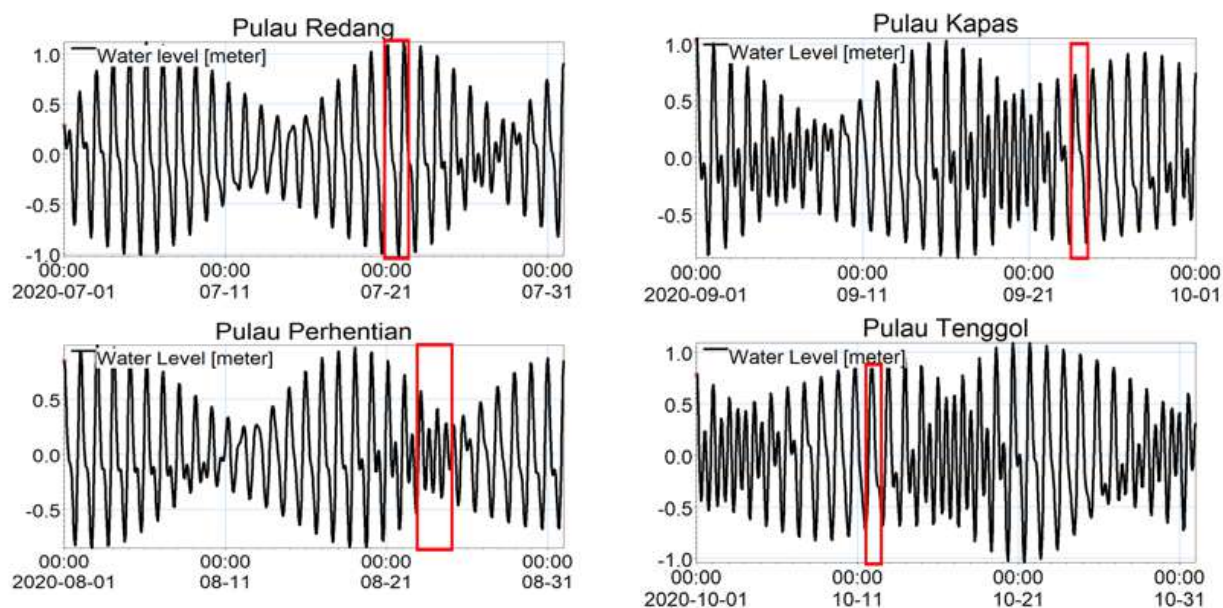


Figure 7.6. Tides from global tidal prediction of height at Pulau Redang (July 2020), Pulau Perhentian (August 2020), Pulau Kapas (September 2020) and Pulau Tenggol (October 2020). Red rectangular box represents sampling dates.

Winds

Wind rose diagrams for Pulau Redang, Pulau Perhentian, Pulau Kapas and Pulau Tenggol were presented in Figure 7.7, 7.8, 7.9 and 7.10 respectively. The winds data were extracted from model outputs at similar period as field observation time. The 'spokes' in a wind rose diagram shows the frequency of time that the wind blows from a particular direction. The colour band shows the wind speed ranges. The direction of the longest spoke shows the wind direction with the greatest frequency. The frequency of calm or nearly calm air is given as a percentage number in the centre.

According to the wind rose diagram for Pulau Redang, between 21 – 22 July 2020 (Figure 7.7), the most dominant wind speeds at these islands were between 2 - 6 ms^{-1} with most dominant wind's direction are south-westerly. Maximum wind speed ranges from 6 – 8 ms^{-1} . Winds were calm 0% within these two days.

As for Pulau Perhentian, between 23 – 25 August 2020 (Figure 7.8), the most dominant wind speed ranged from 2 - 6 ms^{-1} . The winds were mostly blow from south to the north. Maximum wind speed ranged from 6 - 8 ms^{-1} . Winds were calm 9.72% most of the time.

At Pulau Kapas on 24 September 2020 (Figure 7.9), the most dominant wind speed was ranged from 2 to 4 ms^{-1} . Maximum wind speed ranged from 6 – 8 ms^{-1} . The winds were mostly blow from south to the north. Winds were calm 16.87% most of the time.

On 12 October 2020 at Pulau Tenggol (Figure 7.10), the wind direction mostly blew from south-west direction. Most dominant wind speed ranges from 4 – 6 and 6 – 8 ms^{-1} . The maximum wind speed between 6 - 8 ms^{-1} lasted for a longer time compared to in other months. Winds were calm 0% within the time.

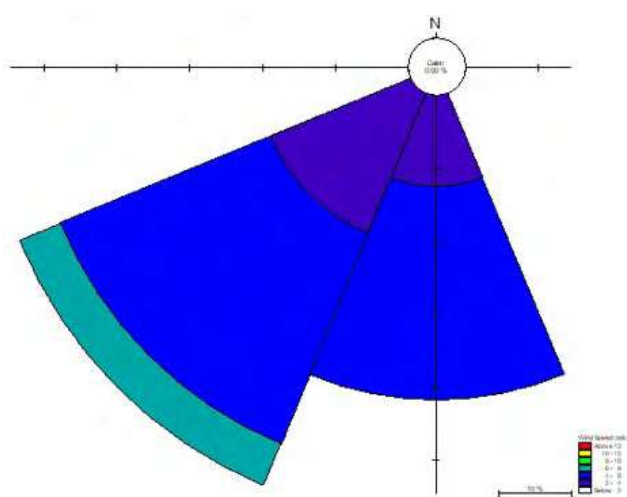


Figure 7.7. Wind rose diagram for Pulau Redang from 21 – 22 July 2020.

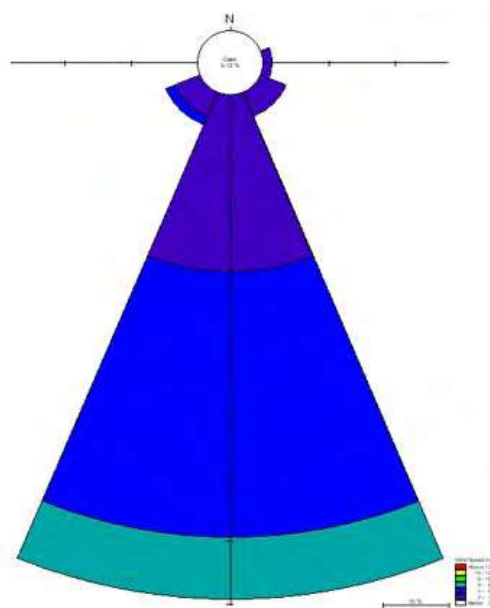


Figure 7.8. Wind rose diagram for Pulau Perhentian from 23 – 25 August 2020.

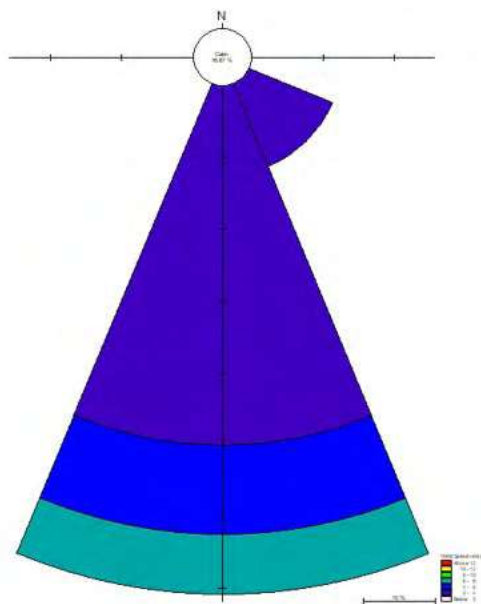


Figure 7.9. Wind rose diagram for Pulau Kapas on 24 September 2020.

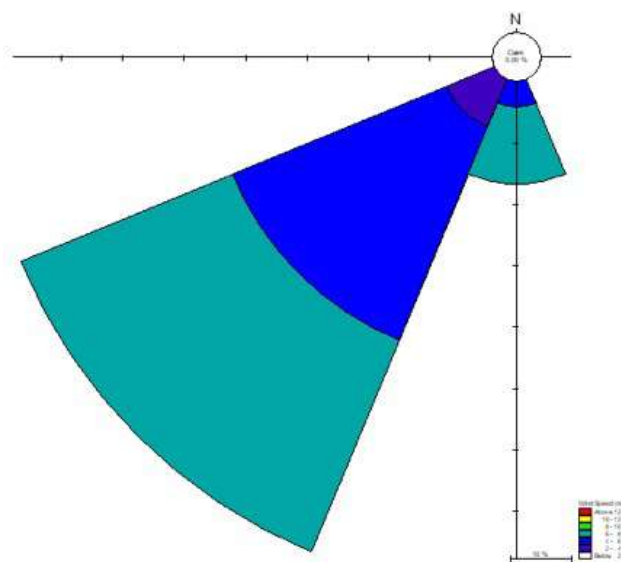


Figure 7.10. Wind rose diagram for Pulau Tenggol on 12 October 2020.

Current Circulations

Pulau Redang

Sampling at Pulau Redang was done between 21 – 22 July 2020. Model outputs from 21 July 2020 (0000hrs) until 22 July 2020 (1800hrs) with 6-hours-time interval is shown in Figure 7.11 and 12 below. There were spring tides with large tidal range and dominant south-westerly winds during these periods.

Based on the results, the current speeds at Pulau Redang ranged from 0.00 - 0.18 ms^{-1} during the two days. The currents direction and speeds varied according to places in the island. The locations with stronger currents are the northern and the south-east of the island.

Near Pasir Cagar Hutan (northern of the islands), strong currents were observed, both during the ebbing and flooding tides. During flooding or high tide (Figure 7.11a and 7.12a), the currents at this side moved westward into the land. During ebbing, the currents moved eastward towards the offshore (Figure 7.11b and 7.12b). However, during the peak low tide, the currents flow northward (Figure 7.12d).

On the east sides of the islands (Pasir Panjang), the currents mostly flow northward except for during ebb tide where the currents moved eastward or towards the offshore. It happened in both days at mid-night 0000hrs (Figure 7.11a and 7.12a). At 0600 hrs in the morning, stronger northward currents (0.12 – 0.16 m/s) were observed (Figure 7.11b and 7.11c).

Currents at the western side of the island is having slow moving currents in the afternoon (1200hrs) and evening (1800hrs) but stronger currents at midnight (0000hrs) and morning (0600hrs). The currents along the western coastal area moved northward during ebbing and southward during flooding.

Currents at the southern part near to Marine Park varied between northward and south-westward. When there were incoming currents from east (westward moving currents), the currents at the southern part will flow south-westward. Other than that, the currents are moving northward.

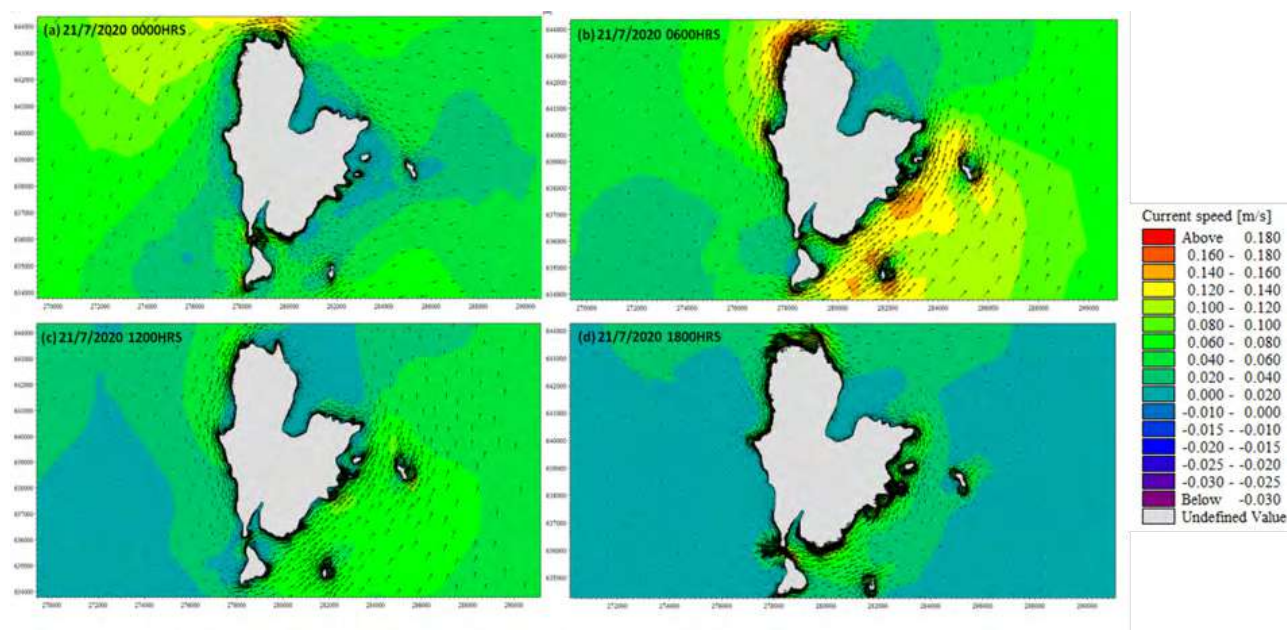


Figure 7.11. 6-hours interval of current circulation around Pulau Redang on 21st July 2020. Current directions are represented by arrows and current speed (m/s) is shown in colour bar.

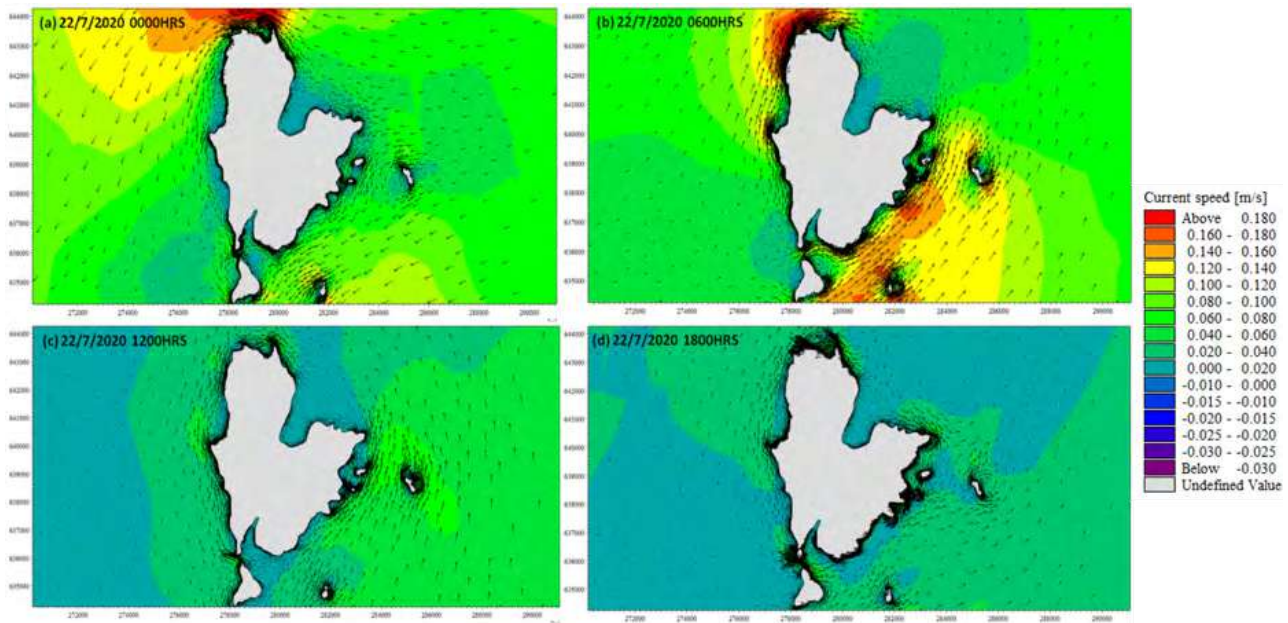


Figure 7.12. 6-hours interval of current circulation around Pulau Redang on 22nd July 2020. Current directions are represented by arrows and current speed (m/s) is shown in colour bar.

Pulau Perhentian

Current circulation outputs for Pulau Perhentian were extracted from 23 August 2020 (0000hrs) until 25 August 2020 (1800hrs) as shown in the Figure 7.13, 7.14 and 7.15.

On 23 and 24 August 2020, the currents changed direction every 6-hours. At 0000hrs and 1200hrs (Figures 7.13a, 7.13c, 7.14a and 7.14c), most of the currents moved westward and south-westward. Meanwhile, at 0600hrs and 1800hrs (Figures 7.13b, 7.13d, 7.14b and 7.14d), the currents moved eastward, northward and north-eastward depending on the locations.

Compared to the first and second day, current speed on the last day (25th August 2020) has different pattern than others. As we can see from Figure 15a and Figure 7.15c, the currents at 0000hrs and 1200hrs respectively were slow and moved westward. The higher current speed was observed only during 0600hrs and 1800hrs (Figures 7.15b and 7.15d); and the currents moved northward.

During these sampling periods, the winds are coming from south with frequent wind speeds ranged from 4 – 6 m/s. Roughly, we can see that current speed at Pulau Perhentian ranges about 0- 0.18 m/s. There are three locations where strong currents were observed; northern Perhentian Kecil, Southern Perhentian Besar and the narrow strait between Perhentian Kecil and Perhentian Besar. Currents speed at these locations ranged from 0.12 m/s to more than 0.18 m/s. The strength and direction of the currents was depending on the tides. During flooding or high tides, the currents moved westward into the land and moved north-eastward towards the offshore during the ebbing or low tides. The narrow strait between the Pulau Perhentian Kecil and Pulau Perhentian Besar is flowing northward during ebbing or low tide and flowing southward during flooding or high tide.

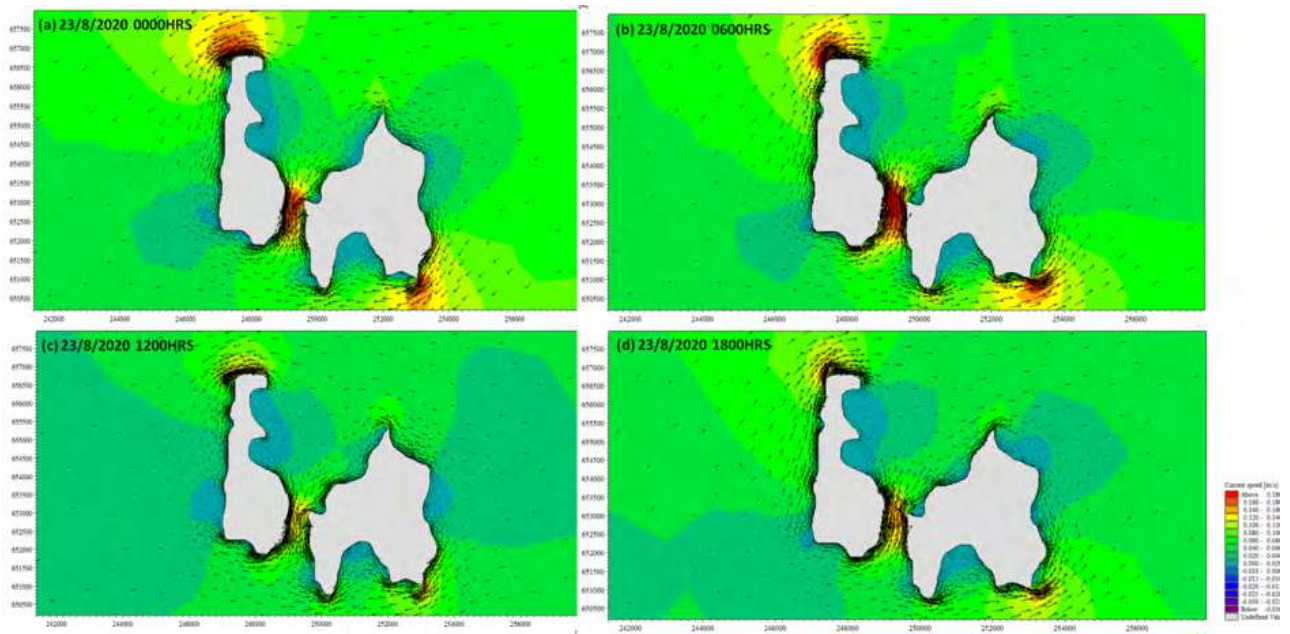


Figure 7.13. 6-hours interval of current circulation around Pulau Perhentian on 23 August 2020. Current directions are represented by arrows and current speed (m/s) is shown in colour bar.

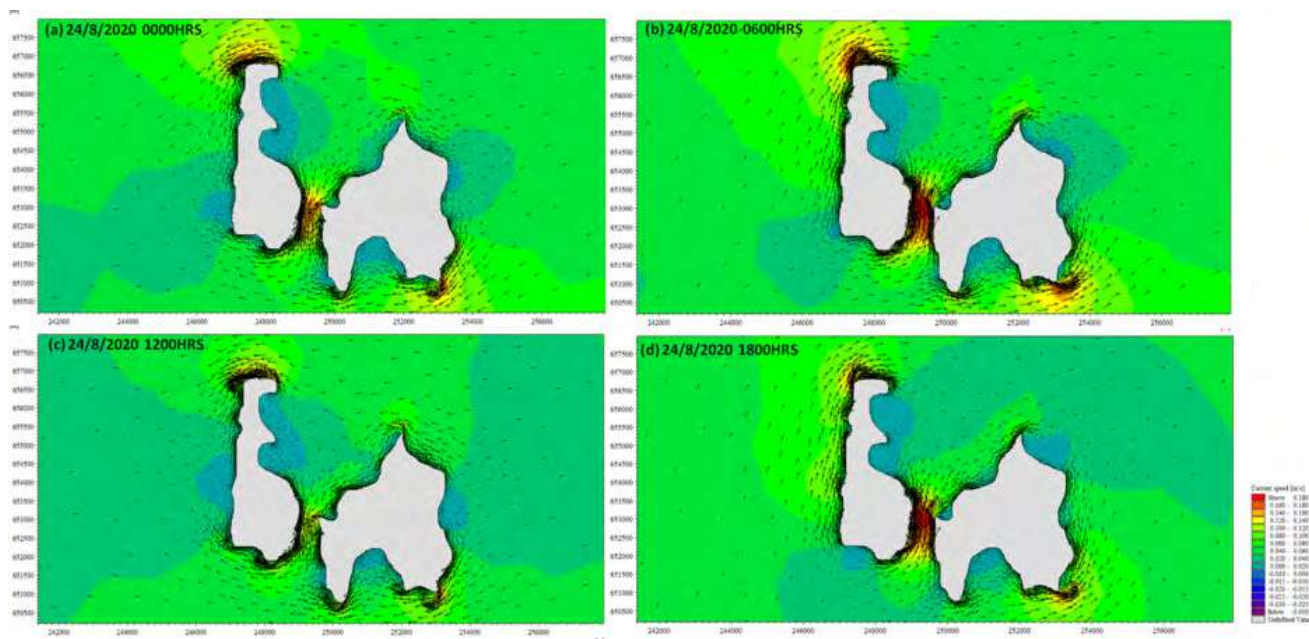


Figure 7.14. 6-hours interval of current circulation around Pulau Perhentian on 24 August 2020. Current directions are represented by arrows and current speed (m/s) is shown in colour bar.

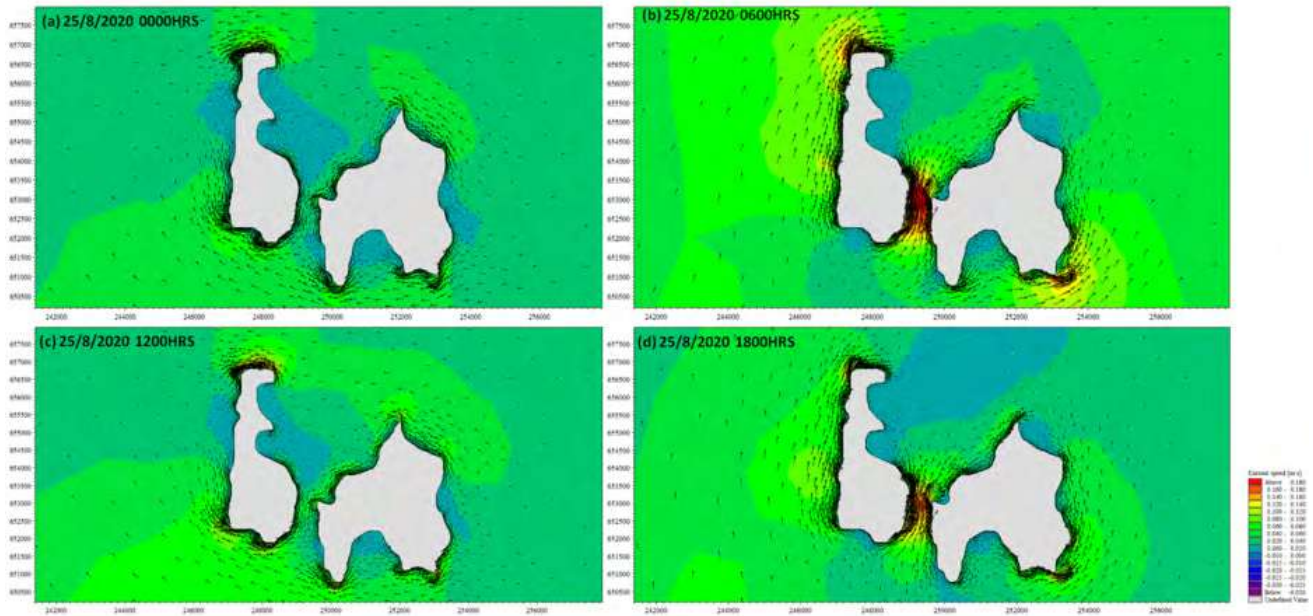


Figure 7.12. 6-hours interval of current circulation around Pulau Redang on 22nd July 2020. Current directions are represented by arrows and current speed (m/s) is shown in colour bar.

Pulau Kapas

For Pulau Kapas, model outputs on 24th September 2020 (0000hrs-1800hrs) were extracted and presented in Figure 7.16. During this sampling day, the tides were the transition from neap tides to spring tides. The dominant wind direction is from the south and the most frequent wind speed ranged from 2 – 4 m/s.

Compared with the other islands, no obvious high-speed currents were observed at Pulau Kapas. The currents speed ranges from 0 – 0.1 m/s. On 24th September 2020, current directions at Pulau Kapas were mostly flowing northward at both east and west sides except during 1200hrs (Figure 7.16c). The currents were moving westward at 1200hrs during starting of flooding. When the high tide is approaching, the currents moved northward around the island. Meanwhile, during ebbing and approaching low tide, the currents moved northward and north-eastward.

In between Pulau Gemia and Pulau Kapas, the currents are slow and circulate clockwise at 0000hrs during the slack ebb tide. At 0600hrs, slightly stronger northeastward currents moved into the strait but the coastal area of Pulau Kapas still have slower currents. At 1200hrs the currents reversed its direction and moved south-westward into the strait with dominant current speed ranged from 0.08 – 0.1 m/s. At 1800hrs the currents reversed to north-eastward with speed ranged from 0.02 – 0.04 m/s.

Pulau Tenggol

The sampling time for Pulau Tenggol was done on 12th October 2020. The current speed at Pulau Tenggol during the sampling day was mainly ranged between 0 – 0.12 m/s. However, during 1200hrs (Figure 7.17c) the island was under influences of lower current value which is ranged between 0 - 0.04 m/s. Other than that, there are no obvious changes of current speed at this island.

The currents directions at Pulau Tenggol were mostly moving northward except at 1800hrs (Figure 7.17d), the currents flow westward. At 1200hrs, the slow westward moving currents was already observed at the northern part of Pulau Tenggol when the flooding was just started. The westward currents were intensified when the high tide is approaching at 1800hrs. Meanwhile, during ebbing, the currents mostly flow northward around the island.

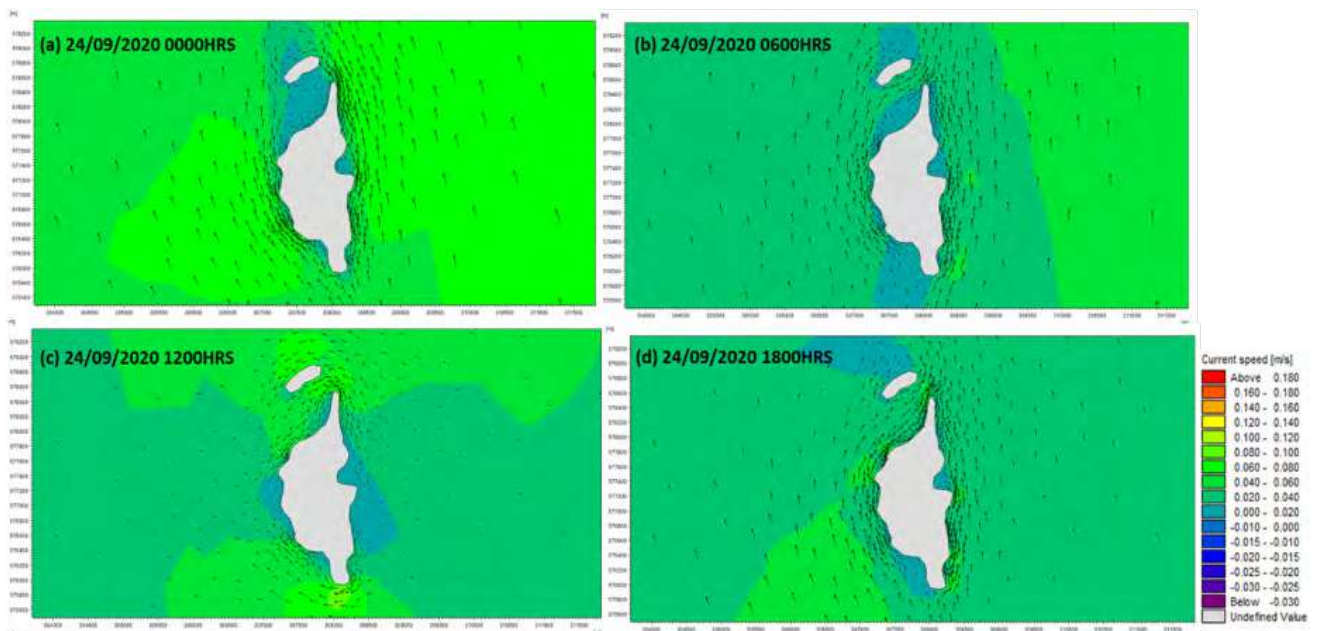


Figure 7.16. 6-hours interval of current circulation around Pulau Kapas on 24 September 2020. Current directions are represented by arrows and current speed (m/s) is shown in colour bar.

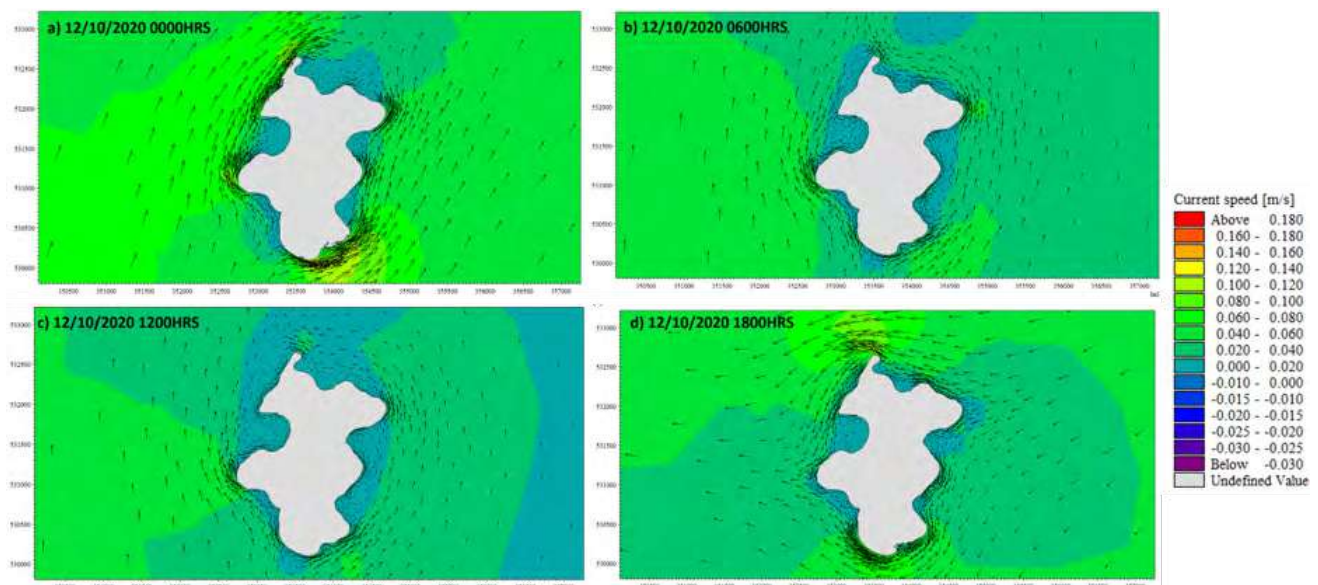


Figure 7.17. 6-hours interval of current circulation around Pulau Tenggol on 12 October 2020. Current directions are represented by arrows and current speed (m/s) is shown in colour bar.

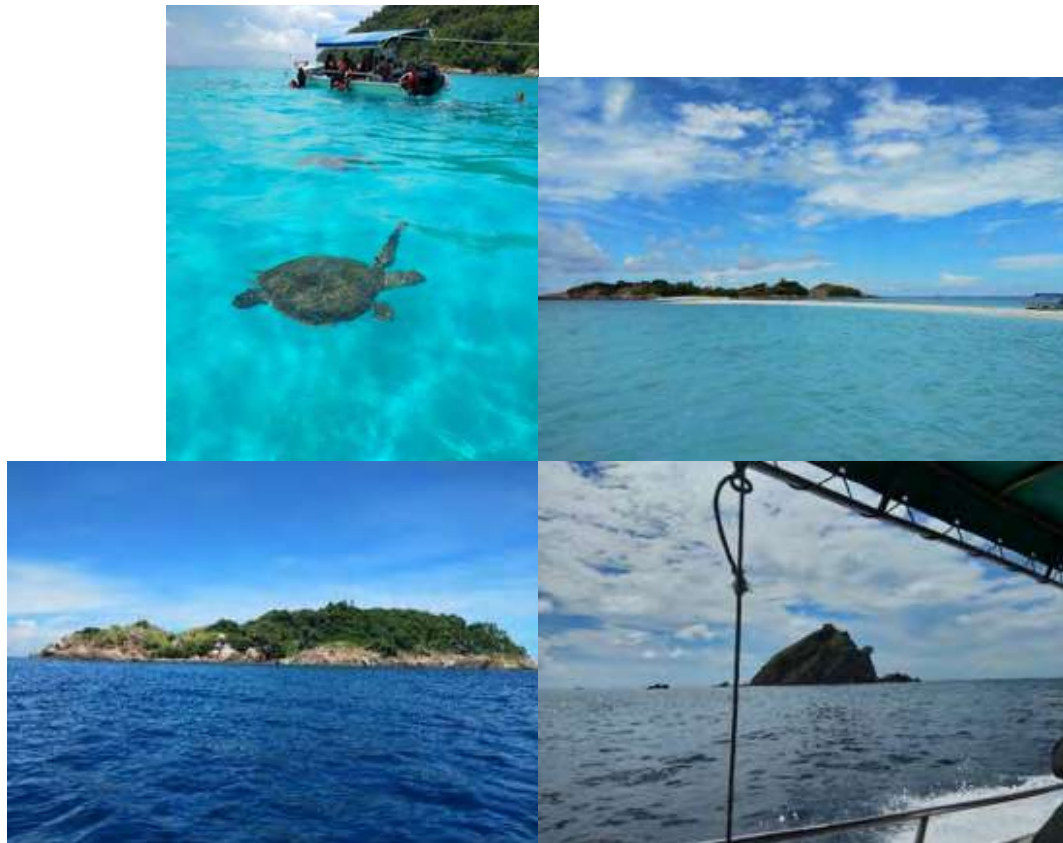
PHOTO GALLERY



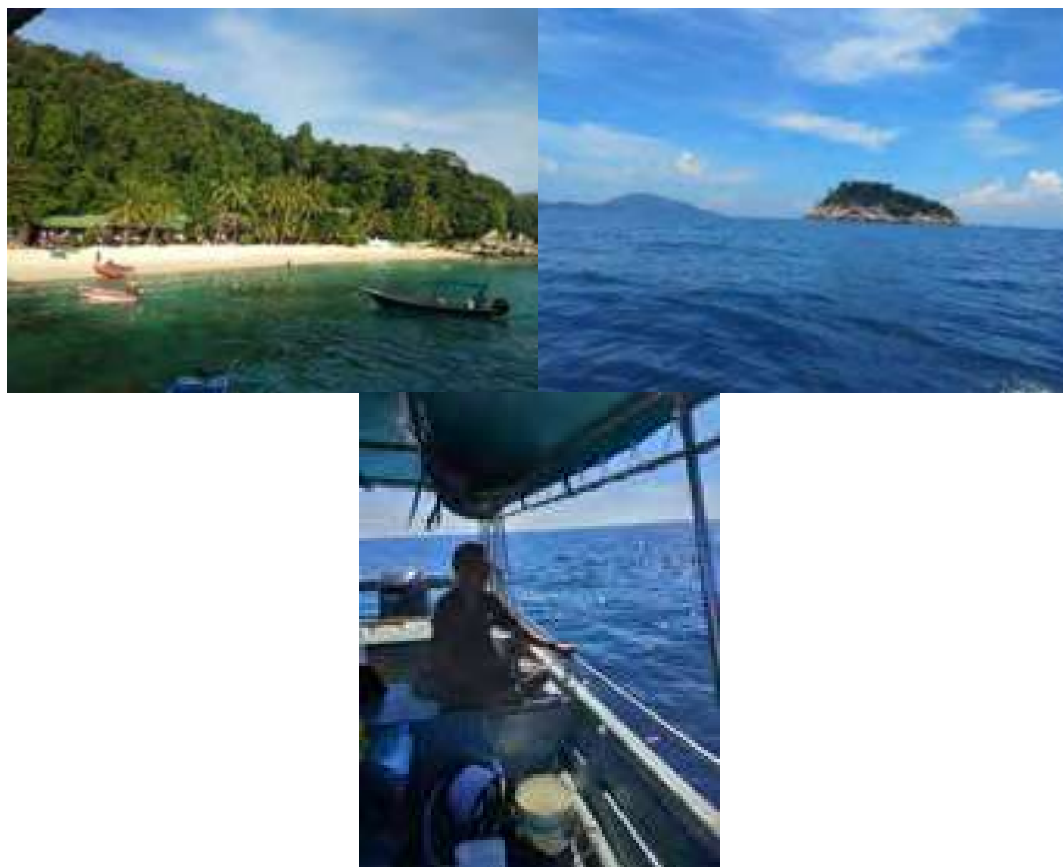
Conductivity-temperature-depth (CTD) used to measure temperature, salinity and pressure.



Acoustic Doppler and Current Profiler (ADCP) used to measure in-situ currents.



Sea and weather conditions during sampling time in Redang (21 – 22 July 2020).



Sea and weather condition during sampling in Perhentian (23 - 25 August 2020).



Sea and weather condition during sampling in Tenggol (12 October 2020).

REFERENCES

- Akhir, M.F., Chuen, Y.J. (2011) Seasonal variation of water characteristics during inter-monsoon along the east coast of Johor. *Journal of Sustainability Science and Management*. 6(2):206–214
- Akhir, M. F. (2012). Surface Circulation and Temperature Distribution of Southern South China Sea from Global Ocean Model (OCCAM). *Sains Malaysiana*. 41. 701-714.
- Daryabor, F., Ooi, S. H., Samah, A. A., & Akbari, A. (2016). Tides and Their Dynamics over the Sunda Shelf of the Southern South China Sea. *PLoS ONE*, 11(9), e0162170. doi: 10.1371/journal.pone.0162170
- Mirzaei, A., Tangang, F., & Juneng, L. (2014). Wave energy potential along the east coast of Peninsular Malaysia. *Energy*, 68, 722–734. doi: 10.1016/j.energy.2014.02.005
- Roseli, N. H., & Akhir, M. F. (2019). Temperature Variability Caused by Internal Tides in the Coastal Waters of East Coast of Peninsular Malaysia. *Acta Oceanologica Sinica*, 38(1), 22-31. doi:10.1007/s13131-019-1367-9.
- Roseli, N. H., Akhir, M.F., Husain M. L., Tangang, L. & Ali A. (2015). Water Mass Characteristics and Stratification at the Shallow Sunda Shelf of Southern South China Sea. *Open Journal of Marine Science*, 5, 455-467. doi:10.4236/ojms.2015.54036.
- Roseli, N. H. & Akhir, M. F. (2014). Variations of Southern South China Sea Characteristics near Pahang. *Sains Malaysiana*, 43(9), 1389-1396. ISSN 0126-6039.
- Tangang, F. T., Changshui, X, Fangli, Q., Liew, J., Feng, S. (2011). Seasonal circulations in the Malay Peninsula Eastern continental shelf from a wave-tide-circulation coupled model. *Ocean Dynamic*, 61 (9), pp 1317 – 1328. <http://dx.doi.org/10.1007/s10236-011-0432-5>
- Zainol, Z., Akhir, M. F., & Abdullah, S. (2020). Hydrodynamics, nutrient concentrations, and phytoplankton biomass in a shallow and restricted coastal lagoon under different tidal and monsoonal environmental drivers. *Regional Studies in Marine Science*, 38, 101376. <https://doi.org/10.1016/j.rsma.2020.101376>
- Zhu, Y., Sun, J., Wang, Y., Li, S., Xu, T., Wei, Z., & Qu, T. (2019). Overview of the multi-layer circulation in the South China Sea. *Progress in Oceanography*. doi:10.1016/j.pocean.2019.04.001

CHAPTER 8

POST COVID-19 EXPEDITIONS: OCCURRENCE OF MICROPLASTICS IN SELECTED ISLAND IN TERENGGANU, SOUTH CHINA SEA

Yusof Shuaib Ibrahim, Sabiqah T. Anuar, Wan Mohd Afiq Wan Mohd Khalik,
Maisarah Jaafar, Noorlin Mohamad, Ku Mohd Kalkausar Ku Yusof, Yuzwan
Mohamad and Zainudin Bachok

8.1 INTRODUCTION

Microplastic sampling expeditions were conducted on Redang Island and Perhentian Island on the 16th and 26th of August 2020, respectively. Six MRIG sampling team members, a UMT intern student, and Prof Zainudin Bachok participated in the trip. The sampling expedition took place on Kapas Island on September 19, 2020, followed by Tenggol Island on October 11, 2020. The primary goal was to analyse seawater surface microplastic using Neuston Net, and it is hoped that the operation will allow both islands to keep track of recent microplastic occurrences and in-situ quality status.

Five (5) main components included four major in-situ parameters, namely temperature (°C), pH (unit), salinity (PSS) and dissolved oxygen (mg/L). The first section covered the status of Redang Island, the second section is about Perhentian Island, the third section is about Kapas Island, the fourth section is about Tenggol Island and the last is about comparing in-situ findings on all islands.

8.2 METHODOLOGY

Survey Location

A total of 23 towing transect (Figure 8.1 to 8.4) over Pulau Redang, Perhentian, Kapas and Tenggol islands were performed. During towing activity, the *in-situ* seawater parameters were also measured.

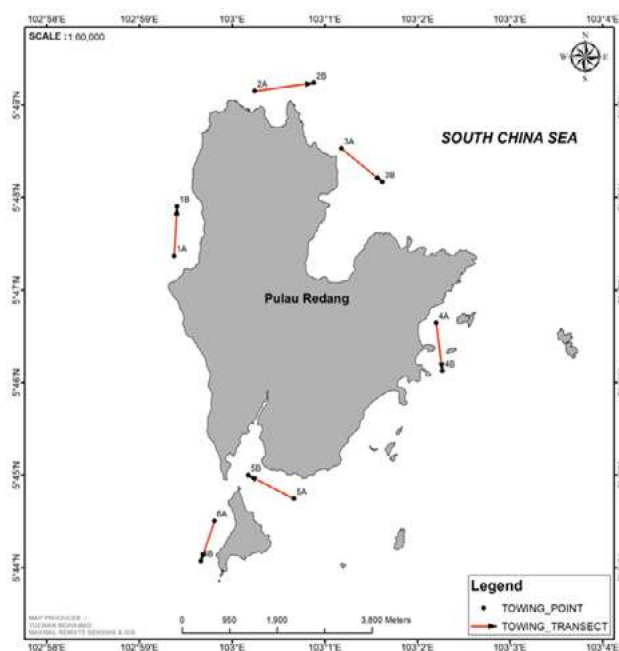


Figure 8.1: Microplastic's towing transect orientation at Pulau Redang during Post COVID-19 expedition.

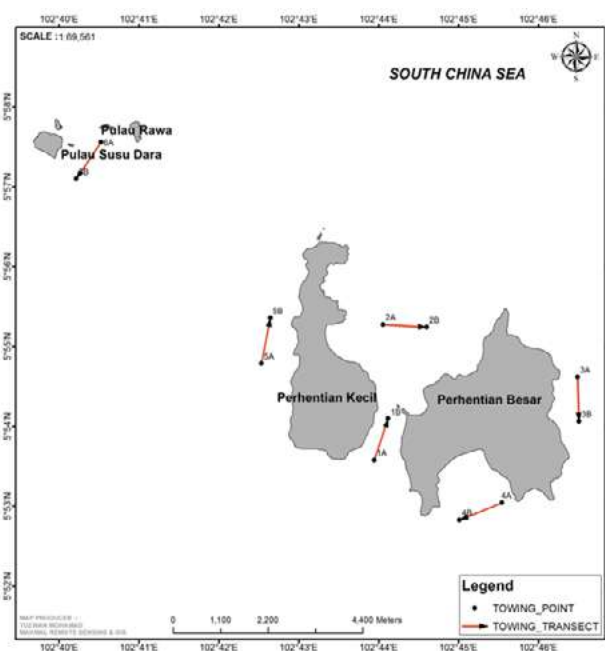


Figure 8.2: Microplastic's towing transect orientation at Pulau Perhentian during Post COVID-19 expedition.

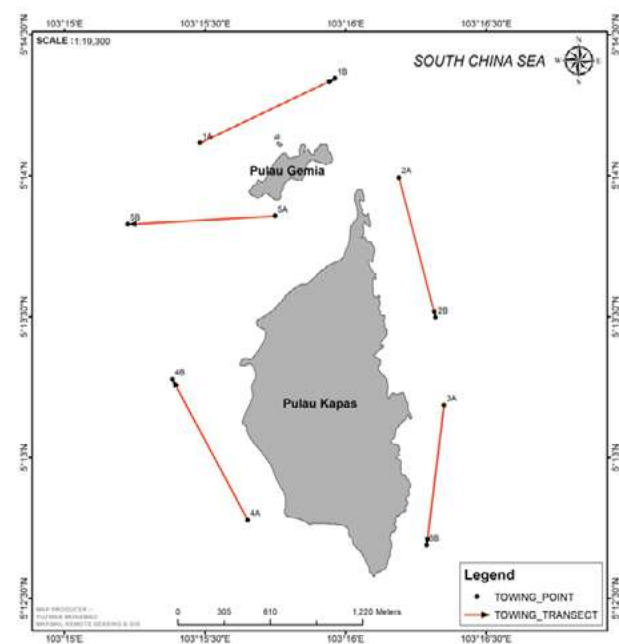


Figure 8.3: Microplastic's towing transect orientation at Pulau Kapas during Post COVID-19 expedition.

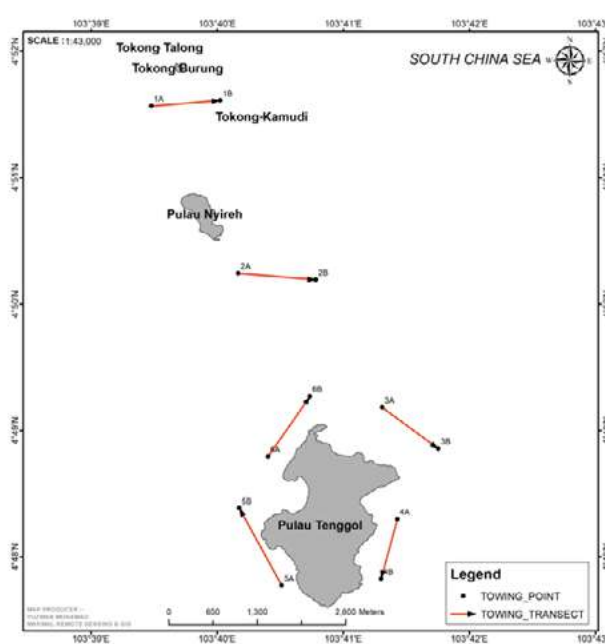


Figure 8.4: Microplastic's towing transect orientation at Pulau Tenggol during Post COVID-19 expedition.

Sample and Data Collection

Microplastics survey was conducted from August to October 2020. Specific schedule as follows:

16 August 2020	P. Redang
26 August 2020	P. Perhentian
19 September 2020	P. Kapas
11 October 2020	P. Tenggok

Upon arrival at the sampling site, the tide condition, cloud coverage and survey time were recorded. The *in-situ* parameters of temperature, pH, salinity, pH and DO were recorded prior and after microplastics collection. CTD castaway was used to measure conductivity, temperature and salinity while the multiparameter Hydrolab DS5X used to record dissolved oxygen and pH.

For microplastic sample collection, the Neuston net (rectangular opening of 335 mm mesh) attached with the flow meter was towed along the surface of seawater for 1 KM distance at the speed of 1 to 2 knots. In order to maintain stability of the net during towing, tow buoys were attached at the top for both left and right corner of the net.

At the end of towing, the net and the tow contents were washed from the outside of the net with MilliQ water. The samples were placed into a 500 mL glass sample Schott bottle with aluminium foil-lined lids and the bottle were capped immediately. Prior to survey, the bottle used to keep the sample should be rinsed with MilliQ water in the laboratory three times, during sampling, the bottle will be rinsed again with seawater. In addition, during, a blank filter paper and milliQ water were brought along for contamination control and blank. The sample was preserved with 80% ethanol and stored at 4°C for further analysis.

Sample and Data Analysis

All the collected water samples were filtered by GF/C glass microfiber filter paper using a vacuum pump. Filtrate was dried and dried filter paper was physically examined under a stereomicroscope (equipped with a Dino-Eye Eyepiece) in a clean lab with contamination control chamber. Microplastic was sorted according to colors, shapes and types. Additionally, the hot-needle test need to be applied to distinguish between the plastic materials and organic matter.

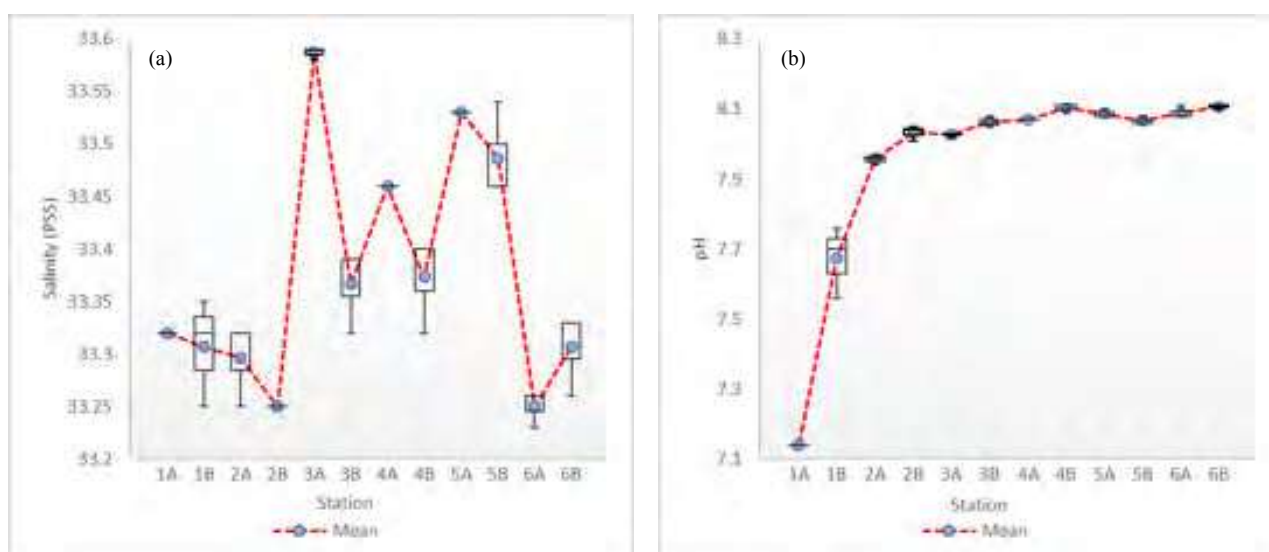
Microplastic from each replicate will be analyzed using a scanning electron microscope (SEM) to determine their size and morphology. To characterize the polymer associated to the microplastics, microFTIR spectroscopy will be used.

The *in-situ* parameters and microplastics occurrence will be compared among study locations and islands. The correlation between microplastics and *in-situ* parameters will be determined.

8.3 RESULTS

Redang Island

Overall, Redang Island's salinity concentration was not much different from station to station. The salinity amount ranged from 33.35 to 33.40 PSS with mean of 33.38 PSS. Stations 6A and 3A were the lowest and highest among monitoring stations. For pH, station 1A to 6B had an upward trend. Station 1A has the lowest pH value at 7.14, the highest at 6B at 8.06. The mean pH value was 7.95. Compared to salinity level, the station temperature was not much different. Station 2A was the lowest reported 29.11°C, while 6B was the highest recorded 29.93°C. Redang Island mean temperature was 29.62°C. Compared to other parameters *in-situ*, DO reported one (1) unusual measurement during sampling. Stations 1B reported huge differences during measurement. Overall, the mean DO value was 6.74 mg/L, but stations 4B were slightly higher than the statistical mean 8.27 mg/L. Station 4B has a wide range, 6.53-10.94 mg/L. The overall *in situ* result can be seen in Figure 8.5(a) – (d).



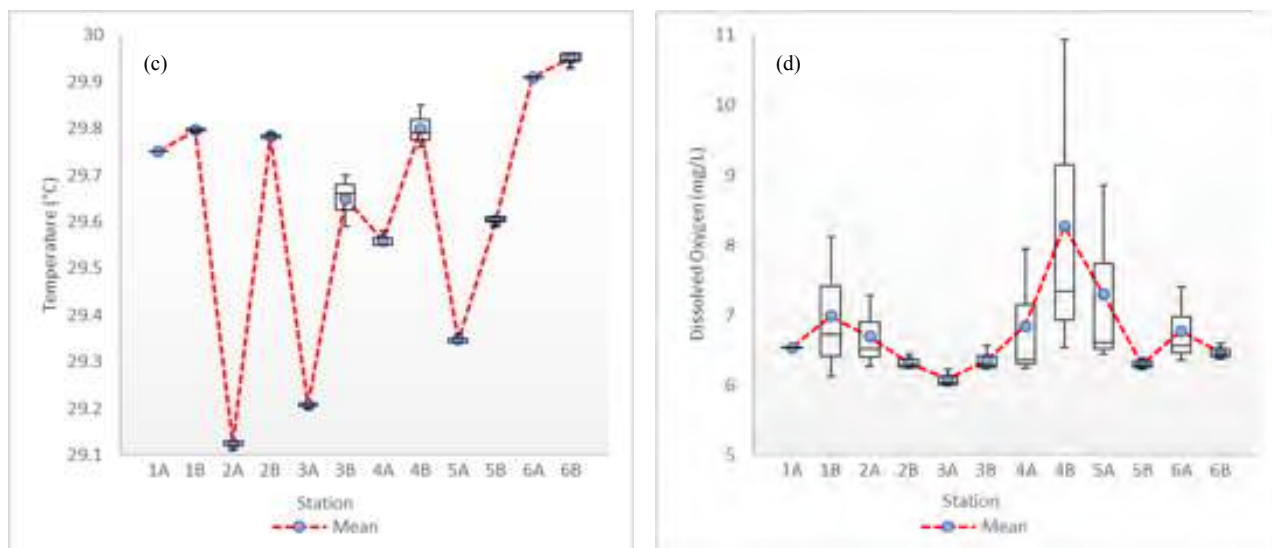


Figure 8.5: Redang Island's In-situ seawater quality status for (a) Salinity, (b) pH, (c) Temperature and (d) Dissolved Oxygen

The total count of microplastics (MPs) in Redang Island was 1887 item/L, with S1 has the highest (421 item/L) and S4 has the lowest (257 item/L). Most of MPs identified in Redang Island were classified as fibers, with very few records for other types of MPs. Colourless fiber was identified as the highest among all stations in S1 (228 item/L), followed by S5 (156 item/L), with variance values of 5542 and 3356, respectively. Transparent fiber had the highest count at S1, S2, S5, and S6 when compared to other fiber colors, with counts of 228 item/L, 121 item/L, 156 item/L, and 115 item/L, respectively. Meanwhile, at S3 (112 item/L) and S4 (87 item/L), black fibers had the highest count. Green, yellow, orange, and purple fibers for all stations showed the lowest MPs counted for Redang Island. Figure 8.6 illustrates the overall MP count on Redang Island.

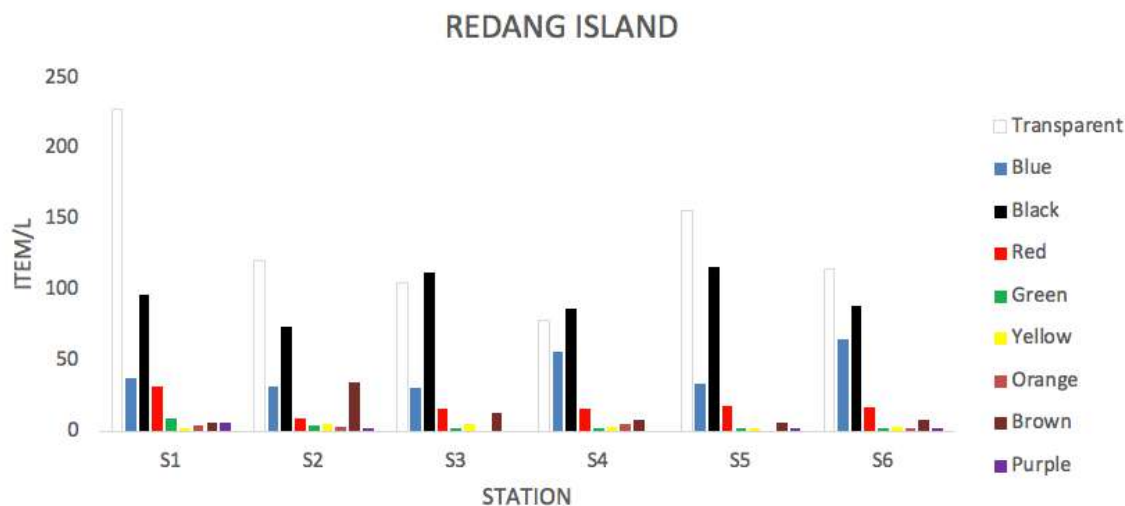


Figure 8.6: Total abundance and color segregation of microplastics in each sampling station on Redang Island

Polymers such as polypropylene, polyethylene, polyurethane, and Poly (Vinyl Methyl Ether) were among the polymers found in Redang Island waters. Figure 8.7 shows the examples of polymer spectra and images for microplastic particles found in Redang Island.

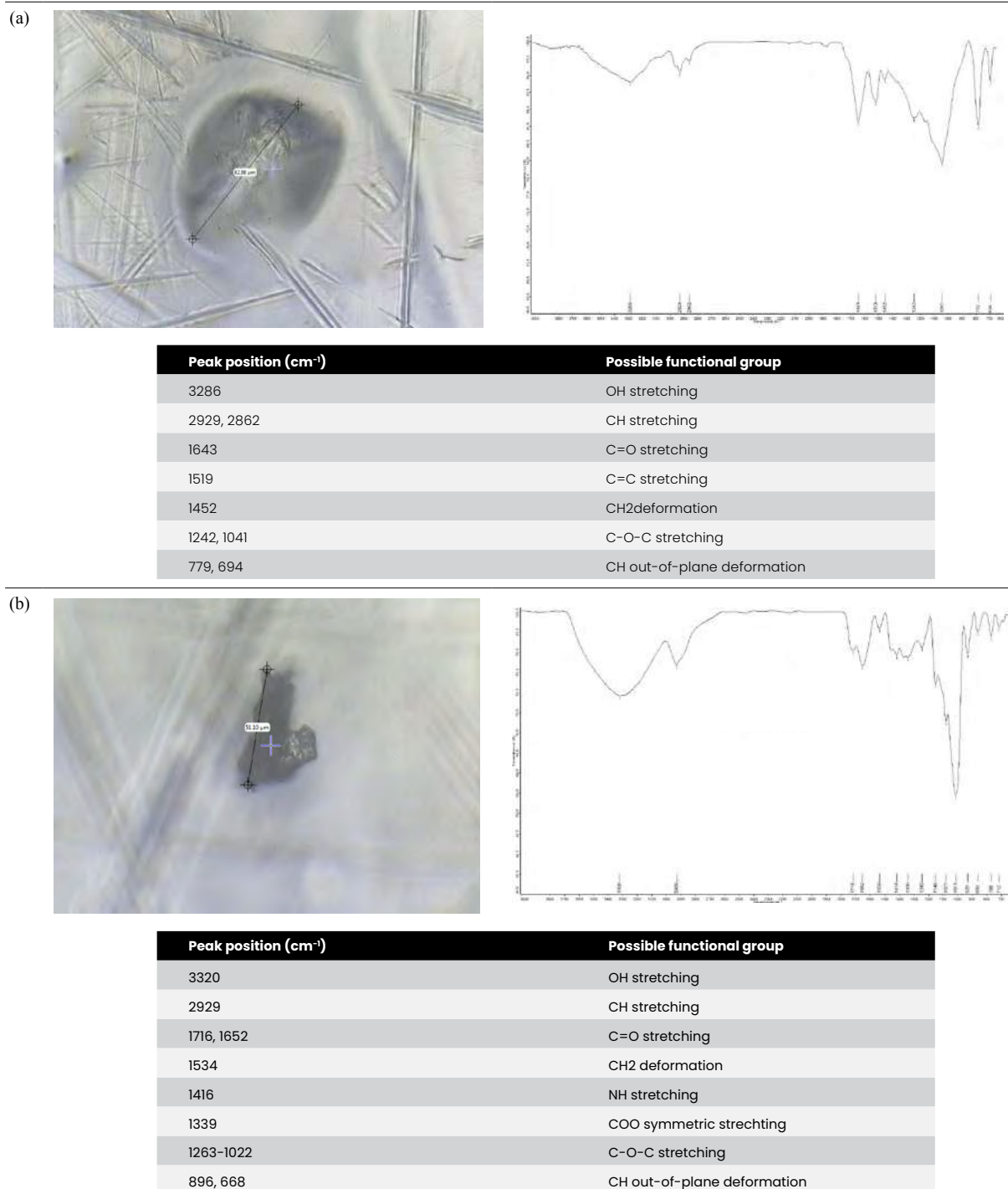


Fig 8.7: Example of microFTIR analysis for microplastic particles from Pulau Perhentian, a) foam and b) fragment

Perhentian Island

Figure 8.8 (a) – (d) showed the in situ result at Perhentian island. Salinity ranged 32.99 – 33.14 PSS with an average of 33.10 PSS. Station 6B and 3B was consistently recorded the lowest and highest. Similar to pH measurement in Redang Island, pH value showed an increase trend towards the end of towing transection activity. The lowest and highest recorded at 1A and station 3A with 6.65 and 8.05, respectively. For temperature, towing transection from station 5A to 5B shows a huge gap measurement between both stations (30.36°C – 30.74°C). Even though it appears odd, it does not show anything odd since this is a normal temperature in Malaysia. Lastly, station 1B and 6B showed a high variance and standard deviation measurement of dissolved oxygen. Both stations had a quite similar pattern with the lowest and highest DO level were recorded at these stations. Station 1B ranged 6.32 – 8.53, meanwhile station 6B ranged 6.3 – 8.90. Compared to both stations, 6B recorded with highest variance and standard deviation with 1.89 and 1.38, respectively.

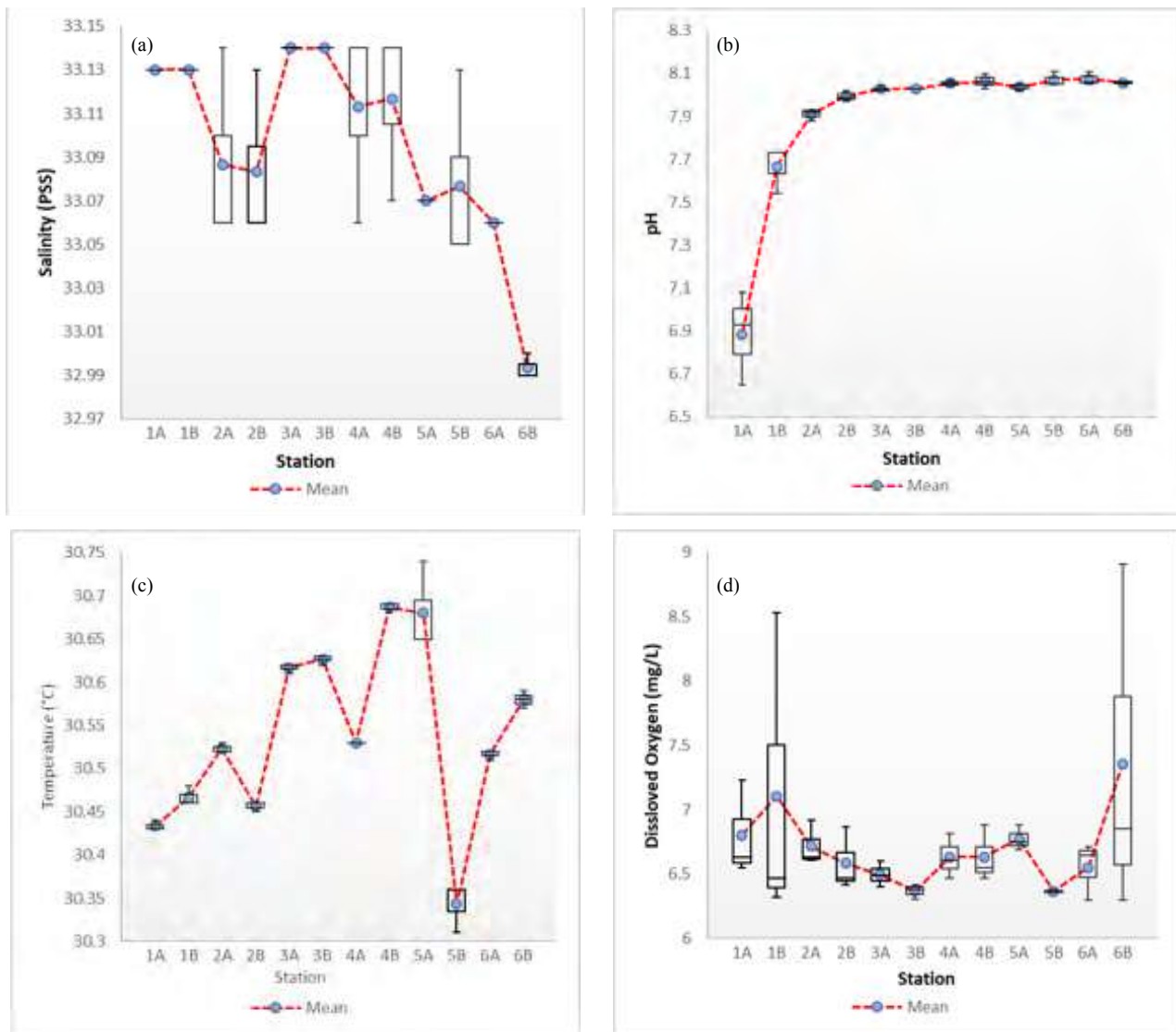


Figure 8.8: Perhentian Island's In-situ seawater quality status for (a) Salinity, (b) pH, (c) Temperature and (d) Dissolved Oxygen

Figure 8.9 illustrated the total count of MPs in Perhentian Island was 3516 item/L, with the highest and lowest counts being S5 (715 item/L) and S2 (410 item/L), respectively. Fiber MPs were the most common type found on Perhentian Island, with other types of MPs being identified and recorded only infrequently. Transparent and black fiber-like MPs were found to be the most abundant when compared to others. Transparent fibers accounted for the greatest number of MPs at S1 (240 item/L), S3 (242 item/L), and S5 (270 item/L), while black fibers accounted for the greatest number of MPs at S2 (129 item/L), S4 (204 item/L), and S6 (194 item/L). Yellow and orange fibers had the lowest MPs detected across all stations.

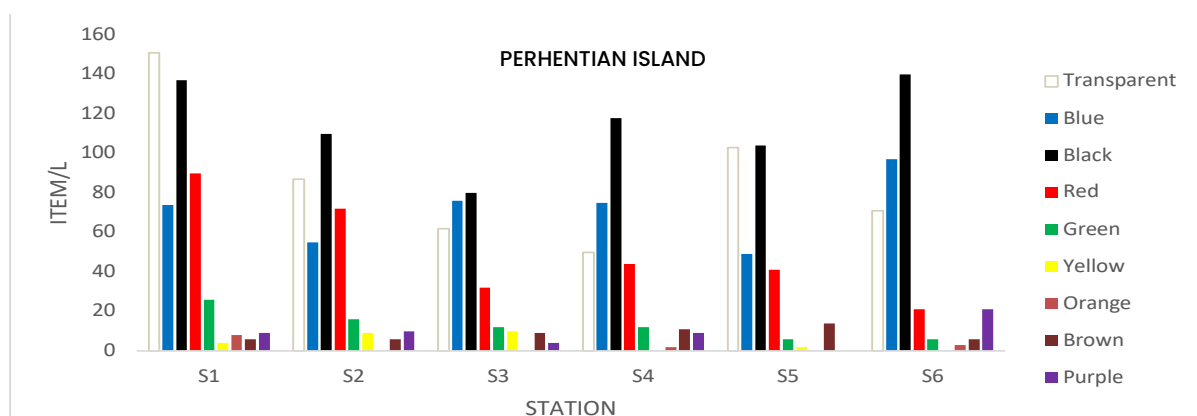


Figure 8.9: Total abundance and color segregation of microplastics in each sampling station on Perhentian Island

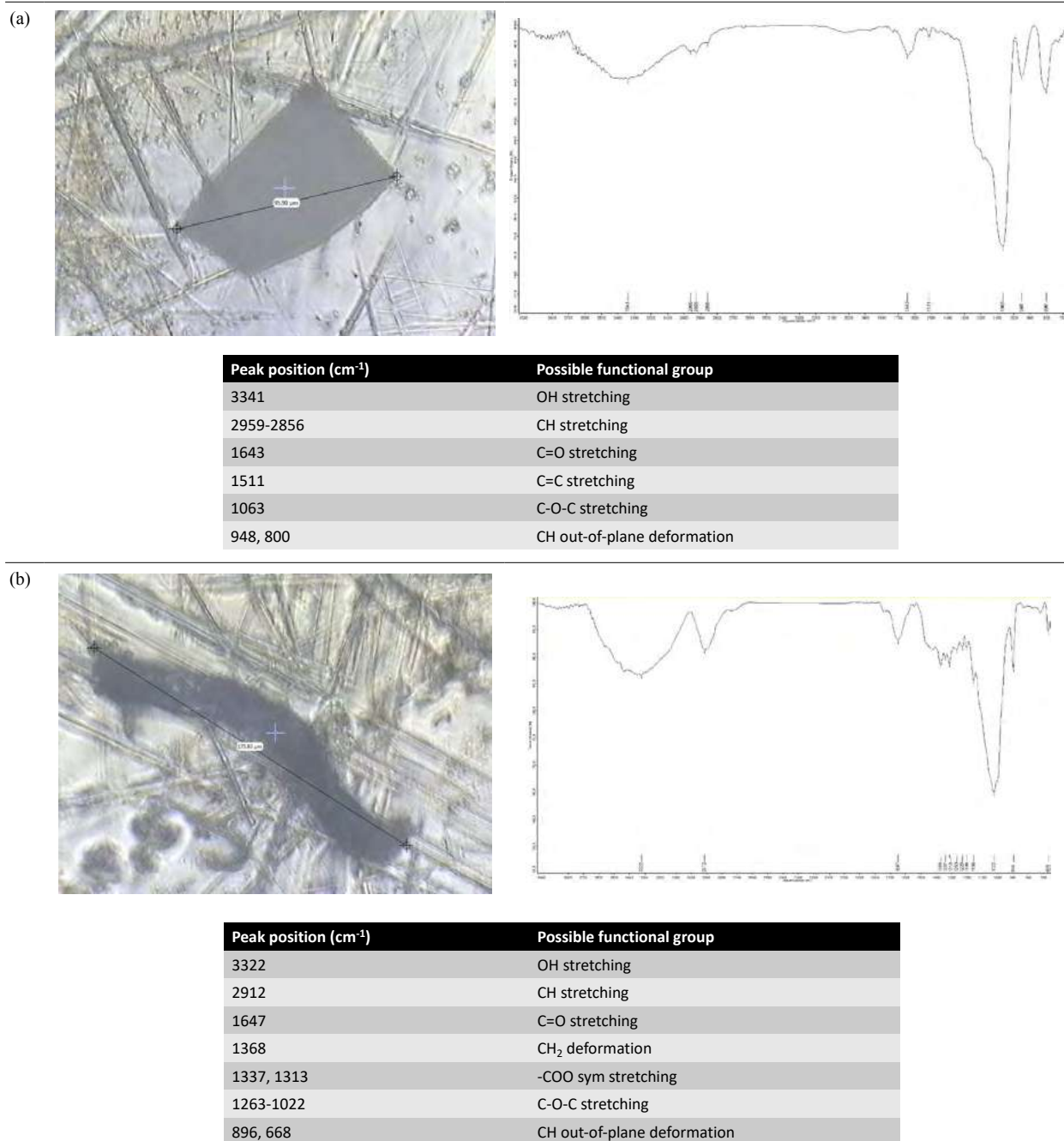


Fig 8.10: Example of microFTIR analysis for microplastic particles from Pulau Perhentian, a) fragment and b) fiber

Polymers such as polypropylene, polyethylene, polyurethane, polyamide and PE copolymers were among the polymers found in Perhentian Island waters. Figure 8.10 shows the examples of polymer spectra and images for microplastic fragment and fiber found in Perhentian Island.

Kapas Island

In Figure 8.11, the in-situ measurement of seawater near Kapas Island revealed a significant difference between all stations for salinity and pH. During the towing transection, a large salinity gap measurement with a value of 33.29 – 33.58 PSS was recorded from station 1B to station 2A. A similar trend of large gaps in pH measurement (8.34 – 8.42) was observed from station 1B to station 2A. This situation could occur as a result of a slight difference in natural conditions during the transition sampling location from station 1B to station 2A. When the salinity and pH levels were compared, the temperature for all stations showed a normal fluctuating value. The temperature ranged from 30.07°C to 30.14°C, with a mean temperature of 30.11°C. Stations 2B and 4A had the lowest and highest temperatures recorded, respectively. Figure 6(d) depicted a normal fluctuation of overall DO between 5.48mg/L and 5.53mg/L, with a mean value of 5.51mg/L. Stations 1A and 2B had the lowest and highest dissolved oxygen levels.

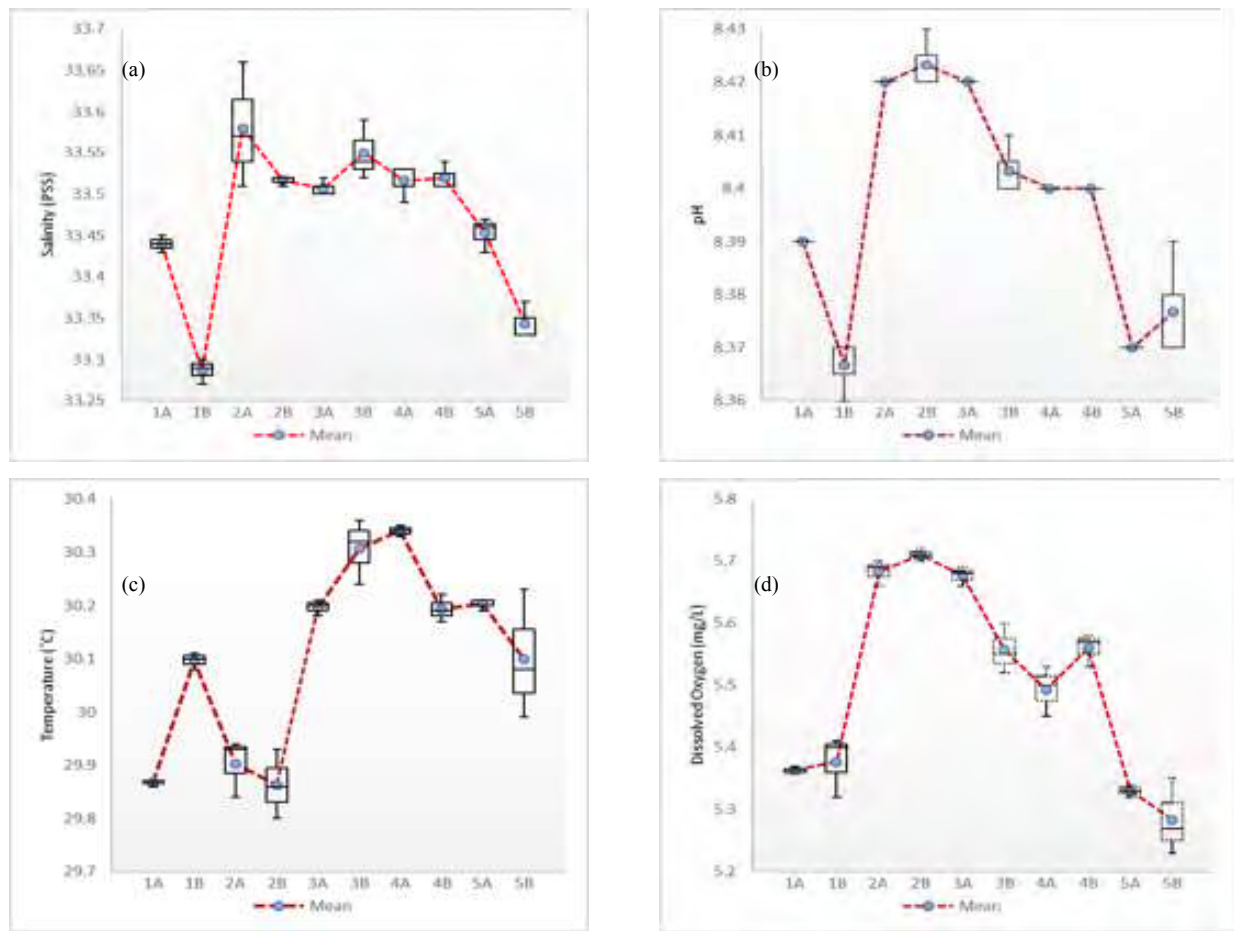


Figure 8.11: Kapas Island's In-situ seawater quality status for (a) Salinity, (b) pH, (c) Temperature and (d) Dissolved Oxygen

As per Figure 8.12, the total count of MPs in Kapas Island was 2160 item/L, with S1 having the highest (505 item/L) and S3 having the lowest (285 item/L). The majority of MPs identified in Kapas Island were classified as fibres, with only a few other types of MPs being identified and recorded. S2 (110 item/L), S3 (80 item/L), S4 (118 item/L), S5 (104 item/L), and S6 (140 item/L) had the highest MPs among all stations, with the exception of S1 (151 item/L), which had transparent fibres. Among all stations, the green, yellow, orange, and brown fibres had the lowest MP count.

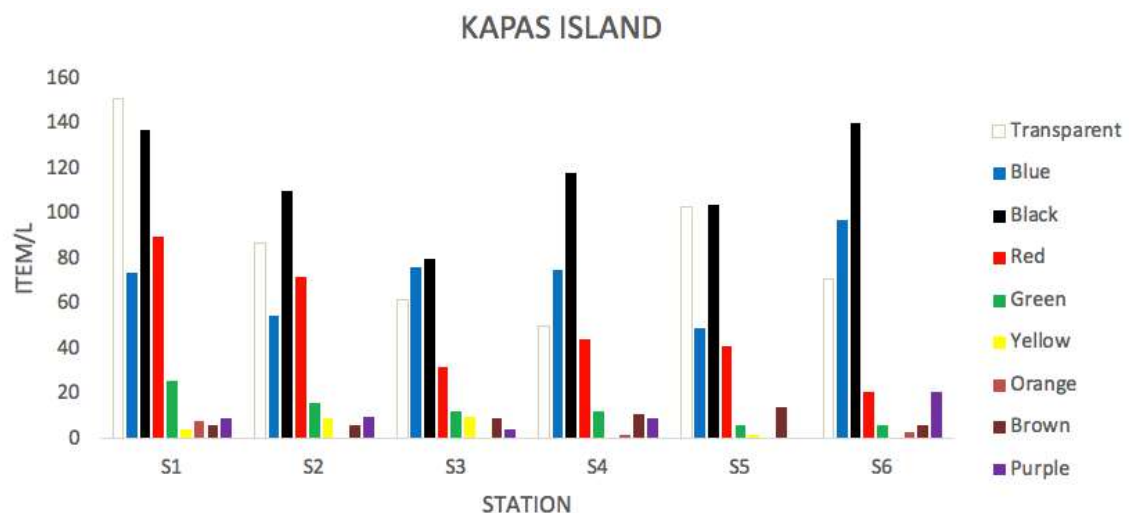


Figure 8.12: Total abundance and color segregation of microplastics in each sampling station on Kapas Island

Polymers such as polypropylene, polyethylene, polyurethane and epoxy resins were among the polymers found in Kapas Island waters. Figure 8.13 shows the examples of polymer spectra and images for microplastic fragment and fiber found in Kapas Island.

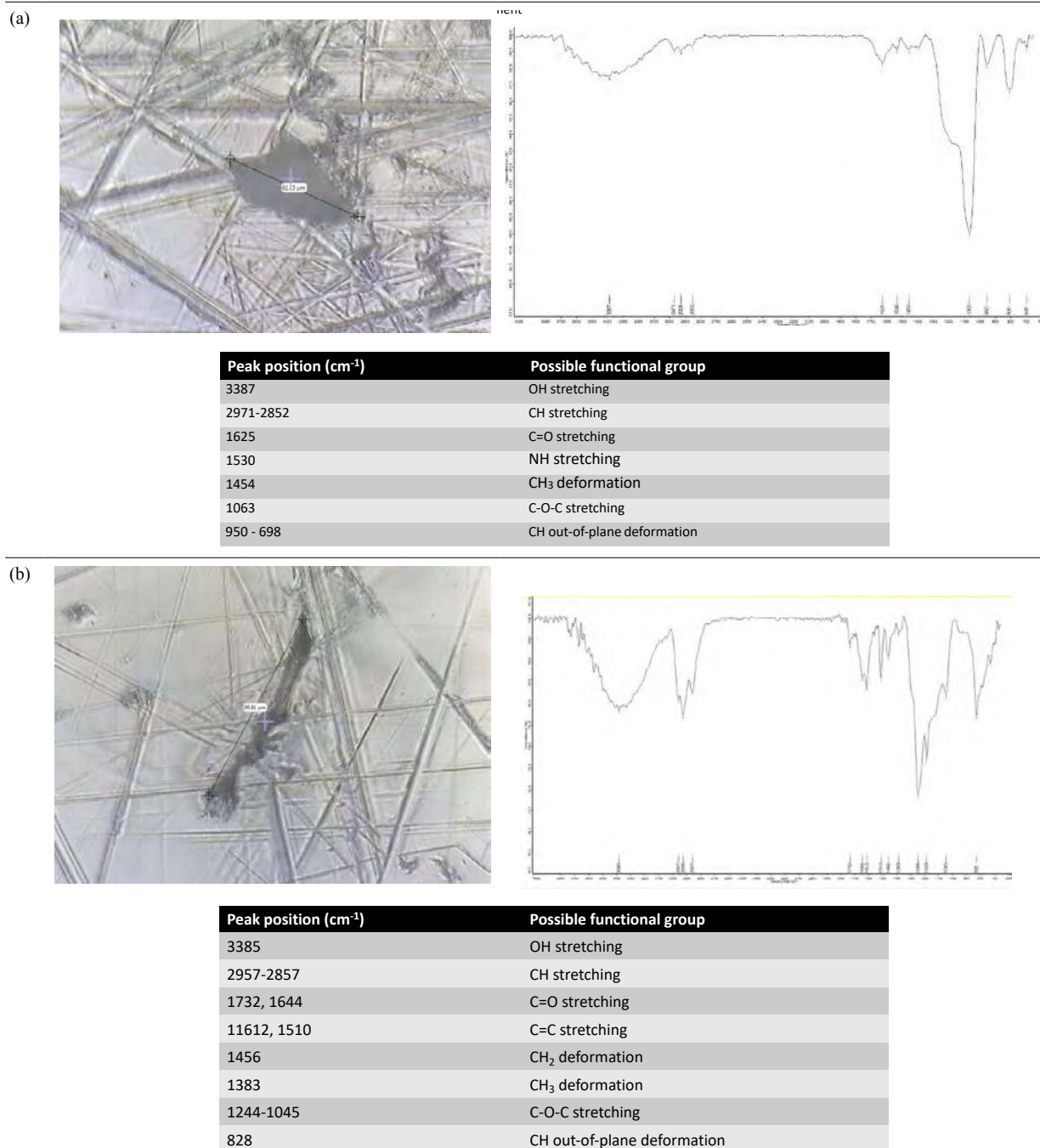


Figure 8.13: Examples of microFTIR analysis for microplastic particles from Kapas Island, a) fragment and b) fiber

Tenggol Island

Tenggol Island's salinity in Figure 8.14(a) showed a nearly identical pattern among 12 stations, ranging from 33.43PSS to 34.00PSS with a mean value of 33.59PSS. Stations 3B and 5A had the lowest and highest salinity levels, respectively. Although there was a slight drop from the beginning to the end of the sampling, the pH level showed an increasing trend. During the towing transection, pH measurements at Stations 1A and 1B showed a large gap (4.2 – 4.4). Figure 8.14(c) shows that temperature varies greatly between sampling stations, with station 5A exhibiting the greatest variance (28.43°C – 29.35°C) and station 1B exhibiting the smallest variance (28.06°C – 29.15°C). When comparing the two stations, Station 5A had the greatest temperature variance, with standard errors of mean values of 0.15 and 0.11, respectively. Although there was a high variation in temperature during the sampling, the tabulation of temperature recorded at each station is normal. Finally, the DO levels recorded at each station varied within a reasonable range from the initial to the final station. Station 4B, on the other hand, had the highest variance among the stations with the largest standard error of mean value (0.091), as shown in Figure 8.14(d).

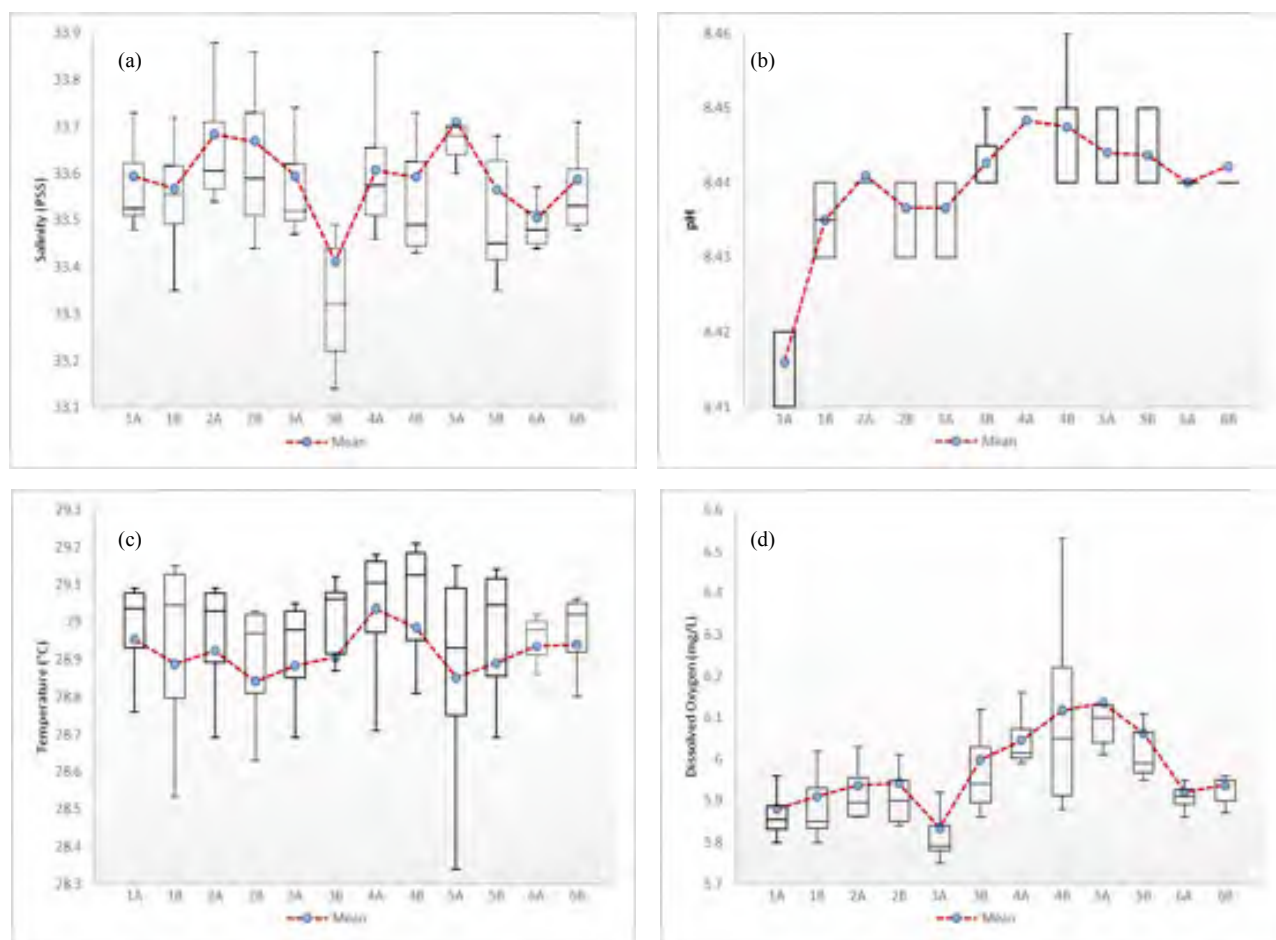


Figure 8.14: Tenggol Island's In-situ seawater quality status for (a) Salinity, (b) pH, (c) Temperature and (d) Dissolved Oxygen

In general, 1762 item/L is the total MPs counted in Tenggol Island, with the highest at S5 (405 item/L) and the lowest at S3 (177 item/L). When compared to other MPs types, fibre was the most common in Tenggol Island. The highest MPs were identified as black fibres at S2 (138 item/L), S3 (69 item/L), S5 (161 item/L), and S6 (81 item/L), blue and transparent fibres with count values of 68 item/L and 158 item/L, respectively. Green, yellow, orange, brown, and purple fibres had the lowest MPs count of all stations. Figure 8.15 illustrated the overall MPs count in Tenggol Island.

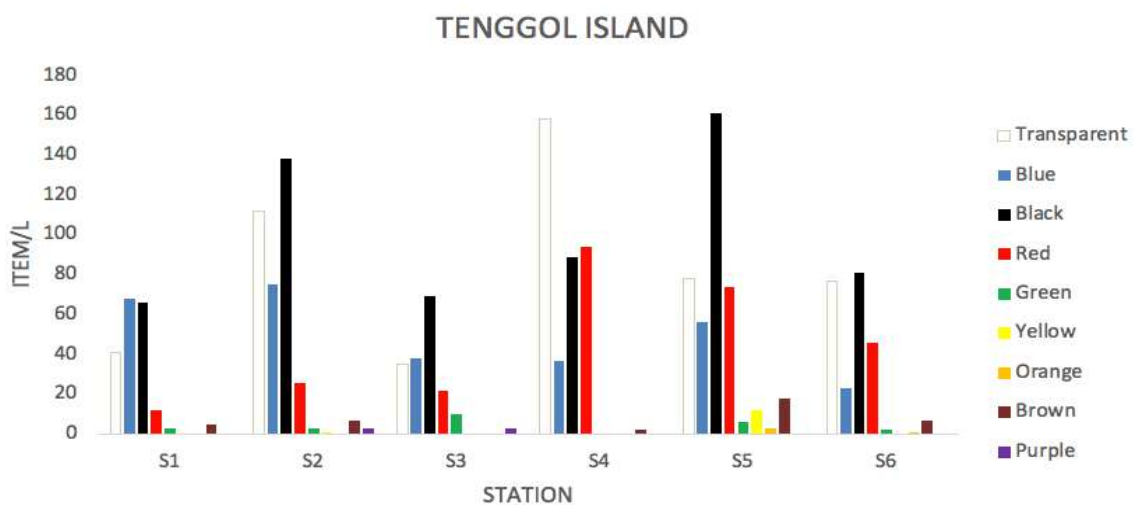


Figure 8.15: Total abundance and color segregation of microplastics in each sampling station on Tenggol Island

Polymers such as polypropylene, polyethylene, and epoxy resins were among the polymers found in Tenggol Island waters. Figure 8.16 shows the examples of polymer spectra and images for microplastic fragment and fiber found in the island.

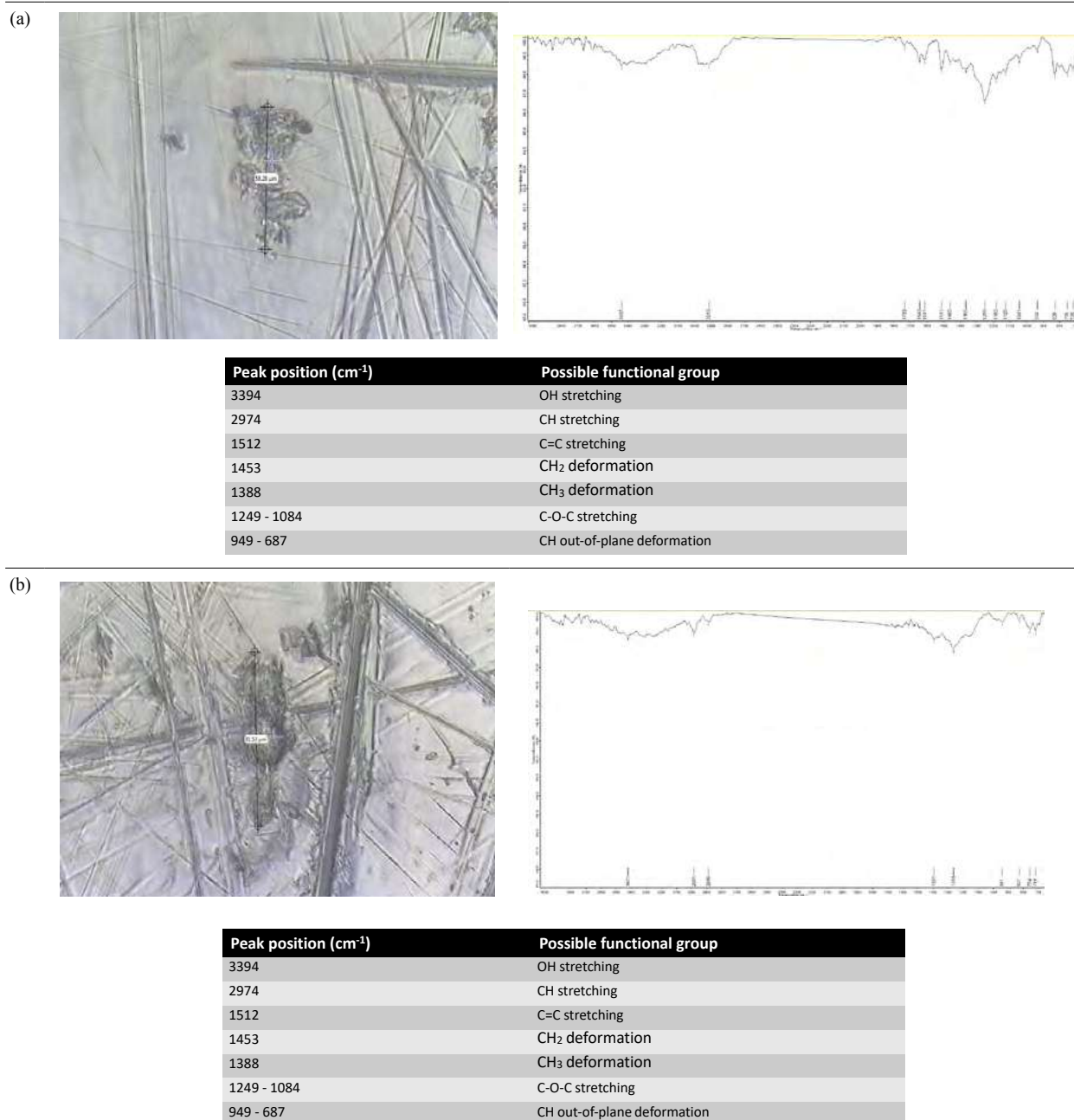


Fig 8.16: Example of microFTIR analysis for microplastic particles from Tenggol Island, a) fragment and b) fiber

Comparison among islands on *in situ* and MPs variation

Redang and Perhentian had higher dissolved oxygen (DO) levels than Tenggol and Kapas, with mean values of 6.74 mg/L and 6.70 mg/L, respectively. Perhentian Island had the highest mean temperature of 33.10 °C, while Tenggol Island had the lowest mean temperature of 28.92°C. In comparison to DO, the highest pH value was recorded at Tenggol, followed by Kapas island, with mean values of 8.44 and 8.40, respectively. The lowest and highest mean salinity values were found on Perhentian (33.10 PSS) and Tenggol islands, respectively (33.59 PSS). Tenggol island had the least varied readings for DO, temperature, and pH, with the lowest standard deviation values of 0.09 mg/L, 0.06 °C, and 0.01 °C, respectively. While on Redang Island, the most varied readings with the highest standard deviation value were recorded for DO (0.59 mg/L), temperature (0.27 °C), and salinity (0.11 PSS). Table 1 displayed a comparison of descriptive analyses for in-situ – water quality, whereas Figure 8.17 and Figure 8.18 depicted a thorough analysis of the box-whisker plot on four (4) in-situ (DO, temperature, pH and salinity) and total abundance of MPs on all islands.

Table 8.1 The comparison of descriptive analysis (insitu – water quality) between Perhentian, Redang, Kapas and Tenggol.

	MIN	MAX	MED	MEAN	SD	SEM
Dissolved Oxygen (mg/L)						
Perhentian	6.37	7.35	6.63	6.70	0.29	0.08
Redang	6.08	8.27	6.62	6.74	0.59	0.17
Kapas	5.28	5.71	5.53	5.50	0.16	0.05
Tenggol	5.83	6.14	5.94	5.98	0.09	0.03
Temperature (°C)						
Perhentian	32.99	33.14	33.10	33.10	0.04	0.01
Redang	29.12	29.95	29.70	29.62	0.27	0.08
Kapas	29.86	30.34	30.15	30.11	0.18	0.06
Tenggol	28.84	29.04	28.92	28.92	0.06	0.02
pH						
Perhentian	6.89	8.07	8.03	7.91	0.34	0.10
Redang	7.14	8.11	8.07	7.95	0.28	0.08
Kapas	8.37	8.42	8.40	8.40	0.02	0.01
Tenggol	8.42	8.45	8.44	8.44	0.01	0.00
Salinity (PSS)						
Perhentian	32.99	33.14	33.10	33.10	0.04	0.01
Redang	33.25	33.59	33.34	33.38	0.11	0.03
Kapas	33.29	33.58	33.51	33.47	0.09	0.03
Tenggol	33.41	33.71	33.59	33.59	0.08	0.02

SD = Standard deviation, SEM = Standard error of mean

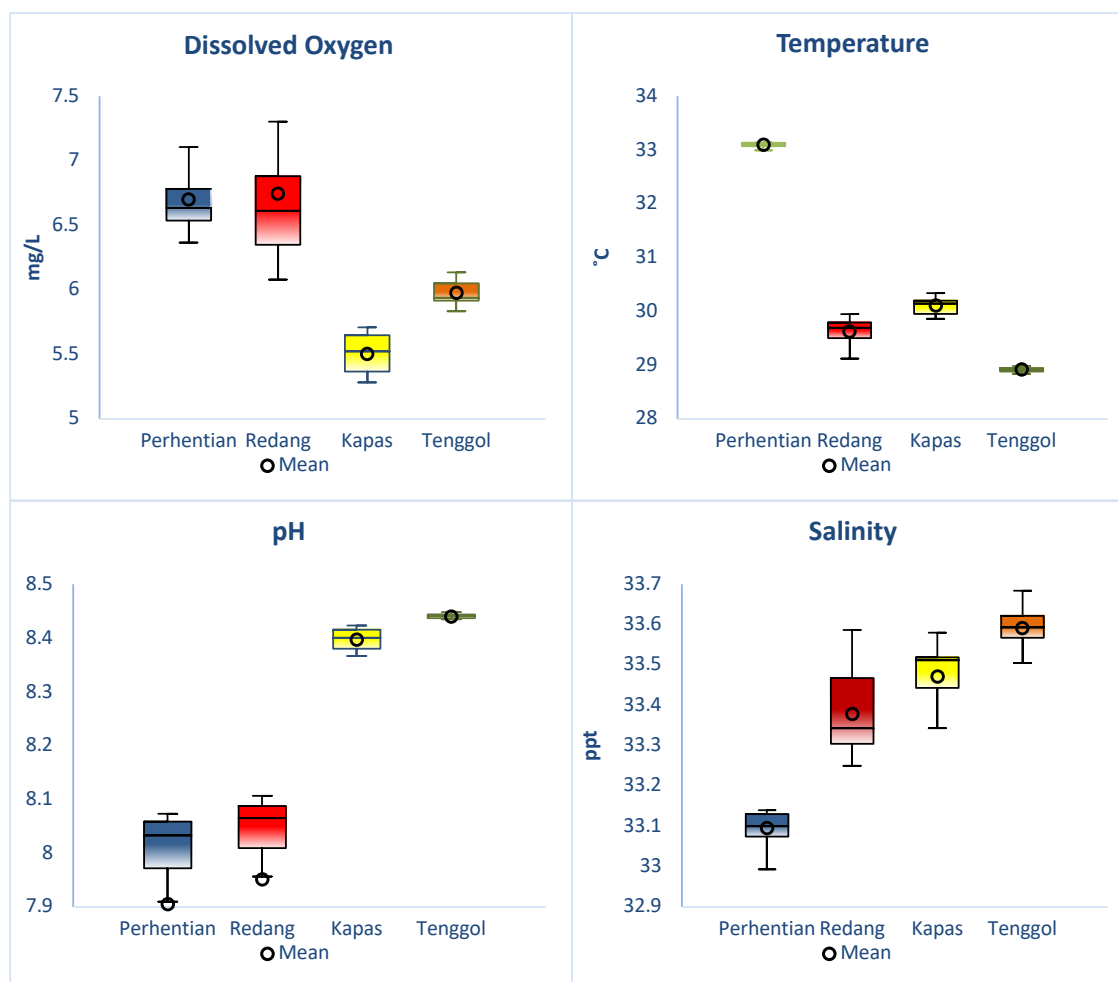


Figure 8.17: Comparison of (a) Dissolved Oxygen, (b) Temperature, (c) pH, (d) Salinity between Perhentian, Redang, Kapas and Tenggol island

Perhentian Island, Redang, Kapas, and Tenggol have total MP abundances of 3516, 1880, 2160, and 1762 item/L, respectively. The variation of MPs in four different islands (Perhentian, Redang, Kapas and Tenggol) is depicted in Figure 11 using box-whisker analysis. Not only was Perhentian recorded as having the highest total abundance, but the MPs in Perhentian ranged between 0 and 270 items/L, demonstrating that it has a diverse range of MPs identified in surface water. Redang came in second with 228 items/L, followed by Tenggol and Kapas with 151 and 161 items/L, respectively. In terms of mean value, Perhentian MPs recorded the highest with 65 items/L, followed by Kapas, Redang, and Tenggol with 40, 35, and 33 items/L, respectively. Perhentian has the highest variance, 5696, in the dataset collected, while Tenggol has the lowest, 1863. From this, it is possible to conclude that the highest MPs value in Perhentian might be due to an increased tourism activity during the sampling period.

Meanwhile data from polymer analysis shows that both polypropylene and polyethylene are common in all islands, whilst polyurethane found in all islands except for the water samples collected in Tenggol island. Additionally, Perhentian island shown the diversity in polymer profile with other notable denser polymers such as polyurethane and polyamide (nylon). Higher number of microplastics found in the Island waters may contribute to the varied polymer profiles. It is interesting to find hydrophilic polymer such as poly vinyl methyl ester that commonly used as adhesives and surface coatings as well as in personal care products was found in Redang island water sample.

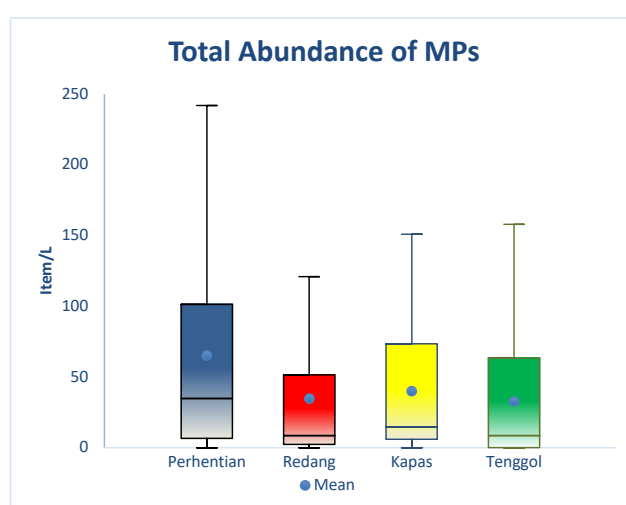


Figure 8.18: Comparison of total microplastic between Perhentian, Redang, Kapas and Tenggol island





Figure 8.9: Compilation of photos during field survey at selected island in Terengganu Marine Parks Islands

CHAPTER 9

POST COVID-19 WATER QUALITY STATUS AT PULAU REDANG, PULAU PERHENTIAN, PULAU KAPAS AND PULAU TENGGOL, MARINE PARK OF TERENGGANU

Poh Seng Chee and Yong Jaw Chuen

9.1 INTRODUCTION:

The Covid-19 outbreak had severely giving an impact to Malaysia and the government has declared the first ever lock down to Malaysia as an approach to curb the spreading chain of this virus. Pulau Redang, Pulau Perhentian, Pulau Kapas and Pulau Tenggol are the important attraction spots to the tourist for having their holidays. The lock down had frozen the visit from the tourist to these islands and giving it a chance to the marine ecosystems to rehabilitate from a long-time disturbance caused by the human activities. When the tourist number had sharply decreased and remaining low for a long period of time. This has provided an opportunity to examine the current water quality through a scientific assessment approach to improve the understand on what are the differences, for the marine environment when there are a large amount of visitors with there is a minimum amount of visitor to these island.

9.2 METHODOLOGY

Altogether there were 104 water samples were collected from Pulau Redang (21 – 22 July 2020), Pulau Perhentian (23 – 25 August 2020), Pulau Kapas (24 September 2020) and Pulau Tenggol (12 October 2020) (Figure 1, Figure 2, Figure 3 and Figure 4). A Niskin water sampler (*Picture pallet-3*) were used to collect the water sample for the surface and the bottom layer. The surface layer was collected at 1 meter depth from the seawater surface and the bottom layer was collected at 1 meter above the seafloor. The water sample was directly kept in a polyethylene bottle and stored in an ice chest that has been filled with ice to kept cold. The samples were processed immediately after the sampling and further laboratory analysis were conducted in an accredited laboratory in Kuala Terengganu.

Water sample assessment could obtain information regarding the actually conditions for the seawater at the sampling location. There is numerous analysis could have been done on these water sample. However, due to the time, funding and apparatus constraint, there are seven parameters has been selected for this investigation as suggested by the Department of Environment, Malaysia (DOE). These parameters are total suspended solid (APHA 2540 D), ammonia-unionized (APHA 4500 NH₃-F), nitrate (APHA 4500 NO₃-E), nitrite (APHA 4500 NO₂-B), phosphate (APHA 4500-P E), *Faecal Coliform* (APHA 9222 D) and Chlorophyll a (APHA 10200 H). Water analysis were conducted in a cooperation with an accredited laboratory using the standard methods and improved in house methods.

The results from a laboratory analysis on the 7 selected parameters will be plug into an equation formulated by the Department of Environment Malaysia (DOE) namely Malaysian Marine Water Quality Index (MMWQI) (Figure 5) alongside with the physical parameters measured *in-Situ* using a multi-parameter (Hydrolab).

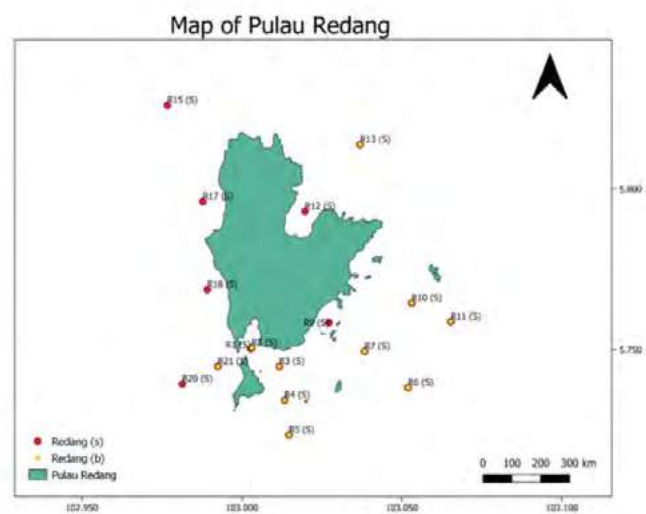


Figure 1: Sampling location of Pulau Redang.

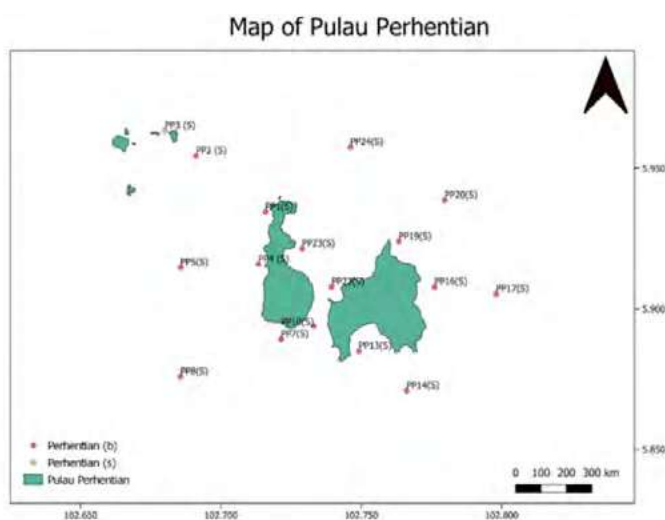


Figure 2: Sampling location of Pulau Perhentian.

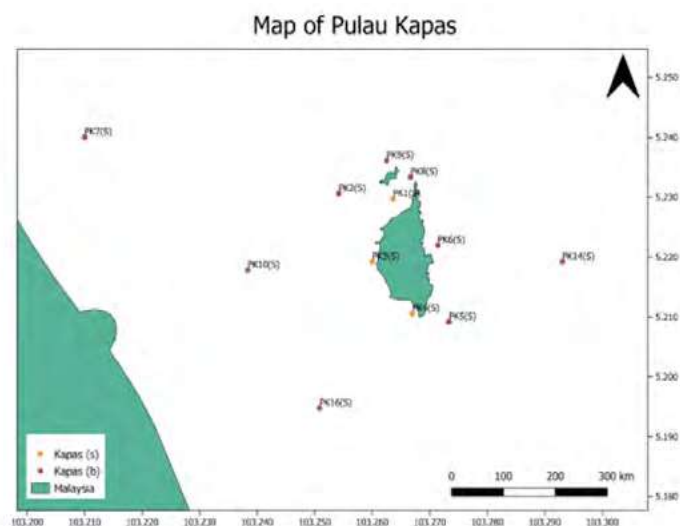


Figure 3: Sampling location of Pulau Kapas.

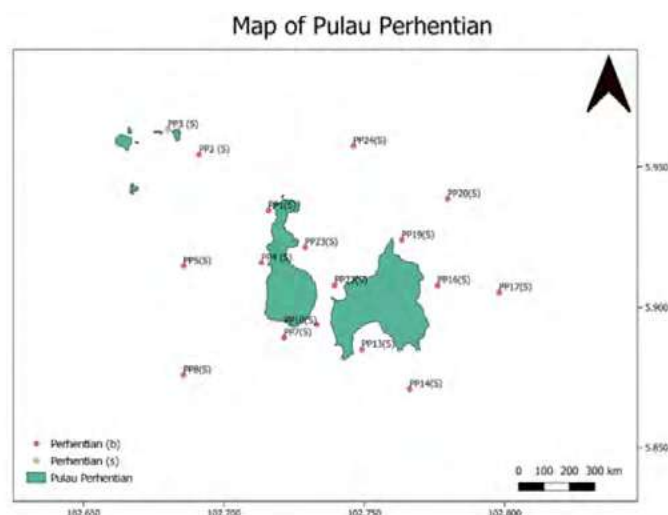


Figure 4: Sampling location of Pulau Tenggol.

3.0 RESULTS AND DISCUSSION

Faecal coliform is the microorganism that indicating the present of the pathogenic microorganisms from the human and animal faeces. A high *Faecal coliform* counts in the sample is indicating there are very likely suggested the water has been polluted by terrestrial domestic waste and may contain pathogenic microorganism. If this phenomenon has been detected, water recreation activities has to be stopped to avoid the potential to get infection from the pathogenic microorganisms.

Ammonia-unionized, phosphorous, nitrite and nitrate are the chemicals present in seawater that usually being grouped under nutrient. The source for these nutrients could have been created locally in seawater through biological processes although usually not significant. The major enrichment factor for these parameters are usually by the anthropogenic waste input from the household, industry and agricultural activities.

Chlorophyll a is an indication for the present of the primary producer in seawater that highly rely on the nutrient. High amount of chlorophyll a may also indicating the marine environment at the sampling location are productive and has utilised the dissolved nutrient in the seawater. If both nutrient and chlorophyll a concentration is low, it may suggested the seawater is in good condition and providing a healthy environment to the marine ecosystem especially coral reef.

Total suspended solid is the particle present in seawater mainly comprised of clay, silt, organic matter that most likely introduced from terrestrial. When a seawater is get to observed having high turbidity. This may suggested the water has been overwhelming by the input of total suspended solid and it could have affected the normal respiration for the marine organisms. This phenomenon could be episodic but if the frequency of occurrence is high and persist for longer time. It may severely give an impact to the marine ecosystems.

The results have shown the water quality in the waters of all four island are remaining low and achieved the marine water quality standard regulated by DOE (Table 1, Table 2, Table 3 and Table 4). Although the faecal coliform count has been recorded relatively high in station R1 with 60 counts/100ml, this should not indicate any danger or pollution as this station is located in the way of the fresh water effluent from the residential area on the Redang island. When these water has entered into the sea and start mixing with seawater, it will dilute the faecal coliform counts and the much higher salinity of seawater could also behave as a simple disinfection medium that very much likely to reduce the survival rate of these pathogenic microorganism.

Seawater may have carried a massive amount of information which may indicating the actual condition during the sampling event. However, it is not necessary to analyse every parameter to have a good information for the marine environment. A quick assessment on the marine environment had been created by DOE. The MMWQI is a formula which had been developed by choosing several parameters according to their weightage factor associated to the beneficial to the protection needs of aquatic ecosystems through an arithmetic approach on a large amount of evidences. The results have suggested that the water quality of these islands are excellent and has no pollution issue during the sampling event (Table 5, Table 6, Table 7 and Table 8; Figure 6). However, at station R1 only able to hit a second class which is good. This single data may not be indicating any potential threat toward the marine ecosystems as at station R1, it is still strongly influenced by freshwater and serve as a source that consequently introduce a reasonable amount of anthropogenic substances into the sea.

Water Quality Parameters:

Table 1: Water quality of selected parameter at Pulau Redang collected on 22nd July 2020.

Parameters	Unit	R1 (S)	R2 (S)	R3 (S)	R4 (S)	R5 (S)	R6 (S)	R7 (S)	R8 (S)	R9 (S)	R10 (S)	R11 (S)	R12 (S)	R13 (S)	R15 (S)	R17 (S)	R18 (S)	R20 (S)	R21 (S)	R21 (B)
Total Suspended Solid	mg/L	1	1	1	1	1	2	1	1	3	1	1	2	1	2	1	1	1	1	1
Ammonia (Unionized)	µg/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Nitrate	µg/L	10	10	<10	<10	10	20	10	<10	<10	<10	<10	<10	<10	10	<10	20	10	20	20
Nitrite	µg/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Phosphate	µg/L	10	20	10	20	30	40	30	50	50	50	40	30	20	10	40	50	50	60	60
Faecal Coliform	CFU/100 mL	1	60	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chlorophyll a	µg/L	0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8

Note: S – surface, B – bottom and R – Pulau Redang

Table 2: Water quality of selected parameter at Pulau Perhentian collected on 24th August 2020.

Parameters	Unit	PP1 (S)	PP1 (B)	PP2 (S)	PP2 (B)	PP3 (S)	PP4 (S)	PP5 (S)	PP7 (S)	PP8 (S)	PP10 (S)	PP11 (S)	PP13 (S)	PP14 (S)	PP16 (S)	PP17 (S)	PP19 (S)	PP20 (S)	PP22 (S)	PP23 (S)	PP24 (S)	PP24 (B)
Total Suspended Solid	mg/L	<1	<1	4	<1	<1	<1	2	1	3	<1	1	2	<1	3	2	2	<1	<1	<1	<1	2
Ammonia (Unionized)	µg/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Nitrate	µg/L	10	<10	<10	<10	<10	<10	<10	20	<10	<10	<10	30	<10	<10	<10	<10	<10	10	<10	<10	<10
Nitrite	µg/L	10	<10	<10	<10	<10	<10	<10	10	<10	<10	<10	10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Phosphate	µg/L	10	20	<10	<10	<10	<10	<10	30	<10	<10	20	<10	30	<10	<10	<10	<10	20	<10	<10	<10
Faecal Coliform	CFU/100 mL	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chlorophyll a	µg/L	0.8	-	<0.8	<0.8	-	<0.8	-	<0.8	-	<0.8	<0.8	-	<0.8	-	-	2	-	<0.8	<0.8	-	2.2

Note: S – surface, B – bottom and R – Pulau Redang

Table 3: Water quality of selected parameter at Pulau Kapas collected on 22nd September 2020.

Parameters	Unit	LOR	PK1	PK2	PK3	PK4	PK5	PK6	PK7	PK8	PK9	PK10	PK14	PK14	PK14	PK14	PK16
			(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)
Total Suspended Solids	mg/L	1	1	2	3	3	1	2	2	2	2	1	1	5	5	3	1
Ammonia (Unionized)	µg/L	10	<10	<10	<10	<10	<10	<10	<10	<10	10	<10	<10	10	<10	<10	10
Nitrate	µg/L	10	<10	<10	<10	<10	<10	<10	10	<10	<10	<10	<10	10	<10	<10	<10
Nitrite	µg/L	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Phosphate	µg/L	10	80	60	60	70	80	60	50	60	80	70	80	60	30	60	80
Free Alkalinity	CF-UV	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Coliform	100 mL																
Chlorophyll a	µg/L	0.8	2	2	1.4	1.7	2.6	1.7	3.4	5.2	2.3	2.9	1.2	2.4	2.4	2.4	2.1

Note: S – surface, B – bottom and R – Pulau Redang

Table4: Water quality of selected parameter at Pulau Tenggara collected on 12th October 2020.

Parameters	Unit	LOR	PT1 (s)	PT1 (B)	PT3 (s)	PT3 (B)	PT4 (s)	PT4 (B)	PT5 (s)	PT5 (B)	PT7 (s)	PT7 (B)	PT8 (s)	PT8 (B)	PT9 (s)	PT9 (B)	PT11 (s)	PT11 (B)	PT13 (s)	PT13 (B)	PT16 (s)	PT16 (B)
Total	mg/L	1	2	1	1	1	1	1	2	1	2	1	1	1	1	3	1	1	1	1	2	1
Suspended Solid	µg/L	10	<10	<10	<10	10	<10	<10	10	10	<10	<10	<10	10	<10	<10	<10	<10	<10	<10	<10	10
Ammonia (Unionized)	µg/L	10	<10	<10	<10	<10	<10	<10	<10	<10	10	<10	<10	<10	10	<10	<10	<10	<10	<10	<10	<10
Nitrate	µg/L	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Phosphate	µg/L	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Faecal	CFU/100 mL	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Coliform	µg/L	0.8	-	0.9	-	0.7	-	1.1	-	<0.8	-	1.0	-	<0.8	-	1.1	-	<0.8	-	0.8	-	0.8
Chlorophyll a	µg/L	0.8	-	0.9	-	0.7	-	1.1	-	<0.8	-	1.0	-	<0.8	-	1.1	-	<0.8	-	0.8	-	0.8

Note: S – surface, B – bottom and R – Pulau Redang

$$\text{MMWQI}^* = q_{\text{DO}}^{0.18} \times q_{\text{FC}}^{0.19} \times q_{\text{NH}_3}^{0.15} \times q_{\text{NO}_3}^{0.16} \times q_{\text{PO}_4}^{0.17} \times q_{\text{TSS}}^{0.15}$$

Whereby,

q_{DO}	$= -85.816 + 55.4768(\text{DO}) - 4.142(\text{DO}^2)$	When DO is < 3 mg/l, $q_{\text{DO}} = 10$ When DO is > 10 mg/l, $q_{\text{DO}} = 10$
q_{FC}	$= 100 \cdot \text{EXP}(-4.005(\text{Faecal coliform}))$	IF FC > 500 Faecal coliform count/100ml, $q_{\text{FC}} = 8$
q_{NH_3}	$= 100 \cdot \text{EXP}(-8.0046(\text{Un-ionized Ammonia}))$	
q_{NO_3}	$= 94.8 \cdot \text{EXP}(-0.0035(\text{Nitrate}))$	
q_{PO_4}	$= 95.2 \cdot \text{EXP}(-0.002(\text{Phosphate}))$	When $\text{PO}_4 > 900 \mu\text{g/l}$, $q_{\text{PO}_4} = 10$
q_{TSS}	$= 95.8 \cdot \text{EXP}(-0.0043(\text{Total Suspended Solids}))$	When TSS > 100 mg/l, $q_{\text{TSS}} = 20$

Figure 5: The Malaysian marine water quality index (MMWQI) adopted from Department of Environment Malaysia.

MMWQI	CLASS
90 - 100	Excellent
80 - 89	Good
50 - 79	Moderate
0 - 49	Poor

Figure 6: The Malaysian marine water quality index (MMWQI) classification adopted from Department of Environment Malaysia.

Table 5: MMWQI of sampling location at Pulau Redang collected on 22nd July 2020.

Station	MMWQI	Class
R1 (S)	86.03	Good
R2 (S)	91.59	Excellent
R3 (S)	91.62	Excellent
R4 (S)	90.69	Excellent
R5 (S)	91.12	Excellent
R6 (S)	91.31	Excellent
R7 (S)	91.43	Excellent
R8 (S)	90.38	Excellent
R9 (S)	90.76	Excellent
R10 (S)	90.79	Excellent
R11 (S)	91.12	Excellent
R12 (S)	91.66	Excellent
R13 (S)	92.03	Excellent
R15 (S)	90.95	Excellent
R17 (S)	91.10	Excellent
R18 (S)	90.69	Excellent
R20 (S)	90.70	Excellent
R21 (S)	90.38	Excellent

Station	MMWQI	Class
R2 (B)	96.13	Excellent
R3 (B)	95.74	Excellent
R4 (B)	95.17	Excellent
R5 (B)	95.19	Excellent
R6 (B)	96.17	Excellent
R7 (B)	94.94	Excellent
R10 (B)	95.03	Excellent
R11 (B)	95.68	Excellent
R13 (B)	96.40	Excellent
R21 (B)	94.64	Excellent

Table 6: MMWQI of sampling location at Pulau Perhentian collected on 24th August 2020.

Station	MMWQI	Class
PP1(S)	95.72	excellent
PP2 (S)	95.12	excellent
PP3 (S)	95.75	excellent
PP4 (S)	95.54	excellent
PP5(S)	95.95	excellent
PP7(S)	96.12	excellent
PP8(S)	96.03	excellent
PP10(S)	95.38	excellent
PP11(S)	95.27	excellent
PP13(S)	96.00	excellent
PP14(S)	96.09	excellent
PP16(S)	96.19	excellent
PP17(S)	95.47	excellent
PP19(S)	96.20	excellent
PP20(S)	96.29	excellent
PP22(S)	95.47	excellent
PP23(S)	95.32	excellent
PP24(S)	96.29	excellent

Station	MMWQI	Class
PP1(B)	96.11	excellent
PP2 (B)	95.40	excellent
PP4 (B)	95.82	excellent
PP5(B)	96.15	excellent
PP7(B)	95.61	excellent
PP8(B)	96.29	excellent
PP11(B)	94.35	excellent
PP13(B)	95.54	excellent
PP14(B)	93.46	excellent
PP16(B)	95.89	excellent
PP17(B)	92.60	excellent
PP19(B)	96.21	excellent
PP20(B)	94.93	excellent
PP22(B)	95.49	excellent
PP23(B)	95.93	excellent
PP24(B)	92.38	excellent

Table 7: MMWQI of sampling location at Pulau Kapas collected on 22nd September 2020.

station	MMWQI	Class
PK1(S)	92.83	excellent
PK2(S)	93.52	excellent
PK3(S)	93.82	excellent
PK4(S)	93.49	excellent
PK5(S)	93.25	excellent
PK6(S)	94.07	excellent
PK7(S)	94.62	excellent
PK8(S)	94.03	excellent
PK9(S)	92.34	excellent
PK10(S)	93.03	excellent
PK14(S)	93.64	excellent
PK16(S)	93.28	excellent

Station	MMWQI	Class
PK2(B)	93.52	excellent
PK5(B)	93.24	excellent
PK6(B)	94.14	excellent
PK7(B)	91.98	excellent
PK8(B)	93.40	excellent
PK9(B)	91.63	excellent
PK10(B)	93.96	excellent
PK14(B)	94.11	excellent
PK16(B)	93.46	excellent

Table 8: MMWQI of sampling location at Pulau Tenggol collected on 12th October 2020.

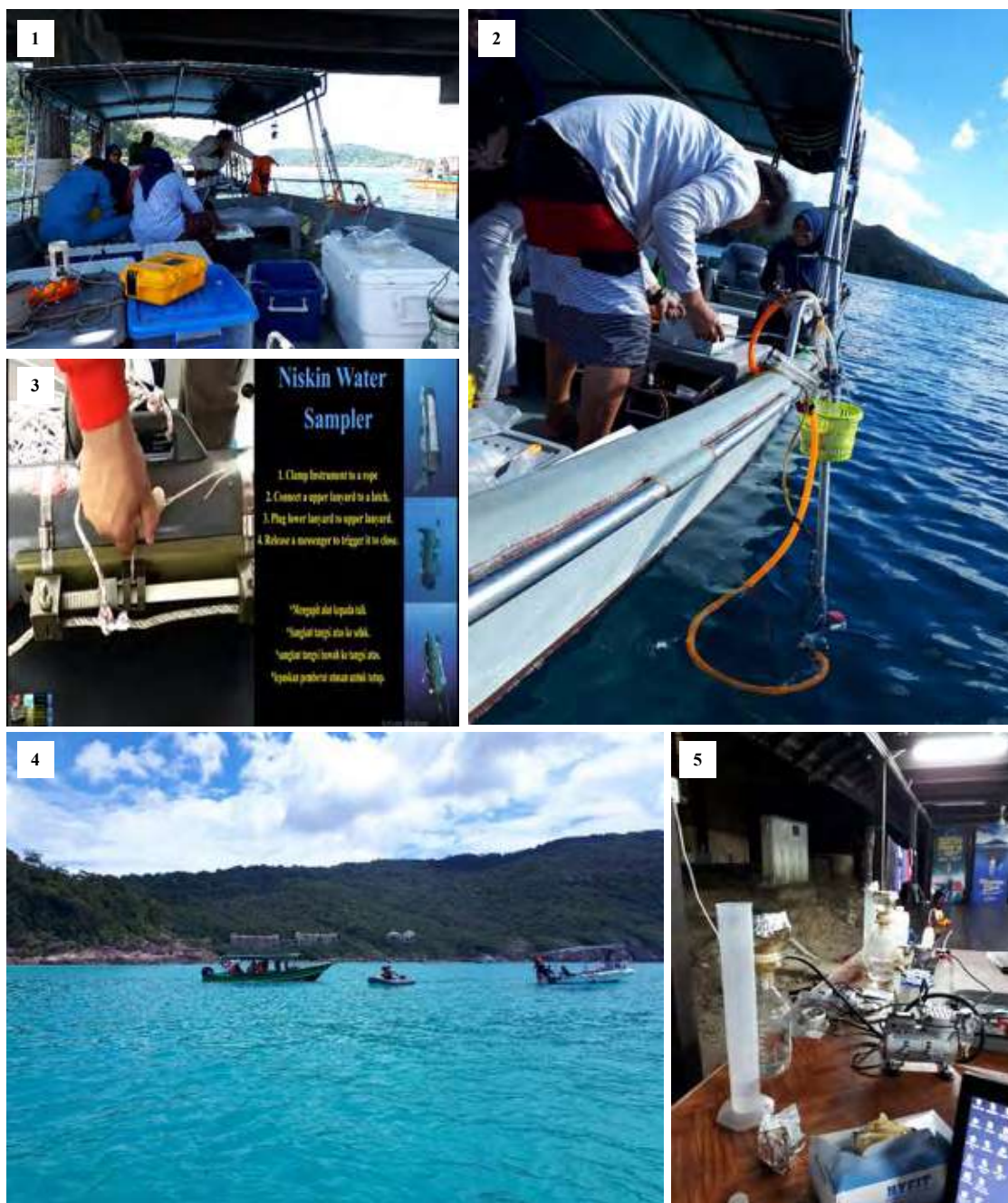
station	MMWQI	Class
PT1(S)	95.31	Excellent
PT3(S)	95.42	Excellent
PT4(S)	95.83	Excellent
PT5(S)	93.91	Excellent
PT7(S)	95.83	Excellent
PT8(S)	95.61	Excellent
PT9(S)	94.52	Excellent
PT11(S)	94.5	Excellent
PT13(S)	95.56	Excellent
PT16(S)	95.51	Excellent

Station	MMWQI	Class
PT1(B)	93.54	Excellent
PT3(B)	95.07	Excellent
PT4(B)	91.88	Excellent
PT5(B)	93.74	Excellent
PT7(B)	95.31	Excellent
PT8(B)	93.63	Excellent
PT9(B)	95.15	Excellent
PT11(S)	94.63	Excellent
PT13(S)	95.43	Excellent
PT16(S)	94.09	Excellent

4.0 CONCLUSION

The lock down action taken by the Malaysian government has been giving a chance to the marine environment for rehabilitation. This outcome has been significantly showed in the results from the scientific assessment. However, if another survey could be conducted when the island is opened to the tourist. This may able to pave a way to make a pollution input budget approach to compliment the marine park authority's data bank in their management. This would also greatly improve their strength in the effort to conserve our nature heritage.

Picture Palette:



1. Sampling operation on a speed boat.
2. Measuring CO₂ content in seawater.
3. Niskin water sampler used during the expedition.
4. A sampling site at Pulau Perhentian.
5. Sample processing set up in Pulau Bidong for samples from Pulau Redang.

CHAPTER 10

THE SOCIO-ECONOMIC IMPACT OF COVID-19 ON: PART 1 - LOCAL COMMUNITIES

Zaleha Mohamad and Noorhaslinda Kulub Abd Rashid

1.0 INTRODUCTION

The issue of COVID-19 has been a 'sensation' topic throughout the world as it has many implications for a country with fast-moving and unexpected variables. The year 2020 for Malaysia will be a simple year of recovery as this pandemic has severely disrupted the Malaysian economy, in fact, as a global health crisis and truly tests the vulnerability and resilience of the communities. The outbreak of COVID-19 has significant impact to Visit Malaysia 2020 (VM2020) with large drop in the number of tourists especially from Singapore and China as 50% of Malaysia's tourist are originate from them (Lee-Peng Foo et al, 2020). It was reported that 170,084 hotel room bookings have been cancelled within 2 months with a loss of revenue approximately to RM68,190, 364 (MAH, 2020). According to the Plan Malaysia (2018), there was 89 resorts encompassing nearly 3,575 rooms in Terengganu with 30% located in 5 Islands. Therefore, it is expected that this number will be affected during MCO due to COVID-19 pandemic. Hence, tourism on the island has also been affected by the spread of Covid-19 pandemic even though there is no new case of Covid-19 reported in Redang, Perhentian, Kapas and Tenggol Islands lately (Refer to Figure 1). It did not only affect the entrepreneurs but also impact to the communities these four islands. As the results, many of them were losing their jobs and income sources as this outbreak were still around.



Figure 1: Statistic of new cases of Covid-19 by districts in Malaysia

2.0 RESEARCH BACKGROUND

The Redang archipelago comprises Redang Island, Pulau Lima, Pulau Paku Besar, Pulau Paku Kecil, Pulau Kerengga Kecil, Pulau Kerengga Besar, Pulau Ekor Tebu, Pulau Ling and Pulau Pinang. Besides, Redang Island is the biggest of all the islands in the Marine Park, measuring about 7 km (4.3 mi) long and 6 km (3.7 mi) wide. Its highest peak is Bukit Besar at 359 metres (1,178 feet) above sea level. Moreover, the boundary of the Redang Island Marine Park is established by a line linking all points 2 nautical miles (3.7 km) from the shores of Redang Island, Pulau Lima, Pulau Ekor Tebu and Pulau Pinang. There are many resorts operate in Redang Island such as Redang Island Resort, Summer Bay resort, Laguna Resort, Redang Reef Resort and others. The types of room services provided in Redang Island are rainforest chalet, seaview chalet, family room, pool view room, standard room and others. Besides, there are many packages are offered by these resorts such as holiday package, diving and snorkelling package, room with breakfast, meeting and event packages, diving courses and others.

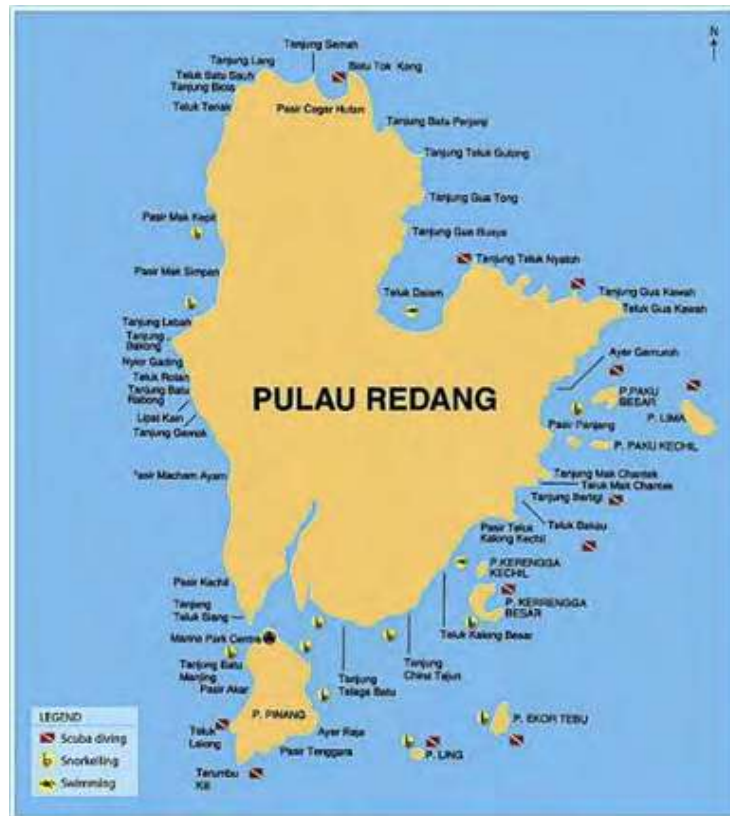


Figure 2: Map of Redang Island

Perhentian Islands are located in Kuala Besut, Terengganu, Malaysia. The larger of the islands are Perhentian Besar and Perhentian Kecil Islands. Except for two main islands of Perhentian Besar and Perhentian Kecil, there are five more islands in the archipelago. All these five islands are uninhabited. Besides, there are many snorkeling and scuba diving spots around it. The amazing sandy beaches are on Rawa, Serengeh and Tokong Burung islands. Besides, the popular tourist activities in Perhentian Islands include scuba-diving, snorkeling, and swimming. There are many resorts provided good services in Perhentian Island such as Ombak Perhentian Island, Perhentian Island Resort, MIMPI Perhentian Resort, Alunan Resort, Arwana Perhentian Resort, Bubu Villa and others. Among the services offered in the resorts and chalets in Perhentian Island were snorkelling package, jungle trekking, diving, squid jigging, kayaking, sunset cruise, island-hopping and fishing trips. Besides, there also comes with oceanfront view, a comfortable bed, and a seaview seating lounge. There were resorts offered the nature exploration or a romantic honeymoon retreat.



Figure 3: Map of Perhentian Island

Kapas Island is located about 6 kilometres east of Marang, Malaysia, with a smaller island, Pulau Gemia, located north of it. It measures roughly 1.5 by 2.5 km. Kapas Turtle Valley Beach Resort, Kapas Island Resort, Ombak Kapas Island Beach Resort and Kapas Coral Island Resort are the resort known in Kapas Island. Other than room services, the resorts and chalets in Kapas Island also offered the seminar room reservation, snorkelling trips, kayak, round island, fishing trip and mask equipment & rental. Besides, Tenggol Island is an island off the coast of Terengganu, Malaysia. It is the last island in a string of islands that include Pulau Perhentian and Pulau Redang. It is connected by ferry to Kuala Dungun on the mainland. Tenggol Coral Beach Resort Tenggol Island Beach Resort and Tenggol Resort are among the resort in Tenggol Island. The package offered in the resorts and chalets in Tenggol Island room package, snorkelling, scuba diving, camera rental, round island, jungle trekking



Figure 4: Map of Kapas and Tenggol Islands

3.0 LITERATURE REVIEWS

In January 2020, Malaysia has been facing a new outbreak known as the a novel coronavirus, 2019-nCoV, or COVID-19 which involved three Chinese citizens, who had entered Johor Bharu, Malaysia via Singapore on 23 January 2020. This virus has been expected to stem from Wuhan, China in December 2019 (Foo, e al, 2020). Hence, the effects of this pandemic caused 313 deaths until 16 November 2020 as well as MCO implementation instructions were carried out to prevent to break the chain of COVID-19 and prevent the spread of this epidemic widely. At the time of writing this report, Malaysia was ranked 85th in the world based on the number of new positive cases. However, Besut, Terengganu was declared as a green area and free of Covid-19 (Ministry of Health Malaysia, 2020). However, the MCO also affects tourism activities in Malaysia while tourism is among the vital industry that contribute to the Malaysian economy (Karim, et al, 2020). Moreover, the cancellation of Visit Malaysia Year 2020 Campaign to the closing down of numerous hotels bought to the other negative implications (Abdul Razak, 2020). Due to the pandemic, it did not only affect the smallest scope of individual income the largest of international trade as the flight operations had to be minimized and employees from different hotels as well as resorts were asked for unpaid leave. Therefore, this cause the decline of the number of tourists due to the Malaysian government imposing travel restrictions and bans (Foo, e al, 2020; Chan & King, 2020). Additionnally, it also give the big impact to the category of B40 who have income lower than RM4850. Most of them have been losing their job and facing the problem business operation. To overcome this problem, an initial financial stimulus amounting to RM 20.0 billion was released in February 2020, before the highlighted PRIHATIN Package, amounting to RM 250 billion, was announced. The PRIHATIN Package as the beneficial initiatives by the government to reduce the income constraints along the pandemics (Shah, et al., 2020). In the longer term, tourism businesses operators should turn this pandemic threat into opportunities by engaging technological innovations to gain efficiency and to decrease operation cost. Besides, to achieve these, the tourism perceptions and suggestions should be implemented via online such as preparing google form in the website (Liew, 2020).

4.0 OBJECTIVES

The objective of this study are i) to examine the factors of social and economic impacts of covid-19 on the affected communities and tourism operators, ii) to identify the problems and challenges of stakeholders from the impacts of covid-19 and iii) to analyze appropriate recommendations based on the results or the issue highlighted.

5.0 AREA OF STUDY

The area of study comprised location, sample, criteria of respondents and date/ duration of study.

5.1 Location of study

Locations of study are Redang, Perhentian, Kapas and Tenggol Islands, Terengganu, Malaysia.

5.2 Sample

This study consist of 297 respondents (communities) and 89 respondents (entrepreneurs) who were interviewed by face to face.

5.3 Criteria of respondents

There are two types of respondents are selected who are community in Redang and Perhentian Islands as well as entrepreneurs in Redang, Perhentian, Kapas and Tenggol Islands.

5.4 Enumerators

There are 8 enumerators participating in this study including Master and PhD students, undergraduate students and others.

5.5 Date/ Duration of study

After the discussion, all parties agreed to start this research on 1 July 2020 until 31 December 2020.

6.0 METHODOLOGY

The methodology study consists of instruments, data collection, data analysis and report writing.

6.1 Study instrument

This study is employed using the questionnaire of 79 items (community) and 93 items (entrepreneurs). This questionnaire comprises 6 sections (A hingga F) which demographic (A), Self-Resistance to Covid-19 (B), Effects on Covid-19 Transmission (C), Government Assistance during Covid-19 Pandemic (D), Behavioral Strategies in the Face of Covid-19 (E) and Shock due to Pandemic.

6.2 Data Collection

Data collection for this study was using face to face technique. This techniques consisted of oral face to face by enumerators or respondents themselves answering the questionnaire with monitored by enumerators. Besides, the interview process took around 30 minutes per respondents.

6.3 Data Analysis and Report Writing

The process of data analysis and report writing is carried out on September 1 until Disember 20, 2020. The report will be submitted to Jabatan Taman Laut Malaysia.

7.0 FINDINGS (COMMUNITY)

This section is the findings of the study resulting from a field study conducted on communities in Redang and Perhentian Islands, Terengganu, Malaysia. Discussions were made based on questionnaires.

7.1 Demographic Profile of Respondents

Table 1 shows the demographic profile of 140 and 157 respondents of Redang and Perhentian Island, respectively. Totally, majority respondent consist of males (69.0%) and 31.0 % females. From these, majority of respondents of Redang and Perhentian Island are also males which is 71.4% and 66.9%. Average of respondents in Redang Island and total both of Islands show the age 21 to 61 years and above which are 16.4% to 21.4% and 22.3% to 26.1%, respectively. Meanwhile, most of respondents (22.3% to 26.1%) of Perhentian Island aged from 21 to 50 years old. Besides, more than 93% are from Terengganu and remaining are others states such as Kelantan and Selangor. Furthermore, over than 82.8% are from Terengganu and remaining are others states such as Johor, Kedah, Kelantan, Perak and Selangor. It makes the overall percentage of respondents from Terengganu are 87.9%. Majority of respondents in Redang and Perhentian Island are married with percentage of 72.9% and 67.5%, respectively. Therefore, overall, 70% respondents are married while 24.2% and 8.3% are single and divorced, respectively. More than 70% respondents have the level of SPM and below as their highest education for both Islands. Majority respondents of Redang Island have the income of RM501 to RM1000 (44.3%) while the average of respondents which are 75.2% and 72.3% of them have the income between RM501 and RM2000 Perhentian Island and both islands, respectively.

Table 1: Frequency (F) and percentage (%) for demographic profile of respondents.

Demographic profile	Redang Island		Perhentian Island		Total	
	F	%	F	%	F	%
Gender						
Male	100	71.4	105	66.9	205	69.0
Female	40	28.6	52	33.1	92	31.0
Total	140	100	157	100	297	100
Age						
20 years and below	6	4.3	14	8.9	20	6.7
21 to 30 years	23	16.4	36	22.9	59	19.9
31 to 40 years	25	17.9	41	26.1	66	22.2
41 to 50 years	30	21.4	35	22.3	65	21.9
51 to 60 years	25	17.9	15	9.6	40	13.5
61 years and above	29	20.7	11	7	40	13.5
Not specified	2	1.4	5	3.2	7	2.4
Total	140	100	157	100	297	100
Place of Birth						
Terengganu	131	93.6	130	82.8	261	87.9
Others	9	6.4	27	17.2	36	12.1
Total	140	100	157	100	297	100
Status of marriage						
Single	30	21.4	38	24.2	68	22.9
Married	102	72.9	106	67.5	208	70.0
Divorced/widow	8	5.7	13	8.3	21	7.1
Total	140	100	157	100	297	100
Educational level						
None	15	10.7	13	8.3	28	9.4
PMR/SRP and below	59	42.1	47	29.9	106	35.7
SPM	51	36.4	68	43.3	119	40.1
STPM/Sijil kemahiran/Diploma	9	6.4	19	12.1	28	9.4
Degree and above	6	4.3	10	6.4	16	5.4
Total	140	100	157	100	297	100
Level of income						
RM500 and below	23	16.4	12	7.6	35	11.8
RM501 to RM1000	62	44.3	59	37.6	121	40.7
RM1001 to RM2000	35	25	59	37.6	94	31.6
RM2001 to RM3000	6	4.3	13	8.3	19	6.4
RM3001 to RM4000	2	1.4	2	1.3	4	1.3
RM4001 to RM5000	0	0.0	5	3.2	5	1.7
RM5001 and above	0	0.0	2	1.3	2	0.7
None	12	8.6	5	3.2	17	5.7
Total	140	100	157	100	297	100

7.2 Number of Dependents

The information of number of dependents are shown in Table 2. Most of respondents have 1 to 3 for the number of total dependents (including children, spouse, parents, siblings/relatives and others) which are 50.7% in Redang Island, 72.0% (Perhentian Island) and 62.0% for both Islands. Over than 40% respondents have 1 to 3 children while more than 14% respondents have dependents of 1 to 2 parents for Redang Island, Perhentian Island and both Islands. Besides, less than 5% respondents in Redang Island, Perhentian Island and both Islands have dependents of siblings/relatives while more than 6% respondents have other dependents.

Table 2: Frequency (F) and percentage (%) for Number of Dependents.

Number of Dependents	Redang Island		Perhentian Island		Total	
	F	%	F	%	F	%
Total of dependents						
1 to 3	71	50.7	113	72.0	184	62.0
4 to 6	32	22.9	21	13.4	53	17.8
7 to 9	9	6.4	7	4.5	16	5.4
10 and above	2	1.4	1	0.6	3	1
None	26	18.6	15	9.6	41	13.8
Total	140	100	157	100	297	100
Number of children						
1 to 3	61	43.6	81	51.6	142	47.8
4 to 6	21	15	19	12.1	40	13.5
7 to 9	3	2.1	3	1.9	6	2
10 and above	2	1.4	1	0.6	3	1
None	53	37.9	53	33.8	106	35.7
Total	140	100	157	100	297	100
Number of Parents						
1	11	7.9	6	3.8	17	5.7
2	9	6.4	21	13.4	30	10.1
3	3	2.1	0	0.0	3	1
None	117	83.6	130	82.8	247	83.2
Total	140	100	157	100	297	100
Number of Siblings/Relatives						
1	3	2.2	2	1.3	5	1.7
2	1	0.7	0	0.0	1	0.3
4	2	1.4	0	0.0	2	0.7
None	134	95.7	155	98.7	289	97.3
Total	140	100	157	100	297	100
Others						
1	9	6.5	10	6.4	19	6.4
2	1	0.7	1	0.6	2	0.7
3	1	0.7	0	0.0	1	0.3
None	129	92.1	146	93	275	92.6
Total	140	100	157	100	297	100

7.3 Occupations

The status of occupation, sector of occupation and earnings are described in Table 3. Majority of respondents (37.9%) in Redang Islands worked before MCO and jobless after MCO while more than 22% of them working before and during MCO (still working and have full income) as well as state in others conditions, respectively. Besides, in Perhentian Islands, 49% respondents worked before MCO and jobless after MCO while 32.5% respondents worked before and during MCO (still working and have full income). Therefore, 38% of respondents worked before and during MCO (still working and have full income) as well as 35% respondents worked before MCO and job less after MCO. Additionally, majority of respondents are under self-employed (more than 42%) and private sectors (more than 31%) for Redang Island, Perhentian Island and both Islands. Moreover, most of them (more than 37%) received their earnings based on monthly income and income based on demand (more than 25%) for Redang Island, Perhentian Island and both Islands.

Table 3: Frequency (F) and percentage (%) for Occupations.

Occupation	Redang Island		Perhentian Island		Total	
	F	%	F	%	F	%
Status of occupation						
Working before and during MCO (Still working and have full income)	36	25.7	77	49.0	113	38.0
Working before MCO and jobless after PKP	53	37.9	51	32.5	104	35.0
Jobless during and after MCO	5	3.6	3	1.9	8	2.7
Others	32	22.9	19	12.1	51	17.2
Unemployed	14	10	7	4.5	21	7.1
Total	140	100	157	100	297	100
Sector						
Government agency	12	8.6	11	7	23	7.7
Private	44	31.4	62	39.5	106	35.7
Self-employed	60	42.9	68	43.3	128	43.1
Others	10	7.1	9	5.7	19	6.4
Government/children support	2	1.4	2	1.3	17	5.7
None	12	8.6	5	3.2	4	1.3
Total	140	100	157	100	297	100
Earnings						
Income per task	19	13.6	11	7	30	10.1
Hourly income	2	1.4	7	4.5	9	3
Weekly income	13	9.3	5	3.2	18	6.1
Monthly income	53	37.9	87	55.4	140	47.1
Income based on demand	39	27.9	40	25.5	79	26.6
None	14	10	7	4.5	21	7.1
Total	140	100	157	100	297	100

7.4 Monthly Expenditure

The following Table 4 indicates the monthly expenditures of the respondents. From the analysis, more than 9% respondents in Redang Island, Perhentian Island and both Islands made a vehicle loan and 7% of them also made a private loan, respectively. Meanwhile, more than 5% respondents in Redang Island, Perhentian Island and both Islands spent for house rent and less than 5% use their expenditure for loan by credit card, educational loan, paying for debt and business premises rent. However, in Redang Island, around 5.1% respondents spent for housing loan while 6.4% respondents in Perhentian Island use their expenditure for business loan. Furthermore, majority respondents in Perhentian Island (52.2%) used for other expenditures.

Table 4: Frequency (F) and percentage (%) for monthly expenditure.

Monthly expenditure		Redang Island		Perhentian Island		Total	
		F	%	F	%	F	%
Housing loan	Yes	0	0	8	5.1	8	2.7
	No	140	100	149	94.9	289	97.3
	Total	140	100	157	100	297	100
Private loan	Yes	11	7.9	12	7.6	23	7.7
	No	129	92.1	145	92.4	274	92.3
	Total	140	100	157	100	297	100
Vehicle loan	Yes	13	9.3	14	8.9	27	9.1
	No	127	90.7	143	91.1	270	90.9
	Total	140	100	157	100	297	100
Loan by credit card	Yes	3	2.1	1	0.6	4	1.3
	No	137	97.9	156	99.4	293	98.7
	Total	140	100	157	100	297	100

Business loan	Yes	9	6.4	4	2.5	13	4.4
	No	131	93.6	153	97.5	284	95.6
	Total	140	100	157	100	297	100
Educational loan	Yes	6	4.3	5	3.2	11	3.7
	No	134	95.7	152	96.8	286	96.3
	Total	140	100	157	100	297	100
Pay for debt	Yes	6	4.3	7	4.5	13	4.4
	No	134	95.7	150	95.5	284	95.6
	Total	140	100	157	100	297	100
House rent	Yes	10	7.1	8	5.1	18	6.1
	No	130	92.9	149	94.9	279	93.9
	Total	140	100	157	100	297	100
Business premises rent	Yes	2	1.4	6	3.8	8	2.7
	No	138	98.6	151	96.2	289	97.3
	Total	140	100	157	100	297	100
Others	Yes	7	5.0	82	52.2	89	30.0
	No	133	95	75	47.8	208	70
	Total	140	100	157	100	297	100

7.5 Threats Of COVID-19 Pandemic

The following table showing the threats of COVID-19 pandemic in term of economic, health, environmental, social and political shocks. The economic and environmental shock is a threats of COVID-19 pandemic in Redang Island that were recorded with largest respondents of 67.9% and 45.0%, respectively. Whereas, majority of respondents (87.9%) state that the threats COVID-19 Pandemic in Perhentian Island is economic shock. However, 22.9% respondents state that health shock in Redang Island and environmental politic shock in Perhentian Island as threats of COVID-19 Pandemic. Additionally, less than 15% mentioned that the politic and social shock as threats of COVID-19 Pandemic in Redang Island, Perhentian Island and both Islands, respectively.

Table 5: Frequency (F) and percentage (%) for Threats of COVID-19 Pandemic.

Threats of COVID-19 Pandemic		Redang Island		Perhentian Island		Total	
		F	%	F	%	F	%
Economic shock (eg. jobless)	Yes	95	67.9	138	87.9	233	78.5
	No	45	32.1	19	12.1	64	21.5
	Total	140	100	157	100	297	100
Health shock (eg. infection)	Yes	32	22.9	20	12.7	52	17.5
	No	108	77.1	137	87.3	245	82.5
	Total	140	100	157	100	297	100
Environmental shock (eg. emergency condition/ MCO)	Yes	63	45.0	36	22.9	99	33.3
	No	77	55	121	77.1	198	66.7
	Total	140	100	157	100	297	100
Social shock (eg. psychology of family institutions)	Yes	11	7.9	24	15.3	35	11.8
	No	129	92.1	133	84.7	262	88.2
	Total	140	100	157	100	297	100
Politic shock (eg. Changes of country administration)	Yes	16	11.4	16	10.2	32	10.8
	No	124	88.6	141	89.8	265	89.2
	Total	140	100	157	100	297	100

7.6 Assistance Mechanism/ Strategy

It could be seen from Table 6, the assistance mechanism or strategy obtained during COVID-19 pandemic. Majority respondents in Redang Island, Perhentian Island and both Islands received the government assistance that is more than 73%, respectively. Besides, in Perhentian Islands, 28% of them also received from neighbours/relatives assistance while 19.3% and 9.3% respondents made consumption expenditure rations and others, respectively. Meanwhile, 26.4%, 17.2% and 21.5% respondents in Redang Island, Perhentian Island and both Islands did not have any assistance mechanism or strategy during COVID-19 pandemic. Additionally, less than 5% respondents made a loan, asset sale, job transition and family changes in Redang Island, Perhentian Island and both Islands, respectively.

Table 6: Frequency (F) and percentage (%) for assistance mechanism/ strategy.

Assistance mechanism/ strategy		Redang Island		Perhentian Island		Total	
		F	%	F	%	F	%
Loan	Yes	4	2.9	7	4.5	11	3.7
	No	136	97.1	150	95.5	286	96.3
	Total	140	100	157	100	297	100
Asset sale	Yes	3	2.1	5	3.2	8	2.7
	No	137	97.9	152	96.8	289	97.3
	Total	140	100	157	100	297	100
Consumption expenditure	Yes	27	19.3	18	11.5	45	15.2
	No	113	80.7	139	88.5	252	84.8
	Total	140	100	157	100	297	100
Job transition	Yes	6	4.3	5	3.2	11	3.7
	No	134	95.7	152	96.8	286	96.3
	Total	140	100	157	100	297	100
Family changes	Yes	0	0.0	1	0.6	1	0.3
	No	140	100	156	99.4	296	99.7
	Total	140	100	157	100	297	100
Neighbours/relatives assistance	Yes	5	3.6	44	28.0	49	16.5
	No	135	96.4	113	72	248	83.5
	Total	140	100	157	100	297	100
Government	Yes	107	76.4	115	73.2	222	74.7
	No	33	23.6	42	26.8	75	25.3
	Total	140	100	157	100	297	100
Others	Yes	13	9.3	6	3.8	19	6.4
	No	127	90.7	151	96.2	278	93.6
	Total	140	100	157	100	297	100
None	Yes	37	26.4	27	17.2	64	21.5
	No	103	73.6	130	82.8	233	78.5
	Total	140	100	157	100	297	100

7.7 Mean of Expenditure

Mean of expenditure are presented in Table 7. The food expenditure record the highest mean during MCO (RM476) compared to after and before MCO in Redang Island. This condition also occurred in medical cost, daily cost and online purchase expenditure in Redang Island. Meanwhile the food expenditure in Perhentian Island record the highest mean before MCO (RM750), which decrease during MCO and then increase after MCO. The same situation in Perhentian Island are also occurred to public transport, daily cost and online purchase expenditure. Medicine, insurance/takaful and electricity bill recorded the highest mean in Redang Island before MCO while insurance/takaful and electricity bill showed the highest mean in Perhentian Island during MCO. In Redang Island, Perhentian Island and both Islands show that the expenditure for paying debt and liability, saving, investment, entertainment (hobby and sport), petrol/diesel eating outside (including online order), contribution to parents and others indicate the highest mean before MCO, compared to during MCO and after MCO. However, there is slightly difference between mean of water bill, telecommunication bill (telephone and internet) and charity/almmsgiving expenditure between before, during and after MCO.

Table 7: Frequency (F) and percentage (%) for mean of expenditure.

Expenditure (RM)	P. Redang			P. Perhentian			Total		
	Before MCO	During MCO	After MCO	Before MCO	During MCO	After MCO	Before MCO	During MCO	After MCO
Food	421	476	408	750	613	721	599	551	580
Medicine	373	170	271	179	182	149	226	179	178
Pay debt and liability	637	92	262	787	472	980	734	338	726
Saving	269	117	177	837	126	585	652	123	446
Investment	389	225	324	445	267	347	414	244	335

Entertainment (hobby and sport)	196	25	56	139	15	69	159	19	65
Insurance/takaful	71	61	26	131	187	141	112	147	104
Electricity bill	100	102	175	150	187	154	123	143	165
Water bill	39	38	59	53	53	58	45	45	59
Telecommunication bill (telephone and internet)	55	50	56	65	62	64	60	56	60
Medical cost	283	346	250	233	233	233	271	318	246
Petrol/ Diesel	108	63	99	732	343	773	346	169	358
Public transport	34	27	32	225	84	212	199	77	188
Daily clothes	89	103	11	193	11	162	154	47	103
Online purchase	88	182	67	221	16	121	141	116	88
Eating outside (including online order)	197	60	98	251	158	219	232	123	179
Charity/almsgiving	45	23	35	64	77	44	53	46	39
Contribution to parents	205	100	156	297	182	252	253	142	206
Others	253	123	123	175	73	175	231	108	138

7.8 Impact Of Transmission Of COVID-19

Table 8 displays the impact of transmission of COVID-19. The biggest impact of transmission of COVID-19 in Redang Island is job loss which recorded the highest number of respondents (34.3%), followed by leave without pay (21.4% respondents) and the decrease of number of working hours (15.7%). However, 22.9% of respondents claim that there is no impact of transmission of COVID-19. Meanwhile, in Perhentian Island the biggest impact of transmission of COVID-19 in Redang Island is leave without pay (35.0%) followed by job loss (24.2%).

Table 8: Frequency (F) and percentage (%) for impact of transmission of COVID-19.

Impact of transmission of COVID-19		Redang Island		Perhentian Island		Total	
		F	%	F	%	F	%
Work from home	Yes	7	5	18	11.5	25	8.4
	No	133	95	139	88.5	272	91.6
	Total	140	100	157	100.0	297	100
Half pay leave	Yes	3	2.1	13	8.3	16	5.4
	No	137	97.9	144	91.7	281	94.6
	Total	140	100	157	100.0	297	100
Leave without pay	Yes	30	21.4	55	35.0	85	28.6
	No	110	78.6	102	65.0	212	71.4
	Total	140	100	157	100.0	297	100
Job loss	Yes	48	34.3	38	24.2	86	29
	No	92	65.7	119	75.8	211	71
	Total	140	100	157	100.0	297	100
The number of working hours decrease	Yes	22	15.7	7	4.5	29	9.8
	No	118	84.3	150	95.5	268	90.2
	Total	140	100	157	100.0	297	100
The number of working hours increase	Yes	3	2.1	0	0.0	3	1
	No	137	97.9	157	100.0	294	99
	Total	140	100	157	100.0	297	100
No impact	Yes	32	22.9	34	21.7	66	22.2
	No	108	77.1	123	78.3	231	77.8
	Total	140	100	157	100.0	297	100

7.9 The Concerns after MCO being Declared

The analysis of concerns after MCO being declared is presented in Table 9. The main concern are worried by most of respondents (50.0%) in Redang Island are COVID-19 infection and insufficient daily expenses (47.9% respondents). Meanwhile in Perhentian Island, no saving for emergency case and COVID-19 infection are the concerns of 54.1% and 51.0% respondents after MCO being declared, respectively. For both islands, the main concern of respondents are no saving for emergency case (41.4%), COVID-19

infection (52.2%) and insufficient daily expenses (40.1%). Besides, over than 30% respondents in Redang Island are worried about lack of expenses for food saving, monthly bills and no saving for emergency case, respectively. Furthermore, more than 30% respondents in both islands concerned about lack of saving. The rest concerns are recorded less than 30% respondents.

Table 9: Frequency (F) and percentage (%) for the concerns after MCO being declared.

The concerns after MCO being declared		Redang Island		Perhentian Island		Total	
		F	%	F	%	F	%
None	Yes	10	7.1	25	15.9	35	11.8
	No	130	92.9	132	84.1	262	88.2
	Total	140	100	157	100	297	100
No saving for emergency case	Yes	43	30.7	80	51.0	123	41.4
	No	97	69.3	77	49.0	174	58.6
	Total	140	100	157	100	297	100
COVID-19 infection	Yes	70	50.0	85	54.1	155	52.2
	No	70	50.0	72	45.9	142	47.8
	Total	140	100	157	100	297	100
Insufficient daily expenses	Yes	67	47.9	52	33.1	119	40.1
	No	73	52.1	105	66.9	178	59.9
	Total	140	100	157	100	297	100
Lack of expenses for food	Yes	51	36.4	32	20.4	83	27.9
	No	89	63.6	125	79.6	214	72.1
	Total	140	100	157	100	297	100
Lack of saving	Yes	51	36.4	39	24.8	90	30.3
	No	89	63.6	118	75.2	207	69.7
	Total	140	100	157	100	297	100
Affordability to pay monthly bills	Yes	47	33.6	25	15.9	72	24.2
	No	93	66.4	132	84.1	225	75.8
	Total	140	100	157	100	297	100
Affordability to pay debt	Yes	28	20.0	13	8.3	41	13.8
	No	112	80	144	91.7	256	86.2
	Total	140	100	157	100	297	100
Job loss	Yes	39	27.9	25	15.9	64	21.5
	No	101	72.1	132	84.1	233	78.5
	Total	140	100	157	100	297	100
Others	Yes	3	2.1	5	3.2	8	2.7
	No	137	97.9	152	96.8	289	97.3
	Total	140	100	157	100	297	100

7.10 Source of Finance or Saving

The analysis of financial source or saving before, during and after MCO are described in Table 10. Before MCO, majority of respondents (30.7%) in Redang Island spend for saving for 2 to 4 weeks while 29.3% and 21.0% respondents in Perhentian Island spend their saving for less than 2 weeks and others before MCO, respectively. Overall, more than 20% spend their saving less than 2 weeks and 2 to 4 weeks, respectively. However, in Redang Island they could save 2 to 4 weeks decrease to 22.9% during MCO while in Perhentian Island save less weeks increase to 39.5%. Consequently, it implies that could save less weeks increase to 32.3% during MCO (for both islands). Moreover, it recovered after MCO for Redang Island, Perhentian Island and both Islands.

Table 10: Frequency (F) and percentage (%) for source of finance or saving.

Source of finance or saving		Redang Island		Perhentian Island		Total	
		F	%	F	%	F	%
Before MCO	<2 weeks	17	12.1	46	29.3	63	21.2
	2 weeks	8	5.7	12	7.6	20	6.7
	2 to 4 weeks	43	30.7	19	12.1	62	20.9
	4 to 6 weeks	14	10.0	8	5.1	22	7.4
	6 to 8 weeks	15	10.7	10	6.4	25	8.4
	Half year	10	7.1	12	7.6	22	7.4
	A year	5	3.6	10	6.4	15	5.1

	Others	14	10.0	33	21.0	47	15.8
	None	14	10.0	7	4.5	21	7.1
	Total	140	100	157	100	297	100
During MCO	< 2 weeks	34	24.3	62	39.5	96	32.3
	2 weeks	12	8.6	11	7.0	23	7.7
	2 to 4 weeks	32	22.9	17	10.8	49	16.5
	4 to 6 weeks	17	12.1	6	3.8	23	7.7
	6 to 8 weeks	6	4.3	8	5.1	14	4.7
	Half year	4	2.9	5	3.2	9	3
	A year	5	3.6	6	3.8	11	3.7
	Others	16	11.4	34	21.7	50	16.8
	None	14	10	8	5.1	22	7.4
	Total	140	100	157	100	297	100
After MCO	< 2 weeks	28	20.0	56	35.7	84	28.3
	2 weeks	11	7.9	12	7.6	23	7.7
	2 to 4 weeks	34	24.3	14	8.9	48	16.2
	4 to 6 weeks	14	10	10	6.4	24	8.1
	6 to 8 weeks	8	5.7	7	4.5	15	5.1
	Half year	5	3.6	12	7.6	17	5.7
	A year	6	4.3	7	4.5	13	4.4
	Others	20	14.3	31	19.7	51	17.2
	None	14	10	8	5.1	22	7.4
	Total	140	100	157	100	297	100

7.11 Impact of MCO on Business Operation

Table 11 shows the analysis of the impact of MCO on business operation descriptively. About 82.2% respondents state the business operation are permanently closed due to MCO in Perhentian Island compared to 57.9% respondents in Redang Island. It brings the total of percentage 70.7% respondents permanently closed their business operation due to MCO. Besides, in Redang Island more than 30% respondents express that the impact of MCO cause the reduction of number employees during MCO (no contract extension), business restructured during MCO, layoffs during MCO, employees' wage deduction during MCO and implementation of unpaid leave to employees. Whereas, in Perhentian Island less than 11% express that the impact of MCO cause the reduction of number employees during MCO (no contract extension), business restructured during MCO, layoffs during MCO, employees' wage deduction during MCO and implementation of unpaid leave to employees. It takes to the total of percentage greater than 20% respondents state that these affected their business operation due to MCO.

Table 11: Frequency (F) and percentage (%) for impact of MCO on business operation.

Impact MCO on business operation		Redang Island		Perhentian Island		Total	
		F	%	F	%	F	%
Permanently closed	Yes	81	57.9	129	82.2	210	70.7
	No	59	42.1	28	17.8	87	29.3
	Total	140	100	157	100	297	100
Reduction of number employees during MCO (No contract extension)	Yes	48	34.3	17	10.8	65	21.9
	No	92	65.7	140	89.2	232	78.1
	Total	140	100	157	100	297	100
Business restructured during MCO	Yes	51	36.4	12	7.6	63	21.2
	No	89	63.6	145	92.4	234	78.8
	Total	140	100	157	100	297	100
Layoffs during MCO	Yes	53	37.9	12	7.6	65	21.9
	No	87	62.1	145	92.4	232	78.1
	Total	140	100	157	100	297	100
Employees' wage deduction during MCO	Yes	52	37.1	17	10.8	69	23.2
	No	88	62.9	140	89.2	228	76.8
	Total	140	100	157	100	297	100
Implementation of unpaid leave to employees	Yes	48	34.3	12	7.6	60	20.2
	No	92	65.7	145	92.4	237	79.8
	Total	140	100	157	100	297	100

7.12 Economic Stimulus Package

Table 12 shows the analysis of economic Stimulus Package. More than 84% and 73% respondents claim that they received the benefit from economic stimulus package and eligibility as a beneficiary/Concerned Economic Stimulus Package in Redang and Perhentian Islands, respectively. Therefore, it makes over than 80% for both islands. Moreover, 76.4% and 59.9% respondents state that it is easy to access the processes / procedures for obtaining concerned economic stimulus package assistance in Redang and Perhentian Island, respectively. Additionally, 67.7% respondents felt easy to access the processes / procedures for obtaining concerned economic stimulus package assistance.

Table 12: Frequency (F) and percentage (%) for economic Stimulus Package.

Economic Stimulus Package		Redang Island		Perhentian Island		Total	
		F	%	F	%	F	%
I get the benefit from Economic Stimulus Package	Yes	125	89.3	115	73.2	240	80.8
	No	15	10.7	42	26.8	57	19.2
	Total	140	100	157	100	297	100
Level of access the processes/ procedures for obtaining Concerned Economic Stimulus Package Assistance	Difficult	23	16.4	36	22.9	59	19.9
	Easy	107	76.4	94	59.9	201	67.7
	Others	10	7.1	27	17.2	37	12.5
	Total	140	100	157	100	297	100
Eligibility as a beneficiary / Concerned Economic Stimulus Package	Eligible	118	84.3	120	76.4	238	80.1
	Not eligible	14	10	29	18.5	43	14.5
	Appeal	8	5.7	6	3.8	14	4.7
	Not apply	0	0.0	2	1.3	2	0.7
	Total	140	100	157	100	297	100

7.13 Impact of Economic Stimulus Package

Table 13 shows the analysis of impact of economic stimulus package among respondents. About 80% respondents express that economic stimulus package is effective to reduce the burden of finance while 42.9% of respondents agree that economic stimulus package fully effective to reduce the burden of finance in Redang Island. However, 69.4% respondents consider that economic stimulus package is effective to reduce the burden of finance and only 17.8% agree that economic stimulus package fully effective to reduce the burden of finance in Perhentian Island. Thus, majority respondents (74.4%) as a whole agree that economic stimulus package is effective to reduce the burden of finance.

Table 13: Frequency (F) and percentage (%) for impact of Economic Stimulus Package.

Impact of Economic Stimulus Package		Redang Island		Perhentian Island		Total	
		F	%	F	%	F	%
Effective to reduce the burden of finance	Yes	112	80.0	109	69.4	221	74.4
	No	28	20.0	48	30.6	76	25.6
	Total	140	100	157	100	297	100
Fully effective to reduce the burden of finance	Yes	60	42.9	28	17.8	88	29.6
	No	80	57.1	129	82.2	209	70.4
	Total	140	100	157	100	297	100
Other	Yes	5	3.6	14	8.9	19	6.4
	No	135	96.4	143	91.1	278	93.6
	Total	140	100	157	100	297	100
Not effective	Yes	14	10.0	15	9.6	29	9.8
	No	126	90.0	142	90.4	268	90.2
	Total	140	100	157	100	297	100

7.14 Types of Assistance Received

Analysis of assistance received is displayed in Table 14. Majority respondents 88.6%, 72.6% and 8.1% receive the cash assistance of National Concern aid (BPN) in Redang, Perhentian Island and both islands respectively. Besides, 15.7% respondents respectively receive other assistances. Whereas, less than 15% respondents receive the IPT student assistance, moratorium, utility discount, EPF cash withdrawal plus private remuneration scheme, wage plus payment subsidies under the ERP program and credit guarantee scheme Redang, Perhentian Island and both islands respectively.

Table 14: Frequency (F) and percentage (%) for types of assistance received.

Types of assistance received		Redang Island		Perhentian Island		Total	
		F	%	F	%	F	%
Cash assistance (National Concern Aid (BPN))	Yes	124	88.6	114	72.6	238	80.1
	No	16	11.4	43	27.4	59	19.9
	Total	140	100	157	100	297	100
IPT Student Assistance, E-Hailing	Yes	2	1.4	4	2.5	6	2
	No	138	98.6	153	97.5	291	98
	Total	140	100	157	100	297	100
Moratorium	Yes	9	6.4	22	14.0	31	10.4
	No	131	93.6	135	86.0	266	89.6
	Total	140	100	157	100	297	100
Utility discount	Yes	17	12.1	21	13.4	38	12.8
	No	123	87.9	136	86.6	259	87.2
	Total	140	100	157	100	297	100
EPF cash withdrawal & Private Remuneration Scheme	Yes	20	14.3	18	11.5	38	12.8
	No	120	85.7	139	88.5	259	87.2
	Total	140	100	157	100	297	100
Wage and payment subsidies under the ERP program	Yes	2	1.4	3	1.9	5	1.7
	No	138	98.6	154	98.1	292	98.3
	Total	140	100	157	100	297	100
Credit Guarantee Scheme	Yes	0	0	1	0.6	1	0.3
	No	140	100	156	99.4	296	99.7
	Total	140	100	157	100	297	100
Others	Yes	22	15.7	8	5.1	30	10.1
	No	118	84.3	149	94.9	267	89.9
	Total	140	100	157	100	297	100

7.15 Asset Ownership

Table 15 shows the analysis of asset ownership. Majority respondents (more than 80%) in Redang Island have motorcycle and mobile phone, respectively. Meanwhile, 30.6% and 58.6% respondents in Perhentian Island have motorcycle and mobile phone, respectively. Besides, 50% and above respondents respectively have their own house and land in Redang Island while 41.4% and 29.9% respondents in Perhentian Island own house and land, respectively. Therefore, as a whole, majority respondents in both islands have mobile phone (71.7%), followed by motorcycle (51.5%), house (48.1%), land (39.4%), car (18.9%), other assets (16.2%) and laptop/computer (11.4%).

Table 15: Frequency (F) and percentage (%) for Asset Ownership.

Asset ownership		Redang Island		Perhentian Island		Total	
		F	%	F	%	F	%
Motorcycle	Yes	116	82.9	48	30.6	164	55.2
	No	24	17.1	109	69.4	133	44.8
	Total	140	100	157	100	297	100
Car	Yes	24	17.1	32	20.4	56	18.9
	No	116	82.9	125	79.6	241	81.1
	Total	140	100	157	100	297	100
Laptop/Computer	Yes	18	12.9	16	10.2	34	11.4
	No	122	87.1	141	89.8	263	88.6
	Total	140	100	157	100	297	100
Mobile phone	Yes	121	86.4	92	58.6	213	71.7
	No	19	13.6	65	41.4	84	28.3
	Total	140	100	157	100	297	100
House	Yes	78	55.7	65	41.4	143	48.1
	No	62	44.3	92	58.6	154	51.9
	Total	140	100	157	100	297	100
Land	Yes	70	50.0	47	29.9	117	39.4
	No	70	50.0	110	70.1	180	60.6
	Total	140	100	157	100	297	100

Others	Yes	13	9.3	35	22.3	48	16.2
	No	127	90.7	122	77.7	249	83.8
	Total	140	100	157	100	297	100

7.16 Satisfaction with current life

Table 16 illustrates the analysis of respondents' satisfaction with their current life. Most of respondents, 83.6% (Redang Island) and 92.4% (Perhentian Island) are satisfied with their current quality of life while the remaining (16.4% and 7.6%) are not satisfied with their current quality of life, respectively. It brings the total of percentage of 88.2% respondent for both islands are satisfied with their current quality of life.

Table 16: Frequency (F) and percentage (%) for satisfaction with current life.

		Redang Island		Perhentian Island		Total	
		F	%	F	%	F	%
Do you think your current life is resilient (satisfied with current quality of life)?	Yes	117	83.6	145	92.4	262	88.2
	No	23	16.4	12	7.6	35	11.8
	Total	140	100	157	100	297	100

7.17 Upcoming Lifestyle Change

Table 17 describes on respondents' upcoming lifestyle change after COVID-19 pandemic. Majority 72.1%, 60.0% and 50.7% respondents in Redang Island wish to improve sanitation/hygiene, self-discipline and limit the social activities, respectively. Moreover, more than 30% respondents want to be more appreciative to the people around and limit the tourism activities while 28.6% will be performing religious and spiritual activities at home while 21.6% will be not eating outside. Additionally, less than 20% respondents will limit the sport and recreational activities and change other upcoming lifestyles.

Table 17: Frequency (F) and percentage (%) for upcoming lifestyle change.

Upcoming lifestyle change		Redang		Perhentian		Total	
		F	%	F	%	F	%
Improve sanitation/hygiene	Yes	101	72.1	98	62.4	199	67.0
	No	39	27.9	59	37.6	98	33
	Total	140	100	157	100	297	100
Improve self-discipline	Yes	84	60.0	78	49.7	162	54.5
	No	56	40.0	79	50.3	135	45.5
	Total	140	100	157	100	297	100
Be more appreciative to the people around	Yes	55	39.3	58	36.9	113	38.0
	No	85	60.7	99	63.1	184	62.0
	Total	140	100	157	100	297	100
Limit the social activities	Yes	71	50.7	47	29.9	118	39.7
	No	69	49.3	110	70.1	179	60.3
	Total	140	100	157	100	297	100
Limit the tourism activities	Yes	45	32.1	23	14.6	68	22.9
	No	95	67.9	134	85.4	229	77.1
	Total	140	100	157	100	297	100
Not eating outside	Yes	30	21.4	16	10.2	46	15.5
	No	110	78.6	141	89.8	251	84.5
	Total	140	100	157	100	297	100
Limit the sport and recreational activities	Yes	25	17.9	20	12.7	45	15.2
	No	115	82.1	137	87.3	252	84.8
	Total	140	100	157	100	297	100
Performing religious and spiritual activities at home	Yes	40	28.6	14	8.9	54	18.2
	No	100	71.4	143	91.1	243	81.8
	Total	140	100	157	100	297	100
Others	Yes	11	7.9	6	3.8	17	5.7
	No	129	92.1	151	96.2	280	94.3
	Total	140	100	157	100	297	100

Majority respondents (62.4%) in Perhentian Island will improve sanitation/hygiene in their upcoming lifestyle change, followed by 49.7% respondents will improve self-discipline, 36.9% respondents will be more appreciative to the people around, 29.9% will limit the social activities and less than 15% respondents limit the tourism activities, not eating outside, limit the sport and recreational activities as well as performing religious and spiritual activities at home. Overall, about 67.0% and 54.5% respondents will improve sanitation/hygiene and self-discipline in their upcoming lifestyle change. Besides, over than 38% will be more appreciative to the people around and limit the social activities, respectively. Meanwhile, less than 23% respondents will be more appreciative to the people around, limit the social activities and tourism activities, not eating outside, limit the sport and recreational activities as well as performing religious and spiritual activities at home, respectively.

7.18 Behavioral Strategies due oo Pandemic

Analysis of behaviour or practice due to pandemic is employed in the context of loan/rent, consumption expenditure and spiritual practice. In the context of loan/rent, more than 84% respondents in Redang Island, Perhentian Island and both islands disagree and strongly disagree with purchasing on credit and making a loan from relatives/ neighbours. Meanwhile, more than 80% respondents disagree and strongly disagree with making a loan from a bank as well as could not afford repaying loans during MCO in Redang Island. Whereas, this percentage are greater compared to 54.8% and 79.7% respondents in Perhentian Island. It brings the total percentage of respondent from both islands which are more than 84% disagree and strongly disagree with purchasing on credit, making a loan from relatives/ neighbours and bank, respectively. Nevertheless, 67.0% respondents could not afford repaying loans during MCO.

In the perspective of consumption expenditure, the average respondents which are 48.5% to 56.4% with making rations on purchasing necessities in Redang Island, Perhentian Island and both islands. However, around 35.7% to 51.5% of them agree and strongly agree making an increase in the purchase of health equipment (temperature scanners, hand sanitation fluids, and face masks). Besides, more than 41% and 47% respondents agree and strongly agree making savings in education expenses and in utility expenses (water and electricity bill) in Redang and Perhentian Island. It takes to the total percentage of 44% respondents in both islands.

Additionally, in term of spiritual practice, more than 91% respondents in Redang Island agree and strongly agree doing self-reflection during the MCO, the MCO period brought them closer to Allah, the PKP period gave them the opportunity to do a lot of spiritual practice with their family and consider the COVID-19 pandemic as a test that brings them closer to Allah. Meanwhile around 73.9% to 84.7% respondents agree and strongly agree adopting these practice due to pandemic in Perhentian Island. Then, it brings the total of percentage of 82.1% to 90.3% respondents for both islands.

Table 18: Behavioral Strategies due to pandemic.

BEHAVIOUR/PRACTICE DUE TO PANDEMIC	Redang Island					Total
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
Loan/Rent						
I purchased on credit	108 (77.1)	12 (8.6)	6 (4.3)	8 (5.7)	6 (4.3)	140 (100)
I made a loan from relatives/ neighbours	115 (82.1)	7 (5.0)	6 (4.3)	8 (5.7)	4 (2.9)	140 (100)
I made a loan from a bank	122 (87.1)	5 (3.6)	4 (2.9)	7 (5.0)	2 (1.4)	140 (100)
I could not afford to repay loans during MCO	105 (75.0)	8 (5.7)	4 (2.9)	13 (9.3)	10 (7.1)	140 (100)
Consumption Expenditure						
I make rations on purchasing necessities	45 (32.1)	6 (4.3)	10 (7.1)	34 (24.3)	45 (32.1)	140 (100)
I made an increase in the purchase of health equipment (temperature scanners, hand sanitation fluids, and face masks)	43 (30.7)	13 (9.3)	12 (8.6)	32 (22.9)	40 (28.6)	140 (100)

I make savings in education expenses	64 (45.7)	5 (3.6)	13 (9.3)	20 (14.3)	38 (27.1)	140 (100)
I make savings in utility expenses (water and electricity bill)	54 (38.6)	6 (4.3)	18 (12.9)	18 (12.9)	44 (31.4)	140 (100)
Spiritual practice						
I did self-reflection during the MCO	3 (2.1)	1 (0.7)	8 (5.7)	30 (21.4)	98 (70.0)	(100) 140
The MCO period brought me closer to Allah	1 (0.7)	0 (0.0)	3 (2.1)	15 (10.7)	121 (86.4)	(100) 140
The PKP period gave me the opportunity to do a lot of spiritual practice with my family	1 (0.7)	1 (0.7)	7 (5.0)	16 (11.4)	115 (82.1)	(100) 140
I consider the COVID-19 pandemic as a test that brings me closer to Allah	1 (0.7)	1 (0.7)	3 (2.1)	9 (6.4)	126 (90.0)	(100) 140

Redang Island						
BEHAVIOUR/PRACTICE DUE TO PANDEMIC	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total
Loan/Rent						
I purchased on credit	112 (71.3)	23 (14.6)	10 (6.4)	4 (2.5)	8 (5.1)	157 (100)
I made a loan from relatives/ neighbours	96 (61.1)	37 (23.6)	18 (11.5)	2 (1.3)	4 (2.5)	157 (100)
I made a loan from a bank	88 (56.1)	37 (23.6)	22 (14.0)	3 (1.9)	7 (4.5)	157 (100)
I could not afford to repay loans during MCO	65 (41.4)	21 (13.4)	32 (20.4)	27 (17.2)	12 (7.6)	157 (100)
Consumption Expenditure						
I make rations on purchasing necessities	30 (19.1)	11 (7.0)	40 (25.5)	42 (26.8)	34 (21.7)	157 (100)
I made an increase in the purchase of health equipment (temperature scanners, hand sanitation fluids, and face masks)	15 (9.6)	27 (17.2)	59 (37.6)	32 (20.4)	24 (15.3)	157 (100)
I make savings in education expenses	45 (28.7)	7 (4.5)	31 (19.7)	41 (26.1)	33 (21.0)	157 (100)
I make savings in utility expenses (water and electricity bill)	41 (26.1)	11 (7.0)	24 (15.3)	43 (27.4)	38 (24.2)	157 (100)
Spiritual practice						
I did self-reflection during the MCO	2 (1.3)	7 (4.5)	32 (20.4)	44 (28.0)	72 (45.9)	157 (100)
The MCO period brought me closer to Allah	0 (0.0)	1 (0.6)	24 (15.3)	47 (29.9)	85 (54.1)	157 (100)
The PKP period gave me the opportunity to do a lot of spiritual practice with my family	0 (0.0)	2 (1.3)	33 (21.0)	46 (29.3)	76 (48.4)	157 (100)
I consider the COVID-19 pandemic as a test that brings me closer to Allah	0 (0.0)	2 (1.3)	22 (14.0)	46 (29.3)	87 (55.4)	157 (100)

Total						
BEHAVIOUR/PRACTICE DUE TO PANDEMIC	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total
Loan/Rent						
I purchased on credit	220 74.1	35 11.8	16 5.4	12 4.0	14 4.7	297 (100)
I made a loan from relatives/ neighbours	211 71	44 14.8	24 8.1	10 3.4	8 2.7	297 (100)

I made a loan from a bank	210	42	26	10	9	297
	70.7	14.1	8.8	3.4	3.0	(100)
I could not afford to repay loans during MCO	170	29	36	40	22	297
	57.2	9.8	12.1	13.5	7.4	(100)
Consumption Expenditure						
I make rations on purchasing necessities	75	17	50	76	79	297
	25.3	5.7	16.8	25.6	26.6	(100)
I made an increase in the purchase of health equipment (temperature scanners, hand sanitation fluids, and face masks)	58	40	71	64	64	297
	19.5	13.5	23.9	21.5	21.5	(100)
I make savings in education expenses	109	12	44	61	71	297
	36.7	4	14.8	20.5	23.9	(100)
I make savings in utility expenses (water and electricity bill)	95	17	42	61	82	297
	32	5.7	14.1	20.5	27.6	(100)
Spiritual practice						
I did self-reflection during the MCO	5	8	40	74	170	297
	1.7	2.7	13.5	24.9	57.2	(100)
The MCO period brought me closer to Allah	1	1	27	62	206	297
	0.3	0.3	9.1	20.9	69.4	(100)
The PKP period gave me the opportunity to do a lot of spiritual practice with my family	1	3	40	62	191	297
	0.3	1.0	13.5	20.9	64.3	(100)
I consider the COVID-19 pandemic as a test that brings me closer to Allah	1	3	25	55	213	297
	0.3	1.0	8.4	18.5	71.7	(100)

7.19 Shock due to the Pandemic

Table 19 describes the analysis of shock due to the pandemic in context of economic, health, environmental, political and risk management. In perspective of economic, majority respondents (82.9%) in Redang Island agree and strongly agree facing lack of income due to the pandemic while more than 60% of respondents agree and strongly agree pandemic causing the job loss, increase in food price and lack of saving. Meanwhile, 71.3% and 63.1% respondents in Perhentian Island agree and strongly agree facing lack of income and saving due to the pandemic, respectively. Besides, over than 35% agree and strongly agree that pandemic causing the job loss and increase the food price. Overall, 76.7% respondents agree and strongly agree facing lack of income, followed by job loss (63.0%), food price increment (52.2%) and lack of saving (47.4%).

In aspect of health, more than 77% respondents in Redang Island disagree and strongly disagree with involving by an accident and others as well as exposed to critical illness, respectively. Meanwhile, over than 54% disagree and strongly disagree covid-19 infection, concerns over food safety, food supply, food quality and nutrient intake, respectively. However, majority respondents (72.0%) in Perhentian Island agree and strongly agree with covid-19 infection due to the pandemic. Besides, more than 52% respondents agree and strongly agree concerns over food safety, food supply, food quality and nutrient intake, respectively. On the contrary, 45.8% respondents disagree and strongly disagree involving by an accident and others. Furthermore, the percentage of respondents agree and disagree being exposed to critical illness are almost the same around 38.3% and 38.2%, respectively. It make the total of percentage more than 51% agree and strongly agree with covid-19 infection and concern over food supply due to the pandemic, respectively. Contrarily, 56.9% and 64% respondents disagree and strongly disagree exposed to critical illness as well as involving by an accident and others, respectively.

Furthermore, in term of environmental shock, 85% respondents in Redang Islands disagree and strongly disagree being under stress with family members (family institutions) due to the pandemic. Besides, over than 60% of respondents disagree and strongly disagree feeling stressed when faced with an emergency or PKP situation and having internet access problems due to the pandemic. Whereas, 57.1% of them refuse that they have a psychological disorder due to the pandemic. Meanwhile, in term of environmental shock, 73.9% respondents disagree and strongly disagree being under stress with family members (family institutions) due to the pandemic. Additionally, more than 50% of respondents disagree and strongly disagree feeling stressed when faced with an emergency or PKP situation and having internet access problems due to the pandemic. Whereas, 44.6% of them refuse that they have a psychological disorder due to the pandemic. It makes the total percentage of 79.2% disagree and strongly disagree being under stress with family members (family institutions) due to the pandemic. Meanwhile, 50% respondents disagree and strongly disagree feeling stressed when faced with an emergency or PKP situation, having internet access problems due to the pandemic having a psychological disorder due to the pandemic.

Moreover, in the point of view of political shock, the percentage of respondents agree and strongly agree putting aside political differences, their welfare defended by the existing leadership, having an effective communication channels between the public and the government as well as the government's concern in reducing the resident's problems (incentives) due to pandemic exceed 85%, 70% and 77% in Redang Island, Perhentian Island and both islands, respectively. In term of risk management, majority respondents with 77.9%, 60.5% and 68.7% in Redang Island, Perhentian Island and both islands agree and strongly agree that the pandemic has resulted in the shortage of economy opportunity. About 57.1% respondents agree and strongly agree and 43.3% respondents not sure with marketability of goods and services. Besides, 49.3% respondents in Redang Island disagree and strongly disagree that the pandemic has caused unmanaged infrastructure management while 42.0% respondents in Perhentian Island being uncertain about that. Moreover, 72.2%, 53.5% and 62.3% respondents refuse about asset damage (premises, vehicles, tools & equipment) due to the pandemic in Redang Island, Perhentian Island and both islands. Meanwhile, majority of respondents (more than 73%) deny about the crime rate increment due to the pandemic in Redang Island, Perhentian Island and both islands.

Table 19: Shock due to the pandemic.

SHOCK DUE TO PANDEMIC	Redang Island					Total
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
Economic shock						
Lack of income	11 (7.9)	6 (4.3)	7 (5.0)	19 (13.6)	97 (69.3)	140 (100)
Job loss	26 (18.6)	5 (3.6)	12 (8.6)	14 (10.0)	83 (59.3)	140 (100)
Increase in food price	32 (22.9)	5 (3.6)	17 (12.1)	21 (15.0)	65 (46.4)	140 (100)
Lack of saving	38 (27.1)	7 (5.0)	7 (5.0)	21 (15.0)	67 (47.9)	140 (100)
Health shock						
Covid-19 infection	70 (50.0)	7 (5.0)	5 (3.6)	11 (7.9)	47 (33.6)	140 (100)
Exposed to critical illness	102 (72.9)	7 (5.0)	5 (3.6)	8 (5.7)	18 (12.9)	140 (100)
Accident and others	108 (77.1)	10 (7.1)	11 (7.9)	7 (5.0)	4 (2.9)	140 (100)
Concerns over food safety	69 (49.3)	8 (5.7)	22 (15.7)	12 (8.6)	29 (20.7)	140 (100)
Concerns over food supply	65 (46.4)	11 (7.9)	6 (4.3)	18 (12.9)	40 (28.6)	140 (100)
Concerns over quality of food	70 (50.0)	10 (7.1)	9 (6.4)	16 (11.4)	35 (25.0)	140 (100)
Concerns over nutrient intake	75 (53.6)	8 (5.7)	11 (7.9)	20 (14.3)	26 (18.6)	140 (100)
Environmental shock						
I have a psychological disorder	70 (50.0)	10 (7.1)	14 (10.0)	26 (18.6)	20 (14.3)	140 (100)
I am under stress with family members (family institutions)	107 (76.4)	12 (8.6)	4 (2.9)	8 (5.7)	9 (6.4)	140 (100)
I feel stressed when faced with an emergency or PKP situation.	75 (53.6)	14 (10.0)	9 (6.4)	27 (19.3)	15 (10.7)	140 (100)
I have internet access problems	80 (57.1)	11 (7.9)	11 (7.9)	13 (9.3)	25 (17.9)	140 (100)
Political shock						
I put aside political differences	3 (2.1)	4 (2.9)	8 (5.7)	15 (10.7)	110 (78.6)	140 (100)
My welfare is defended by the existing leadership.	3 (2.1)	5 (3.6)	13 (9.3)	12 (8.6)	107 (76.4)	140 (100)
Effective communication channels between the public and the government	6 (4.3)	2 (1.4)	12 (8.6)	19 (13.6)	101 (72.1)	140 (100)

Government's concern in reducing the resident's problems (incentives)	2 (1.4)	1 (0.7)	13 (9.3)	12 (8.6)	112 (80.0)	140 (100)
Risk management						
Shortage of economy opportunity	15 (10.7)	3 (2.1)	13 (9.3)	25 (17.9)	84 (60.0)	140 (100)
Marketability of goods and services	28 (20.0)	8 (5.7)	24 (17.1)	23 (16.4)	57 (40.7)	140 (100)
Unmanaged infrastructure management	62 (44.3)	7 (5.0)	24 (17.1)	20 (14.3)	27 (19.3)	140 (100)
Asset damage (premises, vehicles, tools & equipment)	89 (63.6)	12 (8.6)	11 (7.9)	16 (11.4)	12 (8.6)	140 (100)
The increase of crime rate	95 (67.9)	19 (13.6)	8 (5.7)	10 (7.1)	8 (5.7)	140 (100)
Perhentian Island						
SHOCK DUE TO PANDEMIC	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total
Economic shock						
Lack of income	14 (8.9)	6 (3.8)	25 (15.9)	20 (12.7)	92 (58.6)	157 (100)
Job loss	37 (23.6)	27 (17.2)	35 (22.3)	15 (9.6)	43 (27.4)	157 (100)
Increase in food price	30 (19.1)	32 (20.4)	40 (25.5)	29 (18.5)	26 (16.6)	157 (100)
Lack of saving	24 (15.3)	8 (5.1)	26 (16.6)	46 (29.3)	53 (33.8)	157 (100)
Health shock						
Covid-19 infection	20 (12.7)	2 (1.3)	22 (14.0)	41 (26.1)	72 (45.9)	157 (100)
Exposed to critical illness	42 (26.8)	18 (11.5)	37 (23.6)	40 (25.5)	20 (12.7)	157 (100)
Accident and others	52 (33.1)	20 (12.7)	33 (21.0)	37 (23.6)	15 (9.6)	157 (100)
Concerns over food safety	27 (17.2)	17 (10.8)	28 (17.8)	53 (33.8)	32 (20.4)	157 (100)
Concerns over food supply	30 (19.1)	9 (5.7)	23 (14.6)	54 (34.4)	41 (26.1)	157 (100)
Concerns over quality of food	31 (19.7)	11 (7.0)	30 (19.1)	54 (34.4)	31 (19.7)	157 (100)
Concerns over nutrient intake	32 (20.4)	11 (7.0)	32 (20.4)	47 (29.9)	35 (22.3)	157 (100)
Environmental shock						
I have a psychological disorder	45 (28.7)	25 (15.9)	20 (12.7)	32 (20.4)	35 (22.3)	157 (100)
I am under stress with family members (family institutions)	61 (38.9)	55 (35.0)	21 (13.4)	14 (8.9)	6 (3.8)	157 (100)
I feel stressed when faced with an emergency or PKP situation.	51 (32.5)	28 (17.8)	38 (24.2)	28 (17.8)	12 (7.6)	157 (100)
I have internet access problems	59 (37.6)	21 (13.4)	26 (16.6)	31 (19.7)	20 (12.7)	157 (100)
Political shock						
I put aside political differences	10 (6.4)	4 (2.5)	29 (18.5)	39 (24.8)	75 (47.8)	157 (100)
My welfare is defended by the existing leadership	7 (4.5)	5 (3.2)	34 (21.7)	59 (37.6)	52 (33.1)	157 (100)
Effective communication channels between the public and the government	4 (2.5)	3 (1.9)	34 (21.7)	60 (38.2)	56 (35.7)	157 (100)

Government's concern in reducing the resident's problems (incentives)	2 (1.3)	5 (3.2)	28 (17.8)	46 (29.3)	76 (48.4)	157 (100)
Risk management						
Shortage of economy opportunity	15 (9.6)	13 (8.3)	34 (21.7)	51 (32.5)	44 (28.0)	157 (100)
Marketability of goods and services	18 (11.5)	17 (10.8)	68 (43.3)	32 (20.4)	22 (14.0)	157 (100)
Unmanaged infrastructure management	30 (19.1)	24 (15.3)	66 (42.0)	25 (15.9)	12 (7.6)	157 (100)
Asset damage (premises, vehicles, tools & equipment)	35 (22.3)	49 (31.2)	43 (27.4)	22 (14.0)	8 (5.1)	157 (100)
The increase of crime rate	69 (43.9)	46 (29.3)	18 (11.5)	13 (8.3)	11 (7.0)	157 (100)
Total						
SHOCK DUE TO PANDEMIC	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total
Economic shock						
Lack of income	25 (8.4)	12 (4.0)	32 (10.8)	39 (13.1)	189 (63.6)	297 (100)
Job loss	63 (21.2)	32 (10.8)	47 (15.8)	29 (9.8)	126 (42.4)	297 (100)
Increase in food price	62 (20.9)	37 (12.5)	57 (19.2)	50 (16.8)	91 (30.6)	297 (100)
Lack of saving	62 (20.9)	15 (5.1)	33 (11.1)	67 (22.6)	120 (40.4)	297 (100)
Health shock						
Covid-19 infection	90 (30.3)	9 (3.0)	27 (9.1)	52 (17.5)	119 (40.1)	297 (100)
Exposed to critical illness	144 (48.5)	25 (8.4)	42 (14.1)	48 (16.2)	38 (12.8)	297 (100)
Accident and others	160 (53.9)	30 (10.1)	44 (14.8)	44 (14.8)	19 (6.4)	297 (100)
Concerns over food safety	96 (32.3)	25 (8.4)	50 (16.8)	65 (21.9)	61 (20.5)	297 (100)
Concerns over food supply	95 (32.0)	20 (6.7)	29 (9.8)	72 (24.2)	81 (27.3)	297 (100)
Concerns over quality of food	101 (34.0)	21 (7.1)	39 (13.1)	70 (23.6)	66 (22.2)	297 (100)
Concerns over nutrient intake	107 (36.0)	19 (6.4)	43 (14.5)	67 (22.6)	61 (20.5)	297 (100)
Environmental shock						
I have a psychological disorder	115 (38.7)	35 (11.8)	34 (11.4)	58 (19.5)	55 (18.5)	297 (100)
I am under stress with family members (family institutions)	168 (56.6)	67 (22.6)	25 (8.4)	22 (7.4)	15 (5.1)	297 (100)
I feel stressed when faced with an emergency or PKP situation.	126 (42.4)	42 (14.1)	47 (15.8)	55 (18.5)	27 (9.1)	297 (100)
I have internet access problems	139 (46.8)	32 (10.8)	37 (12.5)	44 (14.8)	45 (15.2)	297 (100)
Political shock						
I put aside political differences	13 (4.4)	8 (2.7)	37 (12.5)	54 (18.2)	185 (62.3)	297 (100)
My welfare is defended by the existing leadership.	10 (3.4)	10 (3.4)	47 (15.8)	71 (23.9)	159 (53.5)	297 (100)
Effective communication channels between the public and the government	10 (3.4)	5 (1.7)	46 (15.5)	79 (26.6)	157 (52.9)	297 (100)

Government's concern in reducing the resident's problems (incentives)	4 (1.3)	6 (2.0)	41 (13.8)	58 (19.5)	188 (63.3)	297 (100)
Risk management						
Shortage of economy opportunity	30 (10.1)	16 (5.4)	47 (15.8)	76 (25.6)	128 (43.1)	297 (100)
Marketability of goods and services	46 (15.5)	25 (8.4)	92 (31.0)	55 (18.5)	79 (26.6)	297 (100)
Unmanaged infrastructure management	92 (31)	31 (10.4)	90 (30.3)	45 (15.2)	39 (13.1)	297 (100)
Asset damage (premises, vehicles, tools & equipment)	124 (41.8)	61 (20.5)	54 (18.2)	38 (12.8)	20 (6.7)	297 (100)
The increase of crime rate	164 (55.2)	65 (21.9)	26 (8.8)	23 (7.7)	19 (6.4)	297 (100)

8.0 CONCLUSION

In the Aspect of Community

Majority of respondents in Redang and Perhentian Islands worked before MCO and job loss after MCO as well as most of them working before and during MCO (still working and have full income). Besides, minority respondents in Perhentian Island spend on housing loan, private loan, vehicle loan, loan by credit card, business loan, educational loan, paying debt, house rent, business premises rent and others. Meanwhile, minority respondents in Redang Island spend for all expenditures as respondents in Perhentian Island except housing loan. Moreover, the economic and environmental shock is a threats of COVID-19 pandemic in Redang Island that were recorded with largest respondents. Whereas, majority of respondents state that the threats COVID-19 Pandemic in Perhentian Island is economic shock. Majority respondents in Redang Island, Perhentian Island and both Islands received the government assistance.

The food expenditure, medical cost, daily cost and online purchase expenditure record the highest mean during MCO compared to after and before MCO in Redang Island. Meanwhile the food expenditure, public transport, daily cost and online purchase expenditure in Perhentian Island record the highest mean before MCO, which decrease during MCO and then increase after MCO. Medicine, insurance/takaful and electricity bill recorded the highest mean in Redang Island before MCO while insurance/takaful and electricity bill showed the highest mean in Perhentian Island during MCO. In Redang Island and Perhentian Island show that the expenditure for paying debt and liability, saving, investment, entertainment (hobby and sport), petrol/ diesel eating outside (including online order), contribution to parents and others indicate the highest mean before MCO, compared to during MCO and after MCO. However, there is slightly difference between mean of water bill, telecommunication bill (telephone and internet) and charity/almshgiving expenditure between before, during and after MCO.

Besides, the biggest impact due to the transmission of COVID-19 are job loss and leave without pay which recorded the highest number of respondents in Redang and Perhentian Islands, respectively. Furthermore, the main concern are worried by most of respondents in Redang Island are COVID-19 infection, insufficient daily expenses, lack of expenses for food, lack of saving, affordability to pay monthly bills and others. Whereas, in Perhentian Island, COVID-19 infection, insufficient daily expenses, lack of expenses for food being concerned after MCO being declared.

Majority of respondents in Redang Island spend for saving for 2 to 4 weeks before MCO, less than 2 weeks and 2 to 4 weeks during and after MCO, respectively. Meanwhile, majority of respondents in Perhentian Island spend for saving for less than 2 weeks before, during and after MCO. However, the number of respondents highest recorded spending for saving for less than 2 weeks during MCO compared to before and after MCO. Among the impact of MCO on business operation in Redang Island are their business permanently closed, reduction of number employees during MCO (no contract extension), business restructured during MCO, layoffs during MCO, employees' wage deduction during MCO and implementation of unpaid leave to employees. Meanwhile, the biggest impact in Perhentian Island are they had to permanently close their business operation.

Majority respondents claim that they received the benefit from economic stimulus package and eligibility as a beneficiary/Concerned Economic Stimulus Package in Redang and Perhentian Islands, respectively. Additionally, majority respondents felt easy to access the processes/ procedures for obtaining concerned economic stimulus package assistance. Additionally, most of respondents express that economic stimulus package is effective to reduce the burden of finance and receive the cash assistance of National Concern aid

(BPN). Majority respondents in Redang Island wish to improve sanitation/hygiene, self-discipline and limit the social activities, respectively. Meanwhile, majority respondents in Perhentian Island wish to improve sanitation/hygiene and self-discipline, respectively

In the context of loan/rent, majority respondents in Redang and Perhentian Island purchased on credit and making a loan from relatives/ neighbours. Meanwhile, majority respondents refuse with making a loan from a bank as well as could not afford repaying loans during MCO in Redang Island. Nevertheless, most of respondents could not afford repaying loans during MCO. In the perspective of consumption expenditure, the average respondents made rations on purchasing necessities in Redang and Perhentian Island. However, they increase in the purchase of health equipment, have savings in education expenses and in utility expenses (water and electricity bill) in Redang and Perhentian Island. Additionally, in term of spiritual practice, majority respondents in Redang Island and Perhentian Island did self-reflection during the MCO, the MCO period brought them closer to Allah, the PKP period gave them the opportunity to do a lot of spiritual practice with their family and consider the COVID-19 pandemic as a test that brings them closer to Allah.

Most of respondent in Redang Island were affected from economic shock in term of lack of income, job loss, increase in food price and lack of saving while most of respondent in Perhentian Island had been facing lack of income and lack of saving due to pandemic. The respondent Redang Island, the health shock most affected by covid-19 infection while in Perhentian Island more vulnerable to covid-19 infection, concerns over food safety, supply, quality and nutrient intake. All islands, in term of politic shocks faced by the respondents such as putting aside political differences, welfare defended by the existing leadership, effective communication channels between the public and the government and government's concern in reducing the resident's problems (incentives). Moreover, for both islands, the respondents state that among the risk management had been carried out including shortage of economy opportunity but still having marketability of goods and services.

REFERENCES

- Abdul Razak, N. (2020). Health and tourism: Implications of COVID-19 pandemic to the Malaysian travel and hospitality industry. *International Journal of Supply Chain Management (IJSCM)*, 9(4), 663-670.
- Allen, G.R, and M.V. Erdmann, 2012. Reef fishes of the East Indies. Volumes I-III. Tropical Reef Research, Perth, Australia, 1292 pp.
- APHA (2005) Standard Methods for the Examination of Water and Wastewater. 21st Edition, American Public Health Association/American Water Works Association/Water Environment Federation, Washington DC.
- Chan, J. K. L. & King, V. T. (2020). The Coronavirus Pandemic and Tourism in Southeast Asia: Case Material from Malaysia. *Journal of Humanities and Social Sciences Research*, 2 (S): 87 – 102.
- Chou, L. W., Licuanan, W. R., Alino, P., Cheshire, A. C., Loo, M. G., Tanjaitrong, S., o.a. (1994). Status of the coral reefs in the ASEAN region. in C. R. Wilkinson, S. Sudara, & L. M. Chou, *Proc 3rd Asean-Australia Symp on Living Coastal Resources* (ss. -). Townsville: Australia Institute of Marine Science.
- Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.) 2007. Guide to best practices for ocean CO2 measurements. PICES Special Publication 3, 191 pp.
- English, S., C. Wilkinson and V. Baker (1997). Survey Manual for Tropical Marine Resources. Townsville, Australia, Australian Institute of Marine Science, Townsville Australia: pp. 378
- Foo, L. P, Chin M. Y, Tan, K. L & Phuah, K.T. (2020). The impact of COVID-19 on tourism industry in Malaysia, *Current Issues in Tourism*, DOI:10.1080/13683500.2020.1777951
- Jung, M. R., Horgen, F. D., Orski, S. V., Rodriguez, V., Beers, K. L., Balazs, G. H., ... & Hyrenbach, K. D. (2018). Validation of ATR FT-IR to identify polymers of plastic marine debris, including those ingested by marine organisms. *Marine Pollution Bulletin*, 127, 704–716
- Karim, W., Haque, A., Anis, Z., & Ulfy, M. A. (2020). The movement control order (mco) for covid-19 crisis and its impact on tourism and hospitality sector in Malaysia. *International Tourism and Hospitality Journal*, 3(2), 1-7.
- Khalik W.M.A.W.M., Ibrahim Y.S., Anuar, S.T., Govindasamy S., Baharuddin N.F. (2018). Microplastics analysis in Malaysian marine waters: A field study of Kuala T Nerus and Kuantan. *Marine Pollution Bulletin*, 135, 451-457
- Lee-Peng Foo , Mui-Yin Chin , Kim-Leng Tan & Kit-Teng Phuah (2020): The impact of COVID-19 on tourism

industry in Malaysia, Current Issues in Tourism

Lee, J.N., Yusri, Y., Ab. Rahim, G.Y., Lim, A.G., Noorikhwanie, Z., Izarenah, M.R., Md.Nizam, I., Mohamad Anuar, R. (2019). Garis Panduan Sistem Pemantauan Dan Penilaian Tapak Selam, Jabatan Perikanan Malaysia, Kementerian Pertanian dan Industri Asa Tani. 44pp.

Lee, J.N., Yusri, Y., Md. Nizam, I. & Chan, A.A. (eds) (2020) Climate Change: Coral Reef Communities of Pulau Redang Marine Park, Terengganu. Marine Park and Resource Management Division, Department of Fisheries Malaysia. Ministry of Agriculture and Food Industry. Putrajaya, Malaysia 64pp.

Liew, V. K. S. (2020). The effect of novel coronavirus pandemic on tourism share prices. *Journal of Tourism Futures*. <https://doi.org/10.1108/JTF-03-2020-0045>

Malaysian Association of Hotel (MAH). (2020). Tourism comes to a standstill. <https://www.hotels.org.my/press/22578-tourism-comes-to-a-standstill>

Matsunuma, M. et al., 2011. Fishes of Terengganu- east coast of Malay Peninsula, Malaysia. National Museum of Nature and Science, Universiti Malaysia Terengganu and Kagoshima University Museum, 251 pp.

Ministry of Health, Malaysia. (2020). Situasi Semasa Pandemik COVID-19 Di Malaysia. <http://covid-19.moh.gov.my/>.

MMWQI (2019) Malaysian marine Water Quality Standard and Index, Ministry of Energy, Science, Technology, Environment & Climate change. 19pp.

PLANMalaysia (2018). Pelan Pembangunan Pulau-Pulau Peranginan dan Taman Laut Negeri Terengganu 2030. Shah, A.U.M., Safri, S.N.A., Thevadas, R., Noordin, N.K., Abd Rahman, A., Sekawi, Z., Ideris, A. and Sultan, M.T.H., 2020. COVID-19 Outbreak in Malaysia: Actions Taken by the Malaysian Government. *International Journal of Infectious Diseases*, 108-116.

Tang, K.H.D. (2020). Movement control as an effective measure against Covid-19 spread in Malaysia: an overview. *J Public Health (Berl.): From Theory to Practice*.

CHAPTER 11

THE SOCIO-ECONOMIC IMPACT OF COVID-19: PART 2 - TOURISM ACTIVITIES

Zaleha Mohamad and Noorhaslinda Kulub Abd Rashid

1.0 Demographic profile of respondents (Tourism Operators)

Table 1 shows the demographic profile of respondents. There are 45.5% males and 54.5% females in Redang Island who majority from Terengganu (72.7%) and married (81.8%). Besides, in Perhentian Island, there are 62.3% males and 37.7% females who majority from Terengganu (63.8%) and married (60.9%). All respondents in Kapas Island are males who majority from Terengganu (83.3%) and married (50.0%). All respondents are males who majority from other states which is Kelantan (66.7%) and average respondents (33.3%) are single, married and divorced/widow, respectively. It bring that 64.0% respondents are males while 36.0% are females who majority (60.7) are married. About 36.4% respondents are 31 to 40 years and 51 to 60 years in Redang Island while 82.7% respondents in Perhentian Island are 21 to 50 years. Besides, 50.0% and 66.7% respondents in Kapas and Tenggol Islands are 20 years and below as well as 31 to 40 years, respectively. Overall, 76.4% respondents are 21 to 50 years. Additionally, majority respondents for all islands are from Terengganu and Malaysia as well as have income of RM1,001 to RM5,000. Besides, 21.3% respondents in Redang Island have educational level of SPM and below as well as Degree and above, respectively. Meanwhile, more than 66% respondents have educational level of SPM, STPM/Sijil kemahiran/Diploma as well as degree and above, respectively, in Perhentian and Kapas Island. Moreover, 66.7% respondents have educational level of SPM and 33.3% is under STPM/Sijil kemahiran/Diploma. Hence, majority respondents (69.7%) have educational level of SPM and below as well as Degree and above.

Table 1: Demo graphic profile of respondents

Demographic profile	Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
	N	%	N	%	N	%	N	%	N	%
Gender										
Male	5	45.5	43	62.3	6	100.0	3	100	57	64.0
Female	6	54.5	26	37.7	0	0.0	0	0.0	32	36.0
Total	11	100	69	100	6	100	3	100	89	100
Age										
20 years and below	0	0.0	0	0.0	3	50.0	0	0.0	3	3.4
21 to 30 years	0	0.0	18	26.1	0	0.0	1	33.3	19	21.3
31 to 40 years	4	36.4	22	31.9	1	16.7	2	66.7	29	32.6
41 to 50 years	2	18.2	17	24.6	1	16.7	0	0.0	20	22.5

51 to 60 years	4	36.4	6	8.7	1	16.7	0	0.0	11	12.4
61 years and above	1	9.1	3	4.3	0	0.0	0	0.0	4	4.5
Not specified	0	0.0	3	4.3	0	0.0	0	0.0	3	3.4
Total	11	100	69	100	6	100	3	100	89	100
Place of Birth										
Terengganu	8	72.7	44	63.8	5	83.3	1	33.3	58	65.2
Others	3	27.3	25	36.2	1	16.7	2	66.7	31	34.8
Total	11	100	69	100	6	100	3	100	89	100
Status of marriage										
Single	1	9.1	24	34.8	3	50.0	1	33.3	30	33.7
Married	9	81.8	42	60.9	3	50.0	1	33.3	54	60.7
Divorced/widow	1	9.1	3	4.3	0	0.0	1	33.3	5	5.6
Total	11	100	69	100	6	100	3	100	89	100
Educational level										
PMR/SRP and below	3	27.3	5	7.2	1	16.7	0	0.0	9	10.1
SPM	3	27.3	26	37.7	2	33.3	2	66.7	33	37.1
STPM/Sijil kemahiran/Diploma	2	18.2	13	18.8	1	16.7	1	33.3	17	19.1
Degree and above	3	27.3	24	34.8	2	33.3	0	0.0	29	32.6
Others (Non-citizen)	0	0.0	1	1.4	0	0.0	0	0.0	1	1.1
Total	11	100	69	100	6	100	3	100	89	100
Level of income										
< RM1000	4	36.4	5	7.2	0	0.0	0	0.0	9	10.1
RM1,001 – RM5,000	6	54.5	42	60.9	6	100.0	2	66.7	56	62.9
RM5,001- RM10,000	1	9.1	14	20.3	0	0.0	0	0.0	15	16.9
RM10,001- RM15,000	0	0.0	3	4.3	0	0.0	0	0.0	3	3.4
> RM20,000	0	0.0	5	7.2	0	0.0	1	33.3	6	6.7
Total	11	100	69	100	6	100	3	100	89	100
Nationality										
Malaysia	11	100.0	67	97.1	4	66.7	3	100.0	85	95.5
Other	0	0.0	2	2.9	2	33.3	0	0.0	4	4.5
Total	11	100	69	100	6	100	3	100	89	100

2.0 Number Of Dependents

The number of dependents are shown in Table 2. Majority respondents (81.9%) in Redang Island have 1 to 6 dependents (including children, spouse, parents, siblings/relatives and others). However, 54.5% respondents have 1 to 3 children while 54.5% of them have parents and 9.1% have 1 sibling/relative and others, respectively. Besides in Perhentian Island, most of respondents (71.0%) have 1 to 3 for the number of total dependents (including children, spouse, parents, siblings/relatives and others). Whereas, majority respondents have 1 to 3 children (47.3%), 1 to 4 parents (21.3%), 1 to 2 sibling/relative (2.8%) and 1 other dependents (10.1%). Majority respondents (33.3%) in Kapas Island have 1 to 3 dependents (including children, spouse, parents, siblings/relatives and others). However, 50.5% respondents have 1 to 3 children while 33.3% of them have parents, 1 have sibling/relative and others, respectively. In Tenggol Island, all respondents have 1 to 3 dependents (including children, spouse, parents, siblings/relatives and others). However, 66.7% respondents have 1 to 3 children and have parents, respectively. Meanwhile, 33.3% have 1 sibling/relative and others, respectively. Thus, majority respondents for all islands have have 1 to 3 dependents (including children, spouse, parents, siblings/relatives and others) including 49.4%, 25.9%, 3.3% and 12.4% respondents have 1 to 3 children, 1 to 2 parents, 1 to 2 siblings and others, respectively.

Table 2: Number of Dependents

Number of Dependents	Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
	N	%	N	%	N	%	N	%	N	%
Total of dependents (including children, spouse, parents, siblings/relatives and others)										
1 to 3	4	36.4	49	71.0	5	83.3	3	100	61	68.5
4 to 6	5	45.5	10	14.5	0	0.0	0	0.0	15	16.9
7 to 9	2	18.2	3	4.3	0	0.0	0	0.0	5	5.6
10 and above	0	0.0	0	0.0	1	16.7	0	0.0	1	1.1
None	0	0.0	7	10.1	0	0.0	0	0.0	7	7.9
Total	11	100	69	100	6	100	3	100	89	100

Number of children										
1 to 3	6	54.5	33	47.8	3	50.0	2	66.7	44	49.4
4 to 6	2	18.2	6	8.7	0	0.0	0	0.0	8	9.0
7 to 9	0	0.0	1	1.4	0	0.0	0	0.0	1	1.1
10 and above	0	0.0	1	0.6	0	0.0	0	0.0	0	0.0
None	3	27.3	29	42	3	50.0	1	33.3	36	40.4
Total	11	100	69	100	6	100	3	100	89	100
Number of Parents										
1	0	0.0	5	7.2	0	0.0	2	66.7	7	7.9
2	6	54.5	8	11.6	2	33.3	0	0.0	16	18.0
4	0	0.0	1	1.4	0	0.0	0	0.0	1	1.1
None	5	45.5	55	79.7	4	66.7	1	33.3	65	73.0
Total	11	100	69	100	6	100	3	100	89	100
Number of Siblings/Relatives										
1	1	9.1	1	1.4	0	0.0	1	33.3	2	2.2
2	0	0.0	1	1.4	0	0.0	0	0.0	1	1.1
None	10	90.9	67	97.1	6	100.0	2	66.7	86	96.6
Total	11	100	69	100	6	100	3	100	89	100
Others										
1	1	9.1	7	10.1	2	33.3	1	33.3	11	12.4
None	10	90.9	62	89.9	4	66.7	2	66.7	78	87.6
Total	11	100	69	100	6	100	3	100	89	100

3.0 Occupation

Table 3 describes about occupation. Majority (36.4%) respondents in Redang Island were working before and during MCO (still working and have full income) and others, respectively. Additionally, 54.5% of respondents received income based on demand. Besides, most of 69.0% of respondents in Kapas Island working before and during MCO (still working and have full income). Besides, majority of respondents are under self-employed (49.3), received their earnings based on monthly income (58%) and income based on demand (34.8%). Moreover, around 66.7% respondents in Kapas and Tenggol islands were working before and during MCO (still working and have full income) and 50.0% work under self-employed and under private sectors, respectively. Additionally, all respondents received income by monthly. Therefore, it takes to the total percentage of 58.7% respondents in all islands working before and during MCO (Still working and have full income) while 76.7% respondents work under self-employed and under private sectors. Besides, majority respondents received their earnings by monthly.

Table 3: Occupations

Occupation	Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
	N	%	N	%	N	%	N	%	N	%
Status of occupation										
Working before and during MCO (Still working and have full income)	4	36.4	42	60.9	4	66.7	2	66.7	52	58.4
Working before MCO and jobless after PKP	3	27.3	18	26.1	0	0.0	1	33.3	22	24.7
Jobless during and after MCO	0	0.0	2	2.9	0	0.0	0	0.0	2	2.2
Others	4	36.4	7	10.1	2	33.3	0	0.0	13	14.6
Total	11	100	69	100	6	100	3	100	89	100
Sector										
Private	2	18.2	33	47.8	3	50.0	1	33.3	39	43.8
Self-employed	8	72.7	34	49.3	3	50.0	2	66.7	47	52.8
Others	0	0.0	2	2.9	0	0.0	0	0.0	2	2.2
Government/children support	1	9.1	0	0	0	0.0	0	0.0	1	1.1
Total	11	100	69	100	6	100	3	100	89	100
Earnings										
Income per task	0	0.0	5	7.2	0	0.0	0	0.0	5	5.6
Weekly income	2	18.2	0	0.0	0	0.0	0	0.0	2	2.2
Monthly income	3	27.3	40	58.0	6	100.0	3	100	52	58.4
Income based on demand	6	54.5	24	34.8	0	0.0	0	0.0	30	33.7
Total	11	100	69	100	6	100	3	100	89	100

4.0 Information Of Business Enterprise

Analysis of information is described in Table 4. More than 80% respondents for all islands were sole proprietorship, respectively. About 45.5% respondents in Redang Island implemented the service of resort/hotel/chalet/homestay, followed by food (36.4%), tourism agency (27.3%), souvenir (27.3%), transportation/boat (18.2%), diving / snorkeling (9.1%) and others (9.1%). Besides, all of them provided daily business operation. Whereas, majority respondents (73.9%) in Perhentian Island provide the service of resort/hotel/chalet/homestay followed by diving / snorkeling (39.1%), food (21.7%), transportation/boat (15.9%), tourism agency (15.9%), others (8.7%) and souvenir (1.4%). Furthermore, majority respondents (83.3%) in Kapas Island implemented the service of resort/hotel/chalet/homestay while 16.7% respondents sold souvenir and food. In Tenggol Island, all respondents have the service of diving/snorkeling while 33.7% with the service of tourism agency, transportation/boat and resort/hotel/chalet/homestay, respectively. Overall, majority respondents (69.7%) provide the service of resort/hotel/chalet/homestay. Additionally, most of respondents (36.4%) in Redang Island have experiences as an entrepreneur between 10 years and above while 27.3% with experience of 0 to 3 years. Additionally, most of respondents (42%) in Perhentian Island have experiences as an entrepreneur between 10 years and above while 29.0% respondents with experience of 4 and 6 years. Besides, average respondents (50.0%) have experiences as an entrepreneur between 4 and 6 years while 33.3% with experience of 0 to 3 in Kapas Island. Furthermore, in Tenggol Island, around 33.3% respondents have experiences as an entrepreneur between 4 and 6 years while 66.7% respondents with experience of 10 years and above. Overall, 39.3% and 29.2% respondents have experiences as an entrepreneur between 4 and 6 years as well as 10 years and above, respectively. Besides, more than 97% of respondents provided daily business operation for each island and overall.

Table 4: Information of business enterprise

Enterprise	Redang Island		Perhentian Island		Kapas Island		Tenggol Island		All		
	N	%	N	%	N	%	N	%	N	%	
Types of business											
Sole proprietorship		8	72.7	29	42.0	3	50.0	1	33.3	41	46.1
Private limited company		2	18.2	32	46.4	2	33.3	2	66.7	38	42.7
Partnership		0	0.0	6	8.7	0	0.0	0	0.0	6	6.7
Others		1	9.1	2	2.9	1	16.7	0	0.0	4	4.5
Total		11	100	69	100	6	100	3	100	89	100
Types of services											
Tourism agency	Yes	3	27.3	11	15.9	0	0.0	1	33.3	15	16.9
	No	8	72.7	58	84.1	6	100.0	2	66.7	74	83.1
	Total	11	100	69	100	6	100	3	100	89	100
Transportation/boat	Yes	2	18.2	12	17.4	0	0.0	1	33.3	15	16.9
	No	9	81.8	57	82.6	6	100.0	2	66.7	74	83.1
	Total	11	100	69	100	6	100	3	100	89	100
Resort/hotel/chalet/homestay	Yes	5	45.5	51	73.9	5	83.3	1	33.3	62	69.7
	No	6	54.5	18	26.1	1	16.7	2	66.7	27	30.3
	Total	11	100	69	100	6	100	3	100	89	100
Souvenir	Yes	3	27.3	1	1.4	1	16.7	0	0.0	5	5.6
	No	8	72.7	68	98.6	5	83.3	3	100.0	84	94.4
	Total	11	100	69	100	6	100	3	100	89	100
Food	Yes	4	36.4	15	21.7	1	16.7	0	0.0	20	22.5
	No	7	63.6	54	78.3	5	83.3	3	100.0	69	77.5
	Total	11	100	69	100	6	100	3	100	89	100
Diving / Snorkeling	Yes	1	9.1	27	39.1	0	0.0	3	100	31	34.8
	No	10	90.9	42	60.9	6	100.0	0	0.0	58	65.2
	Total	11	100	69	100	6	100	3	100	89	100
Others	Yes	1	9.1	6	8.7	0	0.0	0	0.0	7	7.9
	No	10	90.9	63	91.3	6	100.0	3	100.0	82	92.1
	Total	11	100	69	100	6	100	3	100	89	100
Work experience as entrepreneur											
0-3 years		3	27.3	12	17.4	2	33.3	0	0.0	17	19.1
4- 6 years		2	18.2	20	29.0	3	50.0	1	33.3	26	29.2
7-10 years		2	18.2	8	11.6	1	16.7	0	0.0	11	12.4
10 years and above		4	36.4	29	42.0	0	0.0	2	66.7	35	39.3
Total		11	100	69	100	6	100	3	100	89	100
Business operation											
Daily		11	100	67	97.1	6	100.0	3	100.0	87	97.8
Weekend		0	0.0	2	2.9	0	0.0	0	0.0	2	2.2
Total		11	100	69	100	6	100	3	100	89	100

5.0 Number Of Employees

Table 5 indicates the analysis number of employees. About 72.7% respondents in Kapas Island have 1 to 20 employees before MCO while this percentage decrease to 54.5% during MCO and then increase to 81.8% after MCO. Meanwhile, number of 51-100 employees increase to 9.1% during MCO. Besides, around 79.7% respondents in Perhentian Island have 1 to 20 employees before MCO while this percentage increase to 88.4% during MCO and then increase to 92.8% after MCO. Besides, 18.8% respondents have 21-50 employees before MCO then decrease to 4.3% during and after MCO, respectively. Meanwhile, number of 51-100 employees increase to 7.2% during MCO and increase to 2.9% after MCO. Moreover, all respondents in Kapas have 1 to 20 employees before, during and after MCO. Therefore, it shows that the number of employees are retained before, during and after MCO. Additionally, 66.7% and 33.3% respondents in Tenggol Island have 1 to 20 employees and 21-50 employees before, during and after MCO, respectively. Therefore, it shows that the number of employees are retained before, during and after MCO. It bring up 79.8% respondents for all islands have 1-20 employees before MCO while increase to 84.3% and 91% respondents during and after MCO, respectively.

Table 5: Number of employees

Number of employees	Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
	N	%	N	%	N	%	N	%	N	%
Before MCO										
1-20 employees	8	72.7	55	79.7	6	100	2	66.7	71	79.8
21-50 employees	1	9.1	13	18.8	0	0.0	1	33.3	15	16.9
51-100 employees	0	0.0	1	1.4	0	0.0	0	0.0	1	1.1
101 employees	1	9.1	0	0.0	0	0.0	0	0.0	1	1.1
None	1	9.1	0	0.0	0	0.0	0	0.0	1	1.1
Total	11	100	69	100	6	100	3	100	89	100
During MCO										
1-20 employees	6	54.5	61	88.4	6	100	2	66.7	75	84.3
21-50 employees	1	9.1	3	4.3	0	0.0	1	33.3	5	5.6
51-100 employees	1	9.1	0	0.0	0	0.0	0	0.0	1	1.1
101 employees	1	9.1	0	0.0	0	0.0	0	0.0	1	1.1
None	2	18.2	5	7.2	0	0.0	0	0.0	7	7.9
Total	11	100	69	100	6	100	3	100	89	100
After MCO										
1-20 employees	9	81.8	64	92.8	6	100	2	66.7	81	91
21-50 employees	1	9.1	3	4.3	0	0.0	1	33.3	5	5.6
51-100 employees	0	0.0	2	2.9	0	0.0	0	0.0	2	2.2
101 employees	1	9.1	0	0.0	0	0.0	0	0.0	1	1.1
None	0	0.0	0	0.0	0	0.0	0	0.0	0	0
Total	11	100	69	100	6	100	3	100	89	100

6.0 Income as an Entrepreneur

Analysis of income as an entrepreneur before MCO, during MCO and after MCO is indicated in Table 6. Before MCO, in Redang Island, the average of respondents with 36.4%, 27.3% and 18.2% of them, have income RM1,001 to RM10,000, RM10,001 to RM20,000 and more than RM20,000, respectively. Meanwhile, majority respondents' (81.8%) income decrease to the less than RM1000. Furthermore, after MCO, 45.5% respondents have income less than RM1000, followed by RM1,001 to RM10,000 (27.3%), more than RM20,000 (18.2%) and RM10,001 to RM20,000 (9.1%). Meanwhile, the average of respondents in Perhentian Island which are 42.0% and 36.2% of them, have income RM1,001 to RM10,000 and more than RM20,000, respectively before MCO. Meanwhile, majority respondents' (60.9%) income decrease to the less than RM1000. Furthermore, after MCO, average respondents have income RM1,001 to RM10,000 (42.0%) and RM10,001 to RM20,000 (33.3%). Moreover, before MCO in Kapas Island, 66.7% respondents have income RM1,001 to RM10,000 while 16.7% have income less than RM1000 and RM10,001 to RM20,000, respectively. Meanwhile, 50.0% respondents' income decrease to the less than RM1000. Besides, there are 16.7% respondents have income of RM1,001 to RM10,000 while 33.3% have no income. Furthermore, after MCO, 83.3% respondents have income RM1,001 to RM10,000 while 16.7% respondents have income of less than RM1000. Whereas, the average of respondents in Tenggol Island which 33.3% have income RM1,001 to RM10,000, RM10,001- RM20,000 less than RM20,000, respectively, before MCO. Meanwhile, 33.3% respondents' income decrease to the less than RM1000. Besides, there are 33.3% respondents have income of RM10,001 to RM20,000 while 33.3% have no income. Furthermore, after MCO, 33.3% respondents have income RM1,001 to RM10,000 while 66.7% respondents have income of RM10,001- RM20,000. Totally, majority of respondents have income of RM1,001 to RM10,000 and more than RM20,000 before and after MCO but reduced to less than RM2000 during MCO.

Table 6: Income as an entrepreneur

Income as an entrepreneur	Redang Island		Perhentian Island		Kapas Island		Tenggol Island		All	
	N	%	N	%	N	%	N	%	N	%
Before MCO										
< RM1000	1	9.1	4	5.8	1	16.7	0	0.0	6	6.7
RM1,001 – RM10,000	4	36.4	29	42.0	4	66.7	1	33.3	38	42.7
RM10,001- RM20,000	2	18.2	11	15.9	1	16.7	1	33.3	15	16.9
> RM20,000	3	27.3	25	36.2	0	0.0	1	33.3	29	32.6
None	1	9.1	0	0.0	0	0.0	0	0.0	1	1.1
Total	11	100	69	100	6	100	3	100	89	100
During MCO										
< RM1000	9	81.8	42	60.9	3	50.0	1	33.3	55	61.8
RM1,001 – RM10,000	0	0.0	6	8.7	1	16.7	0	33.3	7	7.9
RM10,001- RM20,000	0	0.0	4	5.8	0	0.0	1	0.0	5	5.6
> RM20,000	0	0.0	1	1.4	0	0.0	0	0.0	1	1.1
None	2	18.2	16	23.2	2	33.3	1	33.3	21	23.6
Total	11	100	69	100	6	100	3	100	89	100
After MCO										
< RM1000	5	45.5	4	5.8	1	16.7	0	0.0	10	11.2
RM1,001 – RM10,000	3	27.3	29	42.0	5	83.3	1	33.3	38	42.7
RM10,001- RM20,000	1	9.1	12	17.4	0	0.0	2	66.7	15	16.9
> RM20,000	2	18.2	23	33.3	0	0.0	0	0.0	25	28.1
None	0	0	1	1.4	0	0.0	0	0.0	1	1.1
Total	11	100	69	100	6	100	3	100	89	100

7.0 The Month Which Recorded The Highest Number Of Tourists

It could be seen from Table 7 the month which recorded the highest number of tourists. From the analysis, majority respondents (90.9%) state that the month recorded the highest tourists are June, as well as May, July and August (81.8%) in Redang Islands. Whereas, in Kapas Island, majority respondents (78.3%) state that the month recorded the highest tourists are August and July (73.9%). Besides, most of respondents (66.7%) in Kapas Island mentioned that the month recorded the highest tourists are June and July as well as March (50.0%). Additionally, all respondents in Tenggol Island state that August is the month recorded the highest tourists while 66.7% respondents also said April to July and September. Hence, overall, more than 74% respondents claim that July and August are the month recorded the highest tourists.

Table 7: The month which recorded the highest number of tourists

The month which recorded the highest number of tourists		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
January	Yes	0	0	1	1.4	0	0	0	0	1	1.1
	No	11	100	68	98.6	6	100	3	100	88	98.9
	Total	11	100	69	100	6	100	3	100	89	100
February	Yes	0	0	7	10.1	0	0	0	0.0	7	7.9
	No	11	100	62	89.9	6	100	3	100.0	82	92.1
	Total	11	100	69	100	6	100	3	100	89	100
March	Yes	6	54.5	24	34.8	3	50	1	33.3	34	38.2
	No	5	45.5	45	65.2	3	50	2	66.7	55	61.8
	Total	11	100	69	100	6	100	3	100	89	100
April	Yes	5	45.5	24	34.8	1	16.7	2	66.7	32	36.0
	No	6	54.5	45	65.2	5	83.3	1	33.3	57	64.0
	Total	11	100	69	100	6	100	3	100	89	100
May	Yes	9	81.8	29	42	2	33.3	2	66.7	42	47.2
	No	2	18.2	40	58	4	66.7	1	33.3	47	52.8
	Total	11	100	69	100	6	100	3	100	89	100
June	Yes	10	90.9	29	42	4	66.7	2	66.7	45	50.6
	No	1	9.1	40	58	2	33.3	1	33.3	44	49.4
	Total	11	100	69	100	6	100	3	100	89	100

July	Yes	9	81.8	51	73.9	4	66.7	2	66.7	66	74.2
	No	2	18.2	18	26.1	2	33.3	1	33.3	23	25.8
	Total	11	100	69	100	6	100	3	100	89	100
August	Yes	9	81.8	54	78.3	4	66.7	3	100.0	70	78.7
	No	2	18.2	15	21.7	2	33.3	0	0.0	19	21.3
	Total	11	100	69	100	6	100	3	100	89	100
September	Yes	5	45.5	24	34.8	0	0	2	66.7	31	34.8
	No	6	54.5	45	65.2	6	100	1	33.3	58	65.2
	Total	11	100	69	100	6	100	3	100	89	100
October	Yes	3	27.3	9	13	0	0	1	33.3	13	14.6
	No	8	72.7	60	87	6	100	2	66.7	76	85.4
	Total	11	100	69	100	6	100	3	100	89	100
November	Yes	0	0	2	2.9	0	0	0	0	2	2.2
	No	11	100	67	97.1	6	100	3	100	87	97.8
	Total	11	100	69	100	6	100	3	100	89	100
December	Yes	0	0	0	0	0	0	0	0.0	0	0.0
	No	11	100	69	100	6	100	3	100.0	89	100
	Total	11	100	69	100	6	100	3	100	89	100

8.0 Tourism Activities Affected By Covid -19

Table 8 displays the tourism activities that were affected by Covid-19. About 54.5% respondents in Redang Island state that lack of room reservations and other activities were affected by Covid-19. Besides, around 45.5% respondents said that they faced the lack of travel boat bookings, travel package bookings and snorkeling activities during Covid-19. Meanwhile 75.4% and 83.3% respondents have the lack of room reservations due to pandemic Covid-19, respectively. However, more than 66.7% respondents in Tenggol Island having the lack of room reservations, lack of travel boat bookings, travel package bookings and snorkeling activities, respectively. It implies that majority respondents for all islands, 73.0% have the lack of room reservations due to pandemic Covid-19.

Table 8: Tourism activities affected by Covid -19

Tourism activities affected by Covid -19		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
Lack of room reservations	Yes	6	54.5	52	75.4	5	83.3	2	66.7	65	73.0
	No	5	45.5	17	24.6	1	16.7	1	33.3	24	27.0
	Total	11	100	69	100	6	100	3	100	89	100
Lack of travel boat bookings	Yes	5	45.5	27	39.1	2	33.3	2	66.7	36	40.4
	No	6	54.5	42	60.9	4	66.7	1	33.3	53	59.6
	Total	11	100	69	100	6	100	3	100	89	100
Lack of travel package bookings	Yes	5	45.5	23	33.3	2	33.3	3	100.0	33	37.1
	No	6	54.5	46	66.7	4	66.7	0	0.0	56	62.9
	Total	11	100	69	100	6	100	3	100	89	100
Lack of snorkeling activities	Yes	5	45.5	25	36.2	0	0	2	66.7	32	36.0
	No	6	54.5	44	63.8	6	100	1	33.3	57	64.0
	Total	11	100	69	100	6	100	3	100	89	100
Lack of scuba diving / diving activity package	Yes	4	36.4	21	30.4	1	16.7	1	33.3	27	30.3
	No	7	63.6	48	69.6	5	83.3	2	66.7	62	69.7
	Total	11	100	69	100	6	100	3	100	89	100
Others	Yes	6	54.5	16	23.2	0	0	0	0.0	22	24.7
	No	5	45.5	53	76.8	6	100	3	100.0	67	75.3
	Total	11	100	69	100	6	100	3	100	89	100

9.0 Monthly Expenditure

The monthly expenditure is display in Table 9. The average of respondents (45.5%) in Redang Island spent for personal and business loan, respectively. Meanwhile, 36.4% respondents use their expenditure for vehicle loan. Whereas, about 39.1% respondents in Perhentian Island spent for other expenditures. Besides, the average of respondents (50.0%) in Kapas Island spent for other expenditures. Moreover, all respondents in Tenggol state

that they faced the lack of travel boat due to pandemic Covid-19. Besides, around 66.7% respondents claim they were affected by Covid-19 such as lack of room reservations, travel boat bookings, snorkeling activities. Overall, more than 15% respondents use their expenditure for personal, vehicle and business loan.

Table 9: Monthly expenditure

Monthly expenditure		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
Housing loan	Yes	2	18.2	4	5.8	0	0	1	33.3	7	7.9
	No	9	81.8	65	94.2	6	100	2	66.7	82	92.1
	Total	11	100	69	100	6	100	3	100	89	100
Personal loan	Yes	5	45.5	11	15.9	0	0	1	33.3	17	19.1
	No	6	54.5	58	84.1	6	100	2	66.7	72	80.9
	Total	11	100	69	100	6	100	3	100	89	100
Vehicle loan	Yes	4	36.4	10	14.5	0	0	1	33.3	15	16.9
	No	7	63.6	59	85.5	6	100	2	66.7	74	83.1
	Total	11	100	69	100	6	100	3	100	89	100
Loan by credit card	Yes	1	9.1	4	5.8	0	0	1	33.3	6	6.7
	No	10	90.9	65	94.2	6	100	2	66.7	83	93.3
	Total	11	100	69	100	6	100	3	100	89	100
Business loan	Yes	5	45.5	8	11.6	0	0	1	33.3	14	15.7
	No	6	54.5	61	88.4	6	100	2	66.7	75	84.3
	Total	11	100	69	100	6	100	3	100	89	100
Educational loan	Yes	1	9.1	3	4.3	1	16.7	0	0	5	5.6
	No	10	90.9	66	95.7	5	83.3	3	100	84	94.4
	Total	11	100	69	100	6	100	3	100	89	100
Pay for debt	Yes	2	18.2	5	7.2	1	16.7	2	66.7	10	11.2
	No	9	81.8	64	92.8	5	83.3	1	33.3	79	88.8
	Total	11	100	69	100	6	100	3	100	89	100
House rent	Yes	2	18.2	3	4.3	0	0	1	33.3	6	6.7
	No	9	81.8	66	95.7	6	100	2	66.7	83	93.3
	Total	11	100	69	100	6	100	3	100	89	100
Business premises rent	Yes	1	9.1	9	13	0	0	2	66.7	12	13.5
	No	10	90.9	60	87	6	100	1	33.3	77	86.5
	Total	11	100	69	100	6	100	3	100	89	100
Others	Yes	1	9.1	27	39.1	3	50	0	0	31	34.8
	No	10	90.9	42	60.9	3	50	3	100	58	65.2
	Total	11	100	69	100	6	100	3	100	89	100

10.Threats Of COVID-19 Pandemic

Threats of Covid-19 Pandemics are displayed in Table 10. Majority respondents (90.9%) in Redang Island state that the main threat of Covid-19 is the economic shock (eg. jobless). Furthermore, 36.4% of them mentioned that health and social shock are the threats of Covid-19 pandemics, respectively. Besides, majority respondents (87.0%) also mention the economic shock (eg. jobless) is the main threat of Covid-19 in perhentian Island. Moreover, 30.4% of them state that environmental is the threats of Covid-19 pandemics, respectively. Additionally, majority respondents (66.7%) in Kapas Island also state that the main threat of Covid-19 is the economic, health, environmental shock, respectively. Whereas, 33.3% of them said that social and politic shock are the threats of Covid-19 pandemics, respectively. Similarly to Tenggol Island, majority respondents (83.3%) state that the main threat of Covid-19 is the economic shock (eg. jobless). Furthermore, 33.3% of them state that health, environmental and politic shock are the threats of Covid-19 pandemics, respectively. Thus, totally 86.5% respondents state that the main threat of Covid-19 is the economic shock (eg. jobless).

Table 10: Threats of COVID-19 Pandemic

Threats of COVID-19 Pandemic		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
Economic shock (eg. jobless)	Yes	10	90.9	60	87	5	83.3	2	66.7	77	86.5
	No	1	9.1	9	13	1	16.7	1	33.3	12	13.5
	Total	11	100	69	100	6	100	3	100	89	100
Health shock (eg. infection)	Yes	4	36.4	10	14.5	2	33.3	2	66.7	18	20.2
	No	7	63.6	59	85.5	4	66.7	1	33.3	71	79.8
	Total	11	100	69	100	6	100	3	100	89	100

Environmental shock (eg. emergency condition/ MCO)	Yes	3	27.3	21	30.4	2	33.3	2	66.7	28	31.5
	No	8	72.7	48	69.6	4	66.7	1	33.3	61	68.5
	Total	11	100	69	100	6	100	3	100	89	100
Social shock (eg. psychology of family institutions)	Yes	4	36.4	12	17.4	1	16.7	1	33.3	18	20.2
	No	7	63.6	57	82.6	5	83.3	2	66.7	71	79.8
	Total	11	100	69	100	6	100	3	100	89	100
Politic shock (eg. Changes of country administration)	Yes	2	18.2	9	13	2	33.3	1	33.3	14	15.7
	No	9	81.8	60	87	4	66.7	2	66.7	75	84.3
	Total	11	100	69	100	6	100	3	100	89	100

11.0 Assistance mechanism/ strategy

Table 11 shows the assistance mechanism/ strategy due to the pandemic. Around 45.5% respondents in Redang Island obtained from government and other assistances, respectively. Meanwhile, 27.3% of them made consumption expenditure rations due to the pandemic. Besides 44.9% and 50.7% respondents in Perhentian Island received from government and other assistances, respectively. However, about 50.0% respondents in Kapas Island obtained from other assistances. In Tenggol Island, 66.7% respondents get from asset sale and government, respectively. Meanwhile, 33.3% of them made loan, consumption expenditure rations, job transition, family changes, neighbours/relatives assistance and others due to the pandemic, respectively. Overall, majority respondents obtained from government, respectively.

Table 11: Assistance mechanism/ strategy

Assistance mechanism/ strategy		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
Loan	Yes	0	0	4	5.8	0	0	1	33.3	5	5.6
	No	11	100	65	94.2	6	100	2	66.7	84	94.4
	Total	11	100	69	100	6	100	3	100	89	100
Asset sale	Yes	0	0	3	4.3	0	0	2	66.7	5	5.6
	No	11	100	66	95.7	6	100	1	33.3	84	94.4
	Total	11	100	69	100	6	100	3	100	89	100
Consumption expenditure	Yes	3	27.3	7	10.1	1	16.7	1	33.3	12	13.5
	No	8	72.7	62	89.9	5	83.3	2	66.7	77	86.5
	Total	11	100	69	100	6	100	3	100	89	100
Job transition	Yes	0	0	0	0	0	0	1	33.3	1	1.1
	No	11	100	69	100	6	100	2	66.7	88	98.9
	Total	11	100	69	100	6	100	3	100	89	100
Family changes	Yes	0	0	0	0	0	0	1	33.3	1	1.1
	No	11	100	69	100	6	100	2	66.7	88	98.9
	Total	11	100	69	100	6	100	3	100	89	100
Neighbours/relatives assistance	Yes	0	0	2	2.9	0	0	1	33.3	3	3.4
	No	11	100	67	97.1	6	100	2	66.7	86	96.6
	Total	11	100	69	100	6	100	3	100	89	100
Government	Yes	5	45.5	31	44.9	1	16.7	2	66.7	39	43.8
	No	6	54.5	38	55.1	5	83.3	1	33.3	50	56.2
	Total	11	100	69	100	6	100	3	100	89	100
Others	Yes	3	27.3	2	2.9	1	16.7	0	0	6	6.7
	No	8	72.7	67	97.1	5	83.3	3	100	83	93.3
	Total	11	100	69	100	6	100	3	100	89	100
None	Yes	5	45.5	35	50.7	3	50	1	33.3	44	49.4
	No	6	54.5	34	49.3	3	50	2	66.7	45	50.6
	Total	11	100	69	100	6	100	3	100	89	100

12.0 Impact of Transmission Of COVID-19

Analysis of the impact of transmission of COVID-19 are presented in Table 12. About 27.3% respondents in Redang Island have affected by transmission of COVID-19 such as working from home, job loss and reduction of the working hours, respectively. Besides, 18.2% respondents obtained unpaid leave while 9.1% had to obtain half pay leave due to the transmission of COVID-19. The biggest impact of transmission of COVID-19 in Perhentian Island is leave without pay which recorded the highest number of respondents (44.9%), followed by job loss

(17.4% respondents), half pay leave (15.9%), work from home (11.6%) and the decrease of number of working hours (10.1%). Besides, 50.0% and 33.3% respondents in Kapas have affected by transmission of COVID-19 such as working from home and obtaining half pay leave. Besides, 16.7% respondents leave without pay, lose job and face an increment of the working hours due to the transmission of COVID-19, respectively. Meanwhile about 66.7% respondents in Tenggol Island have affected by transmission of COVID-19 with obtaining half pay leave. Besides, 33.3% respondents leave without pay and face the decrease of the working hours due to the transmission of COVID-19, respectively. Therefore, 39.3% respondents in all islands leave without pay due to transmission of COVID-19 while over than 10% of them having work from home, half pay leave, losing job and decline of the number of working hours, respectively.

Table 12: Impact of transmission of COVID-19

Impact of transmission of COVID-19		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
Work from home	Yes	3	27.3	8	11.6	3	50	0	0.0	14	15.7
	No	8	72.7	61	88.4	3	50	3	100.0	75	84.3
	Total	11	100	69	100	6	100	3	100	89	100
Half pay leave	Yes	1	9.1	11	15.9	2	33.3	2	66.7	16	18.0
	No	10	90.9	58	84.1	4	66.7	1	33.3	73	82
	Total	11	100	69	100	6	100	3	100	89	100
Leave without pay	Yes	2	18.2	31	44.9	1	16.7	1	33.3	35	39.3
	No	9	81.8	38	55.1	5	83.3	2	66.7	54	60.7
	Total	11	100	69	100	6	100	3	100	89	100
Job loss	Yes	3	27.3	12	17.4	1	16.7	0	0.0	16	18.0
	No	8	72.7	57	82.6	5	83.3	3	100.0	73	82
	Total	11	100	69	100	6	100	3	100	89	100
The number of working hours decrease	Yes	3	27.3	7	10.1	0	0	1	33.3	11	12.4
	No	8	72.7	62	89.9	6	100	2	66.7	78	87.6
	Total	11	100	69	100	6	100	3	100	89	100
The number of working hours increase	Yes	0	0	2	2.9	1	16.7	0	0.0	3	3.4
	No	11	100	67	97.1	5	83.3	3	100.0	86	96.6
	Total	11	100	69	100	6	100	3	100	89	100
No impact	Yes	1	9.1	9	13	0	0	0	0.0	10	11.2
	No	10	90.9	60	87	6	100	3	100.0	79	88.8
	Total	11	100	69	100	6	100	3	100	89	100

13.0 The Concerns After MCO Being Declared

Table 13 presents the concerns after MCO being declared. Majority respondents (6.3.6%) in Redang Island were worried about COVID-19 infection and 54.5% worrying about losing job. Besides, 45.5% of them concerned about insufficient daily expenses, lack of saving, affordability to pay monthly bills and debt, respectively. Additionally, 36.4% respondents were worried about lack of expenses for food after MCO being declared. Besides, the main concern are worried by most of respondents (63.8%) in Perhentian Island is COVID-19 infection and no saving for emergency case (47.8% of respondents). Moreover, more than 21% and 17.4% respondents worried about insufficient daily expenses, lack of saving, affordability to pay monthly bills, lack of expenses for food and losing job, respectively. In Kapas Island, around 50.0% respondents were worried about COVID-19 infection and insufficient daily expenses, respectively. Meanwhile, 33.3% respondents were worried about lack of expenses for food and no saving for emergency case, respectively, after MCO being declared. However, 66.7% respondents were worried about no saving for emergency case, insufficient daily expenses, lack of expenses for food, saving and losing job, respectively. Meanwhile, 33.3% respondents were worried about COVID-19 infection as well as affordability to pay monthly bills and debt, respectively, after MCO being declared. Overall, majority respondents (61.8%) were worried about COVID-19 infection while 43.8% and 39.3% worrying about having no saving for emergency case and insufficient daily expenses.

Table 13: The concerns after MCO being declared

The concerns after MCO being declared		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
None	Yes	1	9.1	8	11.6	0	0	0	0.0	9	10.1
	No	10	90.9	61	88.4	6	100	3	100.0	80	89.9
	Total	11	100	69	100	6	100	3	100	89	100

No saving for emergency case	Yes	2	18.2	33	47.8	2	33.3	2	66.7	39	43.8
	No	9	81.8	36	52.2	4	66.7	1	33.3	50	56.2
	Total	11	100	69	100	6	100	3	100	89	100
COVID-19 infection	Yes	7	63.6	44	63.8	3	50	1	33.3	55	61.8
	No	4	36.4	25	36.2	3	50	2	66.7	34	38.2
	Total	11	100	69	100	6	100	3	100	89	100
Insufficient daily expenses	No	5	45.5	25	36.2	3	50	2	66.7	35	39.3
	Total	6	54.5	44	63.8	3	50	1	33.3	54	60.7
	Total	11	100	69	100	6	100	3	100	89	100
Lack of expenses for food	No	4	36.4	16	23.2	2	33.3	2	66.7	24	27.0
	Total	7	63.6	53	76.8	4	66.7	1	33.3	65	73
	Total	11	100	69	100	6	100	3	100	89	100
Lack of saving	No	5	45.5	17	24.6	1	16.7	2	66.7	25	28.1
	Yes	6	54.5	52	75.4	5	83.3	1	33.3	64	71.9
	Total	11	100	69	100	6	100	3	100	89	100
Affordability to pay monthly bills	Total	5	45.5	17	24.6	1	16.7	1	33.3	24	27
	Yes	6	54.5	52	75.4	5	83.3	2	66.7	65	73
	Total	11	100	69	100	6	100	3	100	89	100
Affordability to pay debt	Total	5	45.5	12	17.4	1	16.7	1	33.3	19	21.3
	Yes	6	54.5	57	82.6	5	83.3	2	66.7	70	78.7
	Total	11	100	69	100	6	100	3	100	89	100
Job loss	Yes	6	54.5	15	21.7	1	16.7	2	66.7	24	27
	No	5	45.5	54	78.3	5	83.3	1	33.3	65	73
	Total	11	100	69	100	6	100	3	100	89	100
Others	Yes	0	0	3	4.3	0	0	0	0.0	3	3.4
	No	11	100	66	95.7	6	100	3	100.0	86	96.6
	Total	11	100	69	100	6	100	3	100	89	100

14.0 Source of Finance or Saving

Analysis of source of finance or saving are presented in Table 14. In Redang Island, about 36.4% respondents can make a saving for a year while 18.2% of respondents can save for 6 to 8 weeks and others before MCO, respectively. Besides, 9.1% respondents can save for less than 2 weeks, 4 to 6 weeks and half year, respectively. Meanwhile, during MCO, 27.3% respondents have the saving for a year while 18.2% respondents can save for less than 2 weeks, 4 to 6 weeks, half year, and others, respectively. Furthermore, after MCO, about 27.3% respondents have the saving for a year and less than 2 weeks, whereas 18.2% respondents claim that their saving can last up to 6 to 8 weeks and others, respectively. Additionally, 9.1% of them mentioned that their saving can be used for half year.

Before MCO, majority of respondents (20.3%) in Perhentian Island spend of saving for 2 to 4 weeks and others (18.8%). Besides, 13% respondents spend their saving for half year and a year before MCO, respectively. Moreover, 11.6% and 10.1% respondents' finance can last up for 4 to 6 weeks and 6 to 8 weeks, respectively. Whereas, less than 8% of respondents less than 2 weeks and 2 weeks, respectively. During MCO, the number respondents spending their saving for less than 2 weeks and 2 weeks increase to 31.9% and 7.2% respondents, respectively. Furthermore, 18.8% respondents expend for other periods during MCO. Meanwhile, the number of respondents spending their saving for 2 to 4 weeks, 4 to 6 weeks, 6 to 8 weeks, half year and a year decrease during MCO. However, the number of respondents spend of saving for less than 2 weeks decrease to 11.6% after MCO. Meanwhile, the number of respondents spend of saving for 4 to 6 weeks and a year increase to 15.9% and 14.5% after MCO, respectively, compared to before and during MCO.

Meanwhile, 50.0% respondents can make a saving for 2 to 4 weeks while 16.7% of respondents in Kapas Island can save for 4 to 6 weeks, 6 to 8 weeks and a year before MCO, respectively. Meanwhile, during MCO, 50.0% respondents have the saving for 2 to 4 weeks while 16.7% respondents can save for less than 2 weeks, half year and others, respectively. Furthermore, after MCO, about 50.0% respondents have the saving for 2 to 4 weeks, whereas 16.7% respondents claim that their saving can last up to 6 to 8 weeks, half year and others, respectively. However, before MCO, about 33.3% respondents in Tenggol Island can make a saving for less than 2 weeks, 6 to 8 weeks and others, respectively. Meanwhile, during MCO, 66.7% respondents have the saving for less than 2

weeks, half year and others (33.3%). Furthermore, after MCO, about 33.3% respondents have the saving for less than 2 weeks, 2 to 4 weeks and others, respectively.

Totally, less than 20% respondents use their finance and saving before MCO for 2 weeks, 2 to 4 weeks, 4 to 6 weeks, 6 to 8 weeks, half year, a year and others, respectively. Meanwhile 30.3%, 13.5%, 11.2% and 19.1% respondents can make a saving during MCO for less than 2 weeks, 2 to 4 weeks, a year and others, respectively. However, use their finance and saving for 2 weeks to half year before MCO. However, after MCO, 20.2% respondents use their finance and saving before MCO for others period while less than 15% of them spent for 2 weeks, 2 to 4 weeks, 4 to 6 weeks, 6 to 8 weeks, half year, a year and others, respectively.

Table 14: Source of finance or saving

Source of finance or saving		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
Before MCO	Less than 2 weeks	1	9.1	5	7.2	0	0.0	1	33.3	7	7.9
	2 weeks	0	0.0	4	5.8	0	0.0	0	0.0	4	4.5
	2 to 4 weeks	0	0.0	14	20.3	3	50	0	0.0	17	19.1
	4 to 6 weeks	1	9.1	8	11.6	1	16.7	0	0.0	10	11.2
	6 to 8 weeks	2	18.2	7	10.1	1	16.7	1	33.3	11	12.4
	Half year	1	9.1	9	13	0	0.0	0	0.0	10	11.2
	A year	4	36.4	9	13	1	0.0	0	0.0	14	15.7
	Others	2	18.2	13	18.8	0	16.7	1	33.3	16	18.0
	Total	11	100	69	100	6	100	3	100	89	100
During MCO	Less than 2 weeks	2	18.2	22	31.9	1	16.7	2	66.7	27	30.3
	2 weeks	0	0.0	5	7.2	0	0.0	0	0.0	5	5.6
	2 to 4 weeks	2	18.2	7	10.1	3	50	0	0.0	12	13.5
	4 to 6 weeks	0	0.0	6	8.7	0	0.0	0	0.0	6	6.7
	6 to 8 weeks	0	0.0	5	7.2	0	0.0	0	0.0	5	5.6
	Half year	2	18.2	7	10.1	1	16.7	0	0.0	10	11.2
	A year	3	27.3	4	5.8	0	0.0	0	0.0	7	7.9
	Others	2	18.2	13	18.8	1	16.7	1	33.3	17	19.1
	Total	11	100	69	100	6	100	3	100	89	100
After MCO	Less than 2 weeks	3	27.3	8	11.6	0	0.0	1	33.3	12	13.5
	2 weeks	0	0.0	2	2.9	0	0.0	0	0.0	2	2.2
	2 to 4 weeks	0	0.0	8	11.6	3	50	1	33.3	12	13.5
	4 to 6 weeks	0	0.0	11	15.9	0	0.0	0	0.0	11	12.4
	6 to 8 weeks	2	18.2	7	10.1	1	16.7	0	0.0	10	11.2
	Half year	1	9.1	9	13	1	16.7	0	0.0	11	12.4
	A year	3	27.3	10	14.5	0	0.0	0	0.0	13	14.6
	Others	2	18.2	14	20.3	1	16.7	1	33.3	18	20.2
	Total	11	100	69	100	6	100	3	100	89	100

15.0 Impact of MCO on Business Operation

Analysis of the impact of MCO on business operation is shown in Table 15. Most of respondents (63.6%) in Redang Island closed their business operation due to the MCO while 36.4% respondents have to implement the unpaid leave to the employees. Besides, majority respondents (76.8%) in Perhentian Island also state the business operation are permanently closed due to MCO. However, most of respondents (66.7%) made reduction of number employees during MCO (No contract extension) while 50.0% respondents restructured the business during MCO. Most of respondents (66.7%) permanent in Tenggol Island close their business operation while 33.3% made reduction of number employees (no contract extension), business restructured, layoffs, employees' wage deduction and implementation of unpaid leave to employees during MCO, respectively. Overall, majority respondents (74.2%) state that the business operation are permanently closed due to MCO. Whereas, less than 22% respondents make reduction of number employees during MCO (No contract extension), business restructured during MCO, layoffs during MCO, employees' wage deduction during MCO, unpaid leave to employees, respectively.

Table 15: Impact of MCO on business operation

Impact MCO on business operation		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
Permanently closed	Yes	7	63.6	53	76.8	4	66.7	2	66.7	66	74.2
	No	4	36.4	16	23.2	2	33.3	1	33.3	23	25.8
	Total	11	100	69	100	6	100	3	100	89	100
Reduction of number employees during MCO (No contract extension)	Yes	3	27.3	9	13	1	16.7	1	33.3	14	15.7
	No	8	72.7	60	87	5	83.3	2	66.7	75	84.3
	Total	11	100	69	100	6	100	3	100	89	100
Business restructured during MCO	Yes	3	27.3	12	17.4	3	50	1	33.3	19	21.3
	No	8	72.7	57	82.6	3	50	2	66.7	70	78.7
	Total	11	100	69	100	6	100	3	100	89	100
Layoffs during MCO	Yes	2	18.2	7	10.1	1	16.7	1	33.3	11	12.4
	No	9	81.8	62	89.9	5	83.3	2	66.7	78	87.6
	Total	11	100	69	100	6	100	3	100	89	100
Employees' wage deduction during MCO	Yes	2	18.2	10	14.5	2	33.3	1	33.3	15	16.9
	No	9	81.8	59	85.5	4	66.7	2	66.7	74	83.1
	Total	11	100	69	100	6	100	3	100	89	100
Implementation of unpaid leave to employees	Yes	4	36.4	6	8.7	0	0	1	33.3	11	12.4
	No	7	63.6	63	91.3	6	100	2	66.7	78	87.6
	Total	11	100	69	100	6	100	3	100	89	100

16.0 Economic Stimulus Package

Table 16 describes about the economic stimulus package. About 54.5% respondents in Redang Island received the benefit from economic stimulus package while 45.5% respondents state that is easy to access the processes/procedures for obtaining concerned economic stimulus package assistance. Besides, in Perhentian Island, around 50.7% respondents claims that the get the benefit from economic stimulus package. Moreover, 40.6% respondents state that it is easy to access the processes / procedures for obtaining concerned economic stimulus package assistance. However, 50.0% and 33.3% respondents in Kapas and Tenggol Island received the benefit from economic stimulus package, respectively. Meanwhile, 50.0% and 66.7% respondents having difficult to access the processes/procedures for obtaining concerned economic stimulus package assistance in Kapas and Tenggol Island, respectively.

Table 16: Economic Stimulus Package

Economic Stimulus Package		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
I get the benefit from Economic Stimulus Package	Yes	6	54.5	35	50.7	3	50	1	33.3	45	50.6
	No	5	45.5	34	49.3	3	50	2	66.7	44	49.4
	Total	11	100	69	100	6	100	3	100	89	100
Level of access the processes / procedures for obtaining Concerned Economic Stimulus Package Assistance	Difficult	3	27.3	14	20.3	1	16.7	2	66.7	20	22.5
	Easy	5	45.5	28	40.6	2	33.3	1	33.3	36	40.4
	Others	2	18.2	26	37.7	3	50	0	0.0	31	34.8
	Not apply	1	9.1	1	1.4	0	0.0	0	0.0	2	2.2
	Total	11	100	69	100	6	100	3	100	89	100
Eligibility as a beneficiary / Concerned Economic Stimulus Package	Eligible	6	54.5	37	53.6	4	66.7	2	66.7	49	55.1
	Not eligible	4	36.4	28	40.6	2	33.3	1	33.3	35	39.3
	Appeal	0	0	3	4.3	0	0.0	0	0.0	3	3.4
	Not apply	1	9.1	1	1.4	0	0.0	0	0.0	2	2.2
	Total	11	100	69	100	6	100	3	100	89	100

17.0 Impact of Economic Stimulus Package

Table 17 displays the impact of economic stimulus package. Around 54.5% respondents in Redang Island think that economic stimulus package is effective to reduce the burden of finance while 36.4% respondents claim that economic stimulus package is fully effective to reduce the burden of finance. Meanwhile, majority respondents of 46.4% and 50.0% express that economic stimulus package is effective to reduce the burden of

finance in Perhentian and Kapas Island, respectively. Additionally, 33.3% respondents in Tenggol Island think that economic stimulus package is effective to reduce the burden of finance, fully effective to reduce the burden of finance, economic stimulus package is not effective to them and others, respectively. Thus, it brings the total of percentage respondents of 47.2% for all islands stating that the Economic Stimulus Package is effective to reduce the burden of finance.

Table 17: Impact of Economic Stimulus Package

Impact of Economic Stimulus Package		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
Effective to reduce the burden of finance	Yes	6	54.5	32	46.4	3	50	1	33.3	42	47.2
	No	5	45.5	37	53.6	3	50	2	66.7	47	52.8
	Total	11	100	69	100	6	100	3	100	89	100
Fully effective to reduce the burden of finance	Yes	4	36.4	4	5.8	1	16.7	1	33.3	10	11.2
	No	7	63.6	65	94.2	5	83.3	2	66.7	79	88.8
	Total	11	100	69	100	6	100	3	100	89	100
Other	Yes	1	9.1	9	13	1	16.7	1	33.3	12	13.5
	No	10	90.9	60	87	5	83.3	2	66.7	77	86.5
	Total	11	100	69	100	6	100	3	100	89	100
Not effective	Yes	3	27.3	25	36.2	2	33.3	1	33.3	31	34.8
	No	8	72.7	44	63.8	4	66.7	2	66.7	58	65.2
	Total	11	100	69	100	6	100	3	100	89	100

18.0 Types of Assistance Received

The types of assistance received are shown in Table 18. About 54.5% respondents in Redang Island receive the cash assistance (National Concerned Assistance), followed by 36.4% respondents received utility discount, EPF cash withdrawal and private remuneration scheme as well as other, respectively. Majority respondents of 37.7% and 50% in Perhentian and Kapas Island receive the cash assistance of National Concern aid (BPN), respectively. Besides, in Tenggol Island, 66.7% respondents received EPF cash withdrawal & Private Remuneration Scheme while 33.3% respondents get the cash assistance (National Concerned Assistance), moratorium, utility discount, wage and payment subsidies under the EPF program as well as Credit Guarantee Scheme, respectively. Therefore, most of respondent (40.4%) receive the cash assistance of National Concern aid (BPN), overall.

Table 18: Types of assistance received

Types of assistance received		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
Cash assistance (National Concerned Assistance)	Yes	6	54.5	26	37.7	3	50	1	33.3	36	40.4
	No	5	45.5	43	62.3	3	50	2	66.7	53	59.6
	Total	11	100	69	100	6	100	3	100	89	100
IPT Student Assistance, E-Hailing	Yes	0	0	1	1.4	0	0	0	0.0	1	1.1
	No	11	100	68	98.6	6	100	3	100	88	98.9
	Total	11	100	69	100	6	100	3	100	89	100
Moratorium	Yes	1	9.1	16	23.2	1	16.7	1	33.3	19	21.3
	No	10	90.9	53	76.8	5	83.3	2	66.7	70	78.7
	Total	11	100	69	100	6	100	3	100	89	100
Utility discount	Yes	4	36.4	10	14.5	0	0	1	33.3	15	16.9
	No	7	63.6	59	85.5	6	100	2	66.7	74	83.1
	Total	11	100	69	100	6	100	3	100	89	100
EPF cash withdrawal & Private Remuneration Scheme	Yes	2	18.2	6	8.7	1	16.7	2	66.7	11	12.4
	No	9	81.8	63	91.3	5	83.3	1	33.3	78	87.6
	Total	11	100	69	100	6	100	3	100	89	100
Wage and payment subsidies under the ERP program	Yes	1	9.1	9	13	1	16.7	1	33.3	12	13.5
	No	10	90.9	60	87	5	83.3	2	66.7	77	86.5
	Total	11	100	69	100	6	100	3	100	89	100
Credit Guarantee Scheme	Yes	1	9.1	2	2.9	0	0	1	33.3	4	4.5
	No	10	90.9	67	97.1	6	100	2	66.7	85	95.5
	Total	11	100	69	100	6	100	3	100	89	100
Others	Yes	2	18.2	1	1.4	0	0	0	0.0	3	3.4
	No	9	81.8	68	98.6	6	100	3	100	86	96.6
	Total	11	100	69	100	6	100	3	100	89	100

19.0 Asset Ownership

It could be seen analysis of ownership in Table 19. Majority respondents (90.9%) in Redang Island own the motorcycle and mobile phone, respectively. Besides, 81.8% respondents have car as well as 54.5% respondents have laptop/computer, house and land, respectively. Moreover, more than 55% respondents in Perhentian Island have mobile phone, land and others, respectively. Meanwhile, more than 40% respondents have their own car and house. In Kapas Island, around 50.0% own the motorcycle, car, laptop/computer, and mobile phone, respectively, and 33.3% respondents have a land. Furthermore, about 66.7% respondents in Tenggol Island own the motorcycle and mobile phone, respectively. Besides, 33.3% respondents have car, laptop/computer, house and other assets, respectively. It takes to the majority respondents (53%) for all island owning mobile phone and land while the average of them (more than 39%) have car, laptop/computer, house and others

Table 19: Asset Ownership

Asset ownership		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
Motorcycle	Yes	10	90.9	7	10.1	3	50	0	0.0	20	22.5
	No	1	9.1	62	89.9	3	50	3	100	69	77.5
	Total	11	100	69	100	6	100	3	100	89	100
Car	Yes	9	81.8	28	40.6	3	50	2	66.7	42	47.2
	No	2	18.2	41	59.4	3	50	1	33.3	47	52.8
	Total	11	100	69	100	6	100	3	100	89	100
Laptop/Computer	Yes	6	54.5	25	36.2	3	50	1	33.3	35	39.3
	No	5	45.5	44	63.8	3	50	2	66.7	54	60.7
	Total	11	100	69	100	6	100	3	100	89	100
Mobile phone	Yes	10	90.9	39	56.5	3	50	2	66.7	54	60.7
	No	1	9.1	30	43.5	3	50	1	33.3	35	39.3
	Total	11	100	69	100	6	100	3	100	89	100
House	Yes	6	54.5	29	42	1	16.7	1	33.3	37	41.6
	No	5	45.5	40	58	5	83.3	2	66.7	52	58.4
	Total	11	100	69	100	6	100	3	100	89	100
Land	Yes	6	54.5	40	58	2	33.3	0	0.0	48	53.9
	No	5	45.5	29	42	4	66.7	3	100	41	46.1
	Total	11	100	69	100	6	100	3	100	89	100
Others	Yes	3	27.3	38	55.1	1	16.7	1	33.3	43	48.3
	No	8	72.7	31	44.9	5	83.3	2	66.7	46	51.7
	Total	11	100	69	100	6	100	3	100	89	100

20.0 Satisfaction with Current Life

Table 20 shows the analysis of satisfaction with current life. About 81.8% and 85.5% respondents in Redang and Perhentian Island think their current life is resilient (satisfied with current quality of life), respectively. Meanwhile, all respondents think their current life is resilient (satisfied with current quality of life) in Kapas and Tenggol Islands, respectively.

Table 20: Satisfaction with current life

		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
Do you think your current life is resilient (satisfied with current quality of life)?	Yes	9	81.8	59	85.5	6	100.0	3	100.0	77	86.5
	No	2	18.2	10	14.5	0	0.0	0	0.0	12	13.5
	Total	11	100	69	100	11	100	3	100	89	100

21.0 Upcoming Lifestyle Change

Table 21 describes the analysis of upcoming lifestyle change. Most of respondents (90.9%) in Redang Island will improve the sanitation/hygiene and 72.7% are going to improve self-discipline. Meanwhile, 54.5% respondents will be more appreciative to the people around and limit the tourism activities, respectively. Furthermore, 45.5% respondents will limit the social activities. In Perhentian Island, majority respondents (more than 65%)

wish to improve sanitation/hygiene self-discipline, respectively. Moreover, 42% respondents want to be more appreciative to the people around. Besides, all respondents in Kapas Island will improve the sanitation/hygiene and 50.0% are going to improve self-discipline. Meanwhile, 33.3% respondents will be more appreciative to the people around as well as limit the social and tourism activities, respectively. However, around 66.7% respondents in Tenggol Island will improve the sanitation/hygiene, self-discipline as well as limit the social, tourism activities, sport and recreational activities, respectively. Meanwhile, 33.3% respondents will be more appreciative to the people around, no eating outside and performing religious and spiritual activities at home, respectively. Overall, majority respondents will improve the sanitation/hygiene and self-discipline while more than 38% of them will be more appreciative to the people around and limit the social activities, respectively.

Table 21: Upcoming lifestyle change.

Upcoming lifestyle change		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
Improve sanitation/hygiene	Yes	10	90.9	45	65.2	6	100	2	66.7	63	70.8
	No	1	9.1	24	34.8	0	0.0	1	33.3	26	29.2
	Total	11	100	69	100	6	100	3	100	89	100
Improve self-discipline	Yes	8	72.7	46	66.7	3	50	2	66.7	59	66.3
	No	3	27.3	23	33.3	3	50	1	33.3	30	33.7
	Total	11	100	69	100	6	100	3	100	89	100
Be more appreciative to the people around	Yes	6	54.5	29	42	2	33.3	1	33.3	38	42.7
	No	5	45.5	40	58	4	66.7	2	66.7	51	57.3
	Total	11	100	69	100	6	100	3	100	89	100
Limit the social activities	Yes	5	45.5	25	36.2	2	33.3	2	66.7	34	38.2
	No	6	54.5	44	63.8	4	66.7	1	33.3	55	61.8
	Total	11	100	69	100	6	100	3	100	89	100
Limit the tourism activities	Yes	6	54.5	16	23.2	2	33.3	2	66.7	26	29.2
	No	5	45.5	53	76.8	4	66.7	1	33.3	63	70.8
	Total	11	100	69	100	6	100	3	100	89	100
Not eating outside	Yes	1	9.1	9	13	1	16.7	1	33.3	12	13.5
	No	10	90.9	60	87	5	83.3	2	66.7	77	86.5
	Total	11	100	69	100	6	100	3	100	89	100
Limit the sport and recreational activities	Yes	4	36.4	12	17.4	1	16.7	2	66.7	19	21.3
	No	7	63.6	57	82.6	5	83.3	1	33.3	70	78.7
	Total	11	100	69	100	6	100	3	100	89	100
Performing religious and spiritual activities at home	Yes	4	36.4	8	11.6	0	0.0	1	33.3	13	14.6
	No	7	63.6	61	88.4	6	100	2	66.7	76	85.4
	Total	11	100	69	100	6	100	3	100	89	100
Others	Yes	0	0	4	5.8	0	0.0	0	0.0	4	4.5
	No	11	100	65	94.2	6	100	3	100	85	95.5
	Total	11	100	69	100	6	100	3	100	89	100

22.0 Behaviour or Practice Due to Pandemic

Analysis of behaviour or practice due to pandemic are described in Table 22. In the context of loan/rent, majority respondents in Redang, Perhentian, Kapas Island and all islands refuse purchasing on credit, making a loan from relatives/ neighbours and a bank, respectively. Meanwhile, 33.3% respondents in Tenggol Island agree and strongly disagree purchasing on credit and making a loan from a bank, respectively. Besides, 66.7% respondents in Tenggol Island disagree making a loan from relatives/ neighbours while 66.7% of them agree with being not afford to repay loans during MCO. In term of consumption expenditure, most of respondents make rations on purchasing necessities and increase the purchase of health equipment (temperature scanners, hand sanitation fluids, and face masks) in Redang, Perhentian, Kapas, Tenggol Island and all islands, respectively. However, majority respondents deny making savings in education expenses in Redang, Perhentian, Kapas, all islands, respectively. Whereas, most respondents agree making savings in education expenses in Kapas and Tenggol Islands, respectively. Moreover, in aspect of spiritual practice, majority respondents Redang, Perhentian, Kapas, Tenggol Island and all islands, did self-reflection, state the MCO period brought them closer to Allah, the PKP period gave them the opportunity to do a lot of spiritual practice with their family and consider the COVID-19 pandemic as a test that brings them closer to Allah, respectively.

Table 22: Behaviour or practice due to pandemic

BEHAVIOUR/PRACTICE		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
Loan/Rent											
I purchased on credit	Strongly Disagree	6	54.5	44	63.8	0	0.0	1	33.3	51	57.3
	Disagree	2	18.2	9	13.0	4	66.7	0	0	15	16.9
	Neutral	0	0	8	11.6	0	0.0	1	33.3	9	10.1
	Agree	0	0	2	2.9	1	16.7	1	33.3	4	4.5
	Strongly Agree	3	27.3	6	8.7	1	16.7	0	0	10	11.2
	Total	11	100	69	100	6	100	3	100	89	100
I made a loan from relatives/ neighbours	Strongly Disagree	7	63.6	49	71	0	0.0	2	66.7	58	65.2
	Disagree	2	18.2	14	20.3	3	50.0	0	0	19	21.3
	Neutral	1	9.1	4	5.8	2	33.3	0	0	7	7.9
	Agree	1	9.1	1	1.4	1	16.7	1	33.3	4	4.5
	Strongly Agree	0	0	1	1.4	0	0.0	0	0	1	1.1
	Total	11	100	69	100	6	100	3	100	89	100
I made a loan from a bank	Strongly Disagree	5	45.5	37	53.6	2	33.3	1	33.3	45	50.6
	Disagree	0	0	13	18.8	3	50.0	0	0	16	18
	Neutral	1	9.1	9	13	1	16.7	1	33.3	12	13.5
	Agree	3	27.3	2	2.9	0	0.0	1	33.3	6	6.7
	Strongly Agree	2	18.2	8	11.6	0	0.0	0	0	10	11.2
	Total	11	100	69	100	6	100	3	100	89	100
I could not afford to repay loans during MCO	Strongly Disagree	2	18.2	32	46.4	1	16.7	0	0	35	39.3
	Disagree	2	18.2	5	7.2	3	50.0	0	0	10	11.2
	Neutral	1	9.1	13	18.8	0	0.0	1	33.3	15	16.9
	Agree	3	27.3	10	14.5	2	33.3	2	66.7	17	19.1
	Strongly Agree	3	27.3	9	13	0	0.0	0	0	12	13.5
	Total	11	100	69	100	6	100	3	100	89	100
Consumption Expenditure											
I make rations on purchasing necessities	Strongly Disagree	2	18.2	21	30.4	0	0	0	0	23	25.8
	Disagree	1	9.1	2	2.9	0	0	1	33.3	4	4.5
	Neutral	1	9.1	17	24.6	0	0	0	0	18	20.2
	Agree	2	18.2	14	20.3	2	33.3	1	33.3	19	21.3
	Strongly Agree	5	45.5	15	21.7	4	66.7	1	33.3	25	28.1
	Total	11	100	69	100	6	100	3	100	89	100
I increase the purchase of health equipment (temperature scanners, hand sanitation fluids, and face masks)	Strongly Disagree	0	0	0	0	0	0.0	0	0	0	0
	Disagree	0	0	4	5.8	0	0.0	0	0	4	4.5
	Neutral	1	9.1	17	24.6	0	0.0	1	33.3	19	21.3
	Agree	4	36.4	15	21.7	3	50.0	1	33.3	23	25.8
	Strongly Agree	6	54.5	33	47.8	3	50.0	1	33.3	43	48.3
	Total	11	100	69	100	6	100	3	100	89	100
I make savings in education expenses	Strongly Disagree	5	45.5	31	44.9	0	0.0	0	0	36	40.4
	Disagree	2	18.2	5	7.2	0	0.0	0	0	7	7.9
	Neutral	2	18.2	10	14.5	2	33.3	0	0	14	15.7
	Agree	1	9.1	11	15.9	2	33.3	2	66.7	16	18.0
	Strongly Agree	1	9.1	12	17.4	2	33.3	1	33.3	16	18.0
	Total	11	100	69	100	6	100	3	100	89	100

Spiritual practice											
I did self-reflection during the MCO	Strongly Disagree	0	0	2	2.9	0	0.0	0	0	2	2.2
	Disagree	0	0	1	1.4	0	0.0	0	0	1	1.1
	Neutral	0	0	11	15.9	2	33.3	1	33.3	14	15.7
	Agree	2	18.2	23	33.3	0	0.0	1	33.3	26	29.2
	Strongly Agree	9	81.8	32	46.4	4	66.7	1	33.3	46	51.7
	Total	11	100	69	100	6	100	3	100	89	100
The MCO period brought me closer to Allah	Strongly Disagree	0	0	3	4.3	0	0.0	0	0	3	3.4
	Disagree	0	0	1	1.4	0	0.0	0	0	1	1.1
	Neutral	0	0	9	13	2	33.3	1	33.3	12	13.5
	Agree	2	18.2	19	27.5	0	0.0	1	33.3	22	24.7
	Strongly Agree	9	81.8	37	53.6	4	66.7	1	33.3	51	57.3
	Total	11	100	69	100	6	100	3	100	89	100
The PKP period gave me the opportunity to do a lot of spiritual practice with my family	Strongly Disagree	1	9.1	3	4.3	0	0.0	0	0	4	4.5
	Disagree	0	0	2	2.9	0	0.0	0	0	2	2.2
	Neutral	0	0	14	20.3	2	33.3	1	33.3	17	19.1
	Agree	1	9.1	17	24.6	2	33.3	1	33.3	21	23.6
	Strongly Agree	9	81.8	33	47.8	2	33.3	1	33.3	45	50.6
	Total	11	100	69	100	6	100	3	100	89	100
I consider the COVID19 pandemic as a test that brings me closer to Allah	Strongly Disagree	1	9.1	5	7.2	0	0.0	0	0	6	6.7
	Disagree	0	0	1	1.4	0	0.0	0	0	1	1.1
	Neutral	0	0	7	10.1	2	33.3	1	33.3	10	11.2
	Agree	1	9.1	17	24.6	1	16.7	1	33.3	20	22.5
	Strongly Agree	9	81.8	39	56.5	3	50.0	1	33.3	52	58.4
	Total	11	100	69	100	6	100	3	100	89	100

23.0 Shock Due to the Pandemic

Table 23 describes the analysis of shock due to the pandemic. In the context of economic shock, analysis shows that majority respondents faced lack of income during pandemic, increase of food price and having the lack of saving in Redang, Perhentian, Kapas, Tenggol Island and all islands, respectively. Whereas, majority respondents lost their job due to the pandemic in Redang, Tenggol Island and all islands, respectively. Meanwhile, majority respondents refuse losing their job due to the pandemic in Perhentian and Kapas Island, respectively. Besides, in term of health shock, most of respondents in Redang, Perhentian, Kapas, Tenggol Island and all islands agree and strongly agree with covid-19 infection, concerns over food safety, supply and quality, as well as being worried regarding COVID-19 Infection respectively. Meanwhile, majority respondents in Redang, Perhentian, Kapas Island and all islands disagree and strongly disagree being exposed to critical illness and having accident and others, respectively. However, majority respondents in Tenggol Island refuse being exposed to critical illness while 33.3% agree and disagree having accident and others. Furthermore, most respondents Perhentian, Kapas, Tenggol Island and all islands in concern over nutrient intake while majority respondents in Redang Island refuse concerned over nutrient intake.

In environmental shock perspective, majority respondents Redang, Perhentian, Kapas, and all islands agree and strongly agree having a psychological disorder and under stress with family members (family institutions), respectively. However, 33.3% respondents in Tenggol Island agree and strong disagree having a psychological disorder, respectively while 66.7% respondents are uncertain about being under stress with family members (family institutions). Besides, most of respondents in Redang, Perhentian, and all islands refuse feeling stressed when faced with an emergency or PKP situation while in majority in Kapas and Tenggol Island state otherwise.

Moreover, in political views, majority respondents agree putting aside political differences while except most respondents in Kapas Island stated otherwise. Besides, majority respondents mention that their welfare is defended by the existing leadership and they also have the effective communication channels between the public and the government except Tenggol Island. Majority respondents in Tenggol Island being uncertain about their welfare defended by the existing leadership while 33.3% respondents agree and disagree having the effective communication channels between the public and the government, respectively. However,

most respondents Redang, Perhentian, Kapas, Tenggol Island and all islands agree and strongly agree with government's concern in reducing the resident's problems (incentives), respectively.

In aspect of risk management, majority respondents in Redang Island claim the shortage of economy opportunity (occupation) and have the marketability of goods and services. Otherwise, majority respondents refuse encountering with asset damage (premises, vehicles, tools & equipment), unmanaged infrastructure management and the increase of crime rate, respectively. Meanwhile, majority respondents in Perhentian Island agree with about the shortage of economy opportunity (occupation) due to the pandemic. Furthermore, most respondents are uncertain about the marketability of goods as well as unmanaged infrastructure management affected by pandemic. Meanwhile, majority refuse that asset damage (premises, vehicles, tools & equipment) and increase of crime rate caused by pandemic. Besides, majority respondents in Kapas and Tenggol Island agree and strongly agree with the shortage of economy opportunity (occupation), marketability of goods and services as well as asset damage (premises, vehicles, tools & equipment) affected by pandemic. However, most respondents in Kapas Island refuse with unmanaged infrastructure management and increase of crime rate caused by the pandemic. Whereas, most respondents have unmanaged infrastructure management due to the pandemic and being uncertain about the increase of crime rate due to the pandemic. It brings up the majority respondents for all islands having the shortage of economy opportunity (occupation) as well as marketability of goods and services due to the pandemic. Meanwhile, most respondents refuse having unmanaged infrastructure management, asset damage (premises, vehicles, tools & equipment) and the increase of crime rate due to the pandemic.

Table 23: Shock due to the pandemic

Shock due to the pandemic		Redang Island		Perhentian Island		Kapas Island		Tenggol Island		Total	
		N	%	N	%	N	%	N	%	N	%
ECONOMIC SHOCK											
Lack of income	Strongly Disagree	1	9.1	5	7.2	1	16.7	0	0	7	7.9
	Disagree	0	0	0	0	0	0	0	0	0	0
	Neutral	1	9.1	8	11.6	1	16.7	1	33.3	11	12.4
	Agree	3	27.3	11	15.9	2	33.3	1	33.3	17	19.1
	Strongly Agree	6	54.5	45	65.2	2	33.3	1	33.3	54	60.7
	Total	11	100	69	100	6	100	3	100	89	100
Job loss	Strongly Disagree	3	27.3	13	18.8	1	16.7	0	0	17	19.1
	Disagree	2	18.2	15	21.7	5	83.3	0	0	22	24.7
	Neutral	0	0	14	20.3	0	0	1	33.3	15	16.9
	Agree	2	18.2	5	7.2	0	0	2	66.7	9	10.1
	Strongly Agree	4	36.4	22	31.9	0	0	0	0	26	29.2
	Total	11	100	69	100	6	100	3	100	89	100
Increase in food price	Strongly Disagree	3	27.3	11	15.9	0	0	0	0	14	15.7
	Disagree	0	0	7	10.1	0	0	0	0	7	7.9
	Neutral	0	0	20	29	3	50	1	33.3	24	27.0
	Agree	4	36.4	15	21.7	3	50	2	66.7	24	27.0
	Strongly Agree	4	36.4	16	23.2	0	0	0	0	20	22.5
	Total	11	100	69	100	6	100	3	100	89	100
Lack of saving	Strongly Disagree	2	18.2	10	14.5	0	0	0	0	12	13.5
	Disagree	0	0	4	5.8	1	16.7	0	0	5	5.6
	Neutral	1	9.1	9	13	0	0	0	0	10	11.2
	Agree	3	27.3	24	34.8	4	66.7	2	66.7	33	37.1
	Strongly Agree	5	45.5	22	31.9	1	16.7	1	33.3	29	32.6
	Total	11	100	69	100	6	100	3	100	89	100
HEALTH SHOCK											
Covid-19 infection	Strongly Disagree	2	18.2	11	15.9	1	16.7	0	0	14	15.7
	Disagree	1	9.1	5	7.2	2	33.3	0	0	8	9
	Neutral	1	9.1	6	8.7	0	0	2	66.7	9	10.1
	Agree	3	27.3	15	21.7	1	16.7	1	33.3	20	22.5

	Strongly Agree	4	36.4	32	46.4	2	33.3	0	0	38	42.7
	Total	11	100	69	100	6	100	3	100	89	100
Exposed to critical illness	Strongly Disagree	4	36.4	23	33.3	1	16.7	0	0	28	31.5
	Disagree	1	9.1	7	10.1	2	33.3	0	0	10	11.2
	Neutral	1	9.1	20	29	1	16.7	1	33.3	23	25.8
	Agree	3	27.3	9	13	1	16.7	1	33.3	14	15.7
	Strongly Agree	2	18.2	10	14.5	1	16.7	1	33.3	14	15.7
	Total	11	100	69	100	6	100	3	100	89	100
Accident and others	Strongly Disagree	6	54.5	24	34.8	1	16.7	0	0	31	34.8
	Disagree	1	9.1	10	14.5	1	16.7	1	33.3	13	14.6
	Neutral	1	9.1	14	20.3	3	50	1	33.3	19	21.3
	Agree	2	18.2	15	21.7	1	16.7	1	33.3	19	21.3
	Strongly Agree	1	9.1	6	8.7	0	0	0	0	7	7.9
	Total	11	100	69	100	6	100	3	100	89	100
Concerns over food safety	Strongly Disagree	2	18.2	13	18.8	0	0	0	0	15	16.9
	Disagree	0	0	4	5.8	0	0	0	0	4	4.5
	Neutral	0	0	20	29	3	50	1	33.3	24	27
	Agree	6	54.5	14	20.3	2	33.3	2	66.7	24	27.0
	Strongly Agree	3	27.3	18	26.1	1	16.7	0	0	22	24.7
	Total	11	100	69	100	6	100	3	100	89	100
Concerns over food supply	Strongly Disagree	3	27.3	12	17.4	0	0	0	0	15	16.9
	Disagree	0	0	8	11.6	1	16.7	0	0	9	10.1
	Neutral	0	0	7	10.1	0	0	1	33.3	8	9
	Agree	5	45.5	17	24.6	3	50.0	2	66.7	27	30.3
	Strongly Agree	3	27.3	25	36.2	2	33.3	0	0	30	33.7
	Total	11	100	69	100	6	100	3	100	89	100
Concerns over quality of food	Strongly Disagree	3	27.3	14	20.3	0	0	0	0	17	19.1
	Disagree	0	0	4	5.8	1	16.7	0	0	5	5.6
	Neutral	0	0	9	13	0	0	1	33.3	10	11.2
	Agree	5	45.5	19	27.5	4	66.7	2	66.7	30	33.7
	Strongly Agree	3	27.3	23	33.3	1	16.7	0	0	27	30.3
	Total	11	100	69	100	6	100	3	100	89	100
Concerns over nutrient intake	Strongly Disagree	5	45.5	17	24.6	0	0	0	0	22	24.7
	Disagree	1	9.1	4	5.8	1	16.7	0	0	6	6.7
	Neutral	1	9.1	14	20.3	2	33.3	1	33.3	18	20.2
	Agree	3	27.3	12	17.4	1	16.7	2	66.7	18	20.2
	Strongly Agree	1	9.1	22	31.9	2	33.3	0	0	25	28.1
	Total	11	100	69	100	6	100	3	100	89	100
Anxiety regarding COVID-19 Infection	Strongly Disagree	1	9.1	8	11.6	0	0	0	0	9	10.1
	Disagree	1	9.1	2	2.9	0	0	0	0	3	3.4
	Neutral	0	0	3	4.3	3	50	1	33.3	7	7.9
	Agree	5	45.5	26	37.7	1	16.7	2	66.7	34	38.2
	Strongly Agree	4	36.4	30	43.5	2	33.3	0	0	36	40.4
	Total	11	100	69	100	6	100	3	100	89	100

ENVIRONMENTAL SHOCK											
I have a psychological disorder	Strongly Disagree	4	36.4	22	31.9	1	16.7	1	33.3	28	31.5
	Disagree	1	9.1	11	15.9	5	83.3	0	0	17	19.1
	Neutral	1	9.1	17	24.6	0	0	1	33.3	19	21.3
	Agree	4	36.4	10	14.5	0	0	1	33.3	15	16.9
	Strongly Agree	1	9.1	9	13	0	0	0	0	10	11.2
	Total	11	100	69	100	6	100	3	100	89	100
I am under stress with family members (family institutions)	Strongly Disagree	7	63.6	30	43.5	1	16.7	0	0	38	42.7
	Disagree	1	9.1	20	29	5	83.3	0	0	26	29.2
	Neutral	1	9.1	12	17.4	0	0	2	66.7	15	16.9
	Agree	1	9.1	3	4.3	0	0	1	33.3	5	5.6
	Strongly Agree	1	9.1	4	5.8	0	0	0	0	5	5.6
	Total	11	100	69	100	6	100	3	100	89	100
I feel stressed when faced with an emergency or PKP situation.	Strongly Disagree	5	45.5	26	37.7	0	0	0	0	31	34.8
	Disagree	1	9.1	16	23.2	3	50	0	0	20	22.5
	Neutral	1	9.1	16	23.2	0	0	1	33.3	18	20.2
	Agree	1	9.1	7	10.1	2	33.3	1	33.3	11	12.4
	Strongly Agree	3	27.3	4	5.8	1	16.7	1	33.3	9	10.1
	Total	11	100	69	100	6	100	3	100	89	100
POLITICAL SHOCK											
I put aside political differences	Strongly Disagree	0	0	7	10.1	1	16.7	0	0	8	9
	Disagree	0	0	3	4.3	3	50.0	0	0	6	6.7
	Neutral	3	27.3	7	10.1	0	0	1	33.3	11	12.4
	Agree	0	0	18	26.1	0	0	1	33.3	19	21.3
	Strongly Agree	8	72.7	34	49.3	2	33.3	1	33.3	45	50.6
	Total	11	100	69	100	6	100	3	100	89	100
My welfare is defended by the existing leadership	Strongly Disagree	1	9.1	4	5.8	0	0	0	0	5	5.6
	Disagree	1	9.1	7	10.1	3	50	0	0	11	12.4
	Neutral	1	9.1	17	24.6	0	0	2	66.7	20	22.5
	Agree	0	0	18	26.1	1	16.7	1	33.3	20	22.5
	Strongly Agree	8	72.7	23	33.3	2	33.3	0	0	33	37.1
	Total	11	100	69	100	6	100	3	100	89	100
Effective communication channels between the public and the government	Strongly Disagree	1	9.1	4	5.8	0	0	0	0	5	5.6
	Disagree	0	0	6	8.7	2	33.3	1	33.3	9	10.1
	Neutral	2	18.2	11	15.9	1	16.7	1	33.3	15	16.9
	Agree	1	9.1	24	34.8	2	33.3	1	33.3	28	31.5
	Strongly Agree	7	63.6	24	34.8	1	16.7	0	0	32	36
	Total	11	100	69	100	6	100	3	100	89	100
Government's concern in reducing the resident's problems (incentives)	Strongly Disagree	1	9.1	3	4.3	0	0	0	0	4	4.5
	Disagree	1	9.1	5	7.2	0	0	0	0	6	6.7
	Neutral	0	0	9	13	2	33.3	1	33.3	12	13.5
	Agree	2	18.2	25	36.2	3	50	1	33.3	31	34.8
	Strongly Agree	7	63.6	27	39.1	1	16.7	1	33.3	36	40.4
	Total	11	100	69	100	6	100	3	100	89	100

RISK MANAGEMENT											
Shortage of economy opportunity (occupation)	Strongly Disagree	2	18.2	7	10.1	0	0	0	0	9	10.1
	Disagree	0	0	5	7.2	1	16.7	1	33.3	7	7.9
	Neutral	1	9.1	31	44.9	2	33.3	0	0	34	38.2
	Agree	2	18.2	16	23.2	2	33.3	1	33.3	21	23.6
	Strongly Agree	6	54.5	10	14.5	1	16.7	1	33.3	18	20.2
	Total	11	100	69	100	6	100	3	100	89	100
Marketability of goods and services	Strongly Disagree	1	9.1	11	15.9	0	0	0	0	12	13.5
	Disagree	0	0	5	7.2	0	0	0	0	5	5.6
	Neutral	1	9.1	37	53.6	2	33.3	1	33.3	41	46.1
	Agree	0	0	13	18.8	3	50.0	1	33.3	17	19.1
	Strongly Agree	9	81.8	3	4.3	1	16.7	1	33.3	14	15.7
	Total	11	100	69	100	6	100	3	100	89	100
Unmanaged infrastructure management	Strongly Disagree	6	54.5	15	21.7	0	0	0	0	21	23.6
	Disagree	0	0	7	10.1	3	50.0	0	0	10	11.2
	Neutral	1	9.1	33	47.8	2	33.3	1	33.3	37	41.6
	Agree	2	18.2	8	11.6	0	0	1	33.3	11	12.4
	Strongly Agree	2	18.2	6	8.7	1	16.7	1	33.3	10	11.2
	Total	11	100	69	100	6	100	3	100	89	100
Asset damage (premises, vehicles, tools & equipment)	Strongly Disagree	6	54.5	16	23.2	0	0	0	0	22	24.7
	Disagree	1	9.1	26	37.7	1	16.7	0	0	28	31.5
	Neutral	1	9.1	19	27.5	2	33.3	1	33.3	23	25.8
	Agree	0	0	5	7.2	2	33.3	1	33.3	8	9.0
	Strongly Agree	3	27.3	3	4.3	1	16.7	1	33.3	8	9.0
	Total	11	100	69	100	6	100	3	100	89	100
The increase of crime rate	Strongly Disagree	5	45.5	13	18.8	1	16.7	0	0	19	21.3
	Disagree	2	18.2	11	15.9	2	33.3	0	0	15	16.9
	Neutral	0	0	29	42	3	50.0	2	66.7	34	38.2
	Agree	2	18.2	7	10.1	0	0	1	33.3	10	11.2
	Strongly Agree	2	18.2	9	13	0	0	0	0	11	12.4
	Total	11	100	69	100	6	100	3	100	89	100

CHAPTER 12

BELT TRANSECT SURVEY ON CORAL REEF ASSOCIATED INVERTEBRATES IN MARINE PARK ISLAND OF TERENGGANU

Muhammad Hafiz Borkhanuddin, Siti Nurtahirah Jaafar

INTRODUCTION

The ecological importance of invertebrates towards marine ecosystems is essential, as they are converting large quantities of organic matter into protein. Threats to the coral reef ecosystem are rapidly growing and magnified by climate-related events such as tropical storms. The phenomenon not only deteriorates the coral cover, but also causes the loss of invertebrates' diversity and abundance.

As one of the key elements in coral reefs health (Glasl, et al., 2018; Edmunds et al., 2018), invertebrate diversity and abundance in response to coral reefs recovery could provide an additional insight about the recovery process. With a focus on assessment of the resilience of reef communities, invertebrate's survey should be focused on the major functional groups that may be indicators of resilience (in the coral community).

Some invertebrates such as crown of thorns (COT – *Acanthaster planci*) and *Drupella* sp. snails possess threats to corals by predating on them. Other invertebrates communities include giant clam, nudibranch, sea cucumber, snail, scallop, brittle star, feather duster worm, sea urchins and sea cucumber.

METHODOLOGY

Coral Belt Transect

Survey were conducted at Pulau Perhentian, P. Redang, P. Kapas and P. Tenggol. Underwater visual census (UVC) was conducted following English et al. (1994). At each site, divers identified the invertebrates visually along the 100 m transect line. The survey was carried out along a 100m (long) x 5m (width) transect belt, in which 2.5 meter at each side of the transect (English et al., 1994). This covered 500m² of area surveyed. For every 5 meters on the transect line, surveyor stopped and recorded the invertebrate occurrences and number on a slate board (English et al., 1994). The identification was done in situ, and photograph and video were also taken using underwater camera to aid in further identification of reef organisms on land. At the end of survey, researchers gathered all slates and data together, then review them immediately with the team members.

The purpose was to make a quick assessment of the data to determine if there was any error occurred that can be corrected while the team was still on site, and the transect was in place. Typical errors that could be corrected

would be “double-counting”, mis-identification of organisms or mis-labelling the slate. When an error was suspected, a re-survey should be made to check or to correct it. Before departing from the site, researchers were responsible to ensure all required data have been collected, and the slates have been filled out properly, in particular with each individual's work identified. On land after each dives, the data were transferred into the automated Excel Spreadsheets.

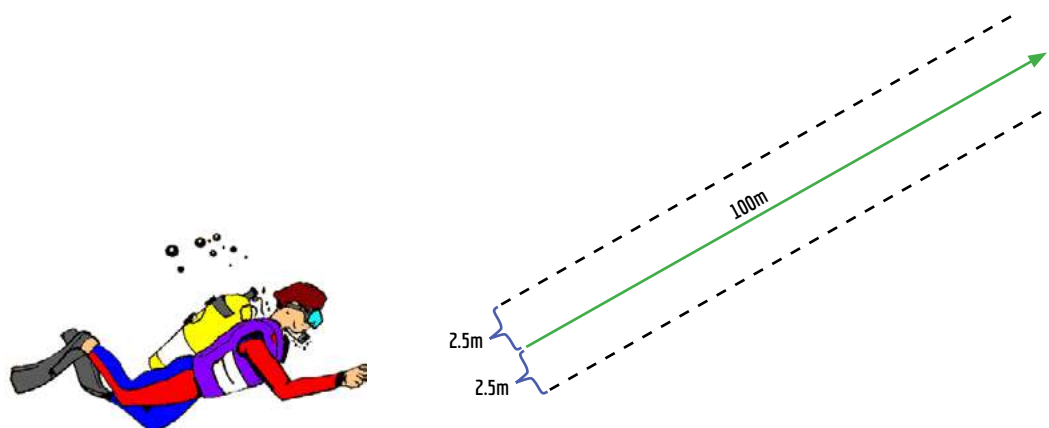


Figure 12.1: Illustration of belt transect for invertebrate survey which cover an area of 500 m².

RESULTS AND DISCUSSION

Invertebrates communities (in term of diversity) differed significantly among islands, however in term of abundance, several taxa dominated in all islands such as *Pedum* sp. (flame scallop) and feathers duster worms (Polychaete). The least abundance group of invertebrate were represented by several taxa such as turbo snail, *Tridacna gigas* (giant clam) and *Cypraea* sp. (Cowrie snail), and *Cassis* sp. (helmet shell).

Remarks on Feeding Behavior

According to United Nations Environment Programme (UN), there were six top essential recovery resilience indicators in coral reefs assessment, which are 1-resistant of coral species, 2-coral diversity, 3-herbivore biomass, 4-coral disease, 5-macroalgae cover and 6-recruitment of corals (Maynard et al., 2017). According to Mazzuco et al. (2019), herbivorous invertebrates has shown to respond more effectively towards environmental change. Therefore, to evaluate the recovery of damaged coral reefs, invertebrates are considered essential and will be important to be studied in nearly all resilience assessment (Meyer et al., 2018; Mazzuco et al., 2019). Additionally, herbivorous invertebrate diversity can also be assessed as the number of key functional groups present at a minimum abundance.

Most marine invertebrates live by filter feeding which involve internal and external filter feeders. The most abundant invertebrates live by filter feeding such as bivalve mollusks (clams, mussels and oysters) and polychaete worms. These marine animals filter out and feed huge amounts of phytoplankton, microorganisms such as bacteria and other particles and at the same time maintain the quality of the water surrounding their habitat.

Interestingly, these marine invertebrates can sense molecules from other organisms and potentially use these molecules to search and screen the organisms as the sources of food. These unique processes depend on the detection and differentiation of the molecules carried in the seawater surrounding them and in the mouths of these animals (Kamio and Derby, 2017).

Giant Clams

Giant clams, the largest living bivalves, live in close association with coral reefs throughout the Indo-Pacific. These iconic invertebrates perform numerous important ecological roles as well as serve as flagship species-drawing attention to the ongoing destruction of coral reefs and their associated biodiversity.

Giant clams undergo several shifts in their mode of acquiring nutrition; starting with a lecithotrophic and planktotrophic diet as larvae, switching to pedal feeding after metamorphosis followed by the transition to a dual mode of filter feeding and phototrophy once symbiosis with zooxanthellae (*Symbiodinium* spp.) is

established. They pump water into their mantle cavity through an inhalant siphon and filter plankton using ciliated tracts on their gills. The great size exhibited in giant clams cannot be achieved by these ctenidial feeding mechanisms alone these accomplished together with symbiotic photosynthetic dinoflagellate algae, or zooxanthellae (*Symbiodinium* spp.), that live within the mantle tissues. These Zooxanthellae do not pass from one generation to another but they are permanently established only after metamorphosis from larva to juvenile (Soo and Todd, 2014).

Giant clams increase the topographic heterogeneity of the reef, act as reservoirs of zooxanthellae (*Symbiodinium* spp.), and also potentially counteract eutrophication via water filtering. Giant clams are considered as self-sustaining animals, their population and conservation are crucial. They should be the highlight and priorities when planning marine protected areas and integrated coastal management; national or local assessments can be part of this process (Neo et. al, 2015). Notably, not only are giant clams useful for the functioning of coral reefs, they can help protect them by acting as surrogate species.

Knowledge on the behaviour of giant clams will benefit conservation and restocking efforts and help fine-tune mariculture techniques. Understanding the repertoire of giant clam behaviours will also facilitate the prediction of threshold levels for sustainable exploitation as well as recovery rates of depleted clam populations.

Scallop (*Pedum* sp.)

Scallop sp. occurs almost exclusively on massive coral colonies especially on the genus *Porites*. These scallops have reduced the effects of heavy levels of predation by the starfish *Acanthaster planci* on their coral hosts. Scallops fight off foraging starfish and other echinoderms on contact by repeated expulsion of jets of water. Scallops act as the protector of the corals and these acts increase the survivability also enhancing recovery and preserving the population structure of *Porites* (Devantier and Endean, 1988). The coral-bivalve relationship may be mutualistic, with the coral providing the bivalve with support and protection, and the bivalve enhancing water circulation for coral feeding. But, on the other hand, *Pedium* sp. may cause some structural weakness to its coral host, since its impact, both alive and dead, results in a cavity within the coral structure (Scaps and Denis, 2007)

Pulau Redang

One of the most abundance organism was the *Pedium* sp. (flame scallop) at all the surveyed locations. Apart from that, one of the highlighted findings from our survey was the higher abundance of giant clam in Pulau Kerengga which raise significant conservation concerns. Within the 100 meter transect survey, we recorded up to 72 individuals of giant clams, surpassing the other surveyed location by almost tenth fold. Interestingly, further observation beyond the transect line around Pulau Kerengga revealed high number of giant clams. It is also observed that a mixed age group of giant clams were presented in this area, indicating a possible favourable settlement area of the animal (Figure 12.1 and 12.2).

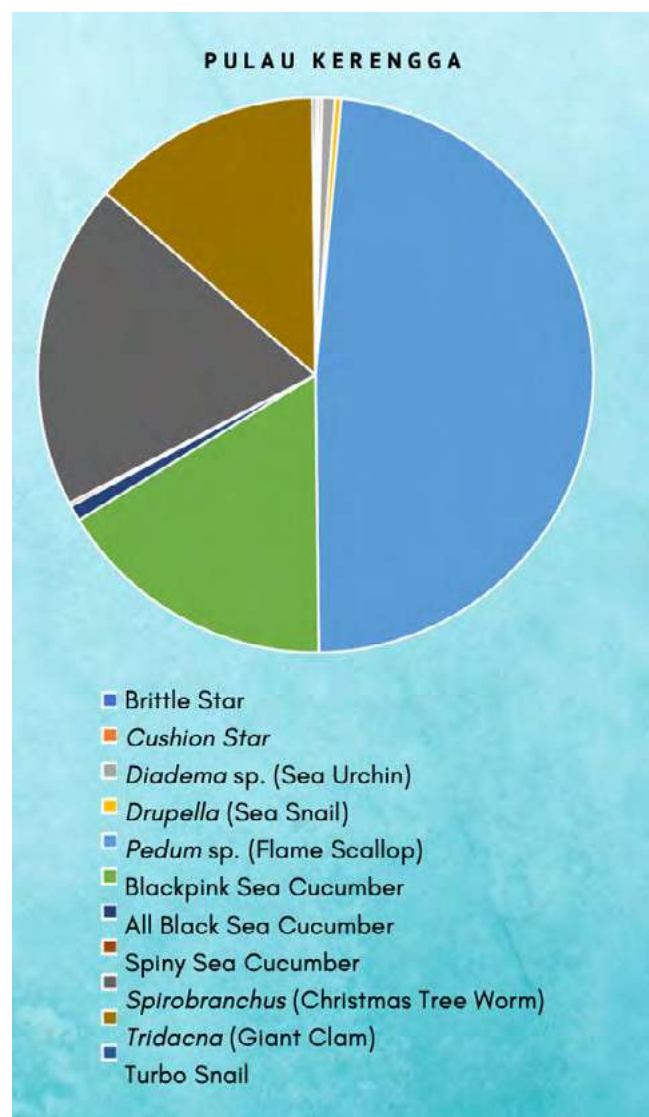


Figure 12.1: Abundance of invertebrates at Pulau Kerengga showing the higher occurrence of giant clams.

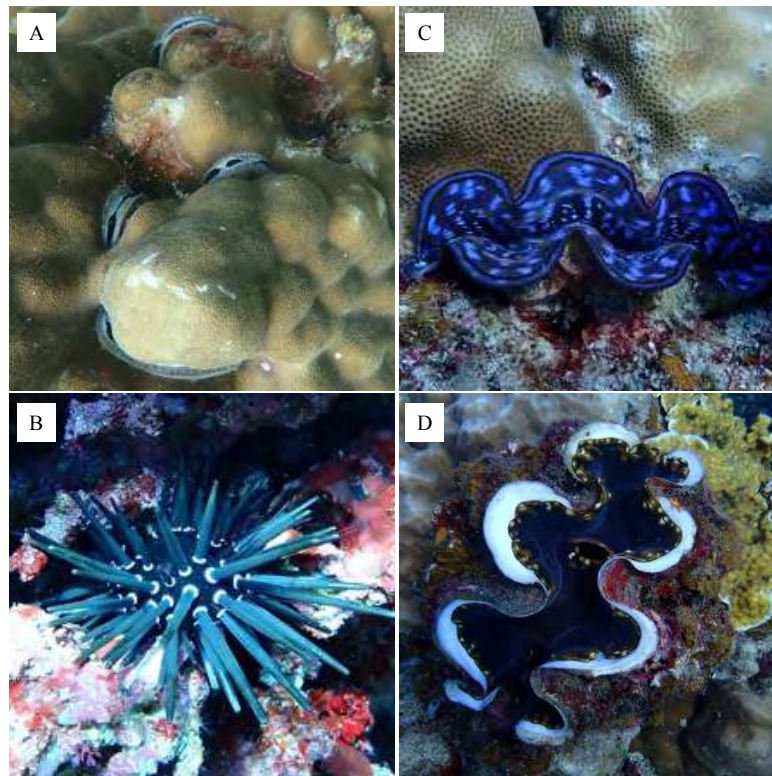


Figure 12.2: A. *Pedum* sp. (flame scallop); B. Juvenile *Diadema* sp. (sea urchin); C, D. *Tridacna gigas* (giant clams)

Pulau Perhentian

Like other surveyed islands, the most abundance invertebrates recorded was the *Pedum* sp. (flame scallop). One of the important observation was the occurrence of a white sea cucumber (*Synaptula* sp.) in several of the surveyed location such as Tokong Burung and Rawa. On other hand, Pulau Perhentian recorded one of the highest occurrence of feather stars collectively (Figure 12.3 and 12.4).

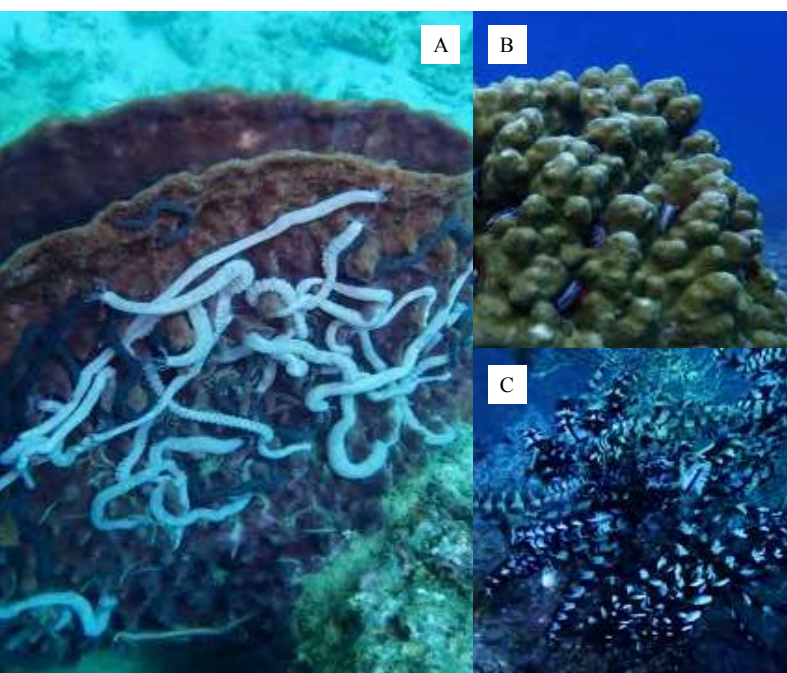
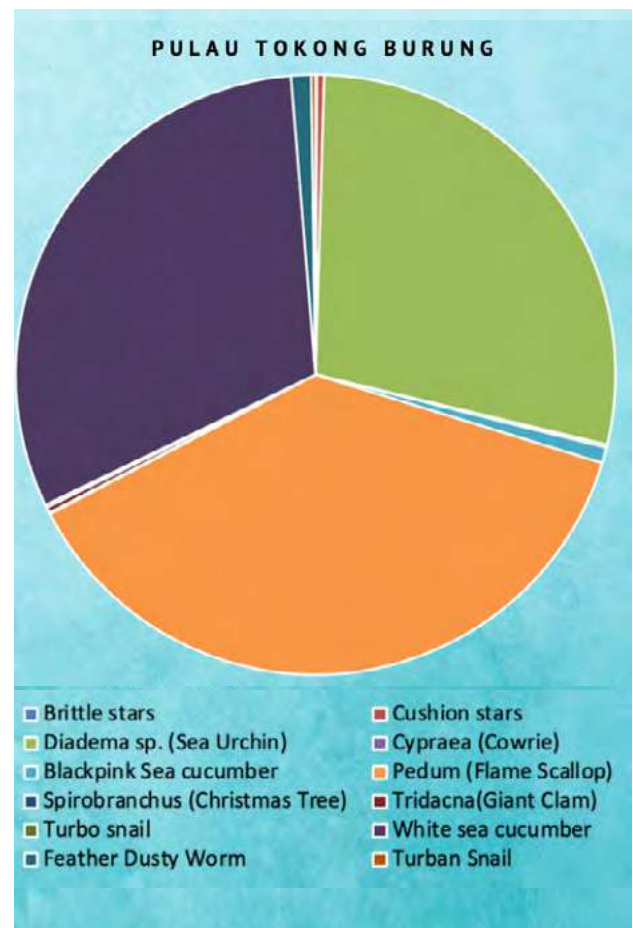


Figure 12.4: A. White sea cucumber (*Synaptula* sp.) B. *Pedum* sp. (flame scallop); C. Feather stars



Pulau Kapas

In general, a mixture of invertebrates dominated at different surveyed location such as the nudibranch, feather dusty worms, sea cucumber and flame scallop. Unlike other island, the occurrence of *Pedum* sp. (flame scallop) was not too dominant at Pulau Kapas. The more interesting findings derived from our survey at Pulau Kapas was the occurrence of nudibranch, in large number, at no less than two survey locations. Given the high species diversity of the nudibranch in Pulau Kapas, suggesting there is a potential area to be promoted for eco-tourism activities, especially for nudibranch enthusiasts. Nevertheless, we also believed that the high occurrence of the nudibranch were related to their biological or reproduction cycle in which usually taken place before the monsoon season (Figure 12.5 and 12.6).

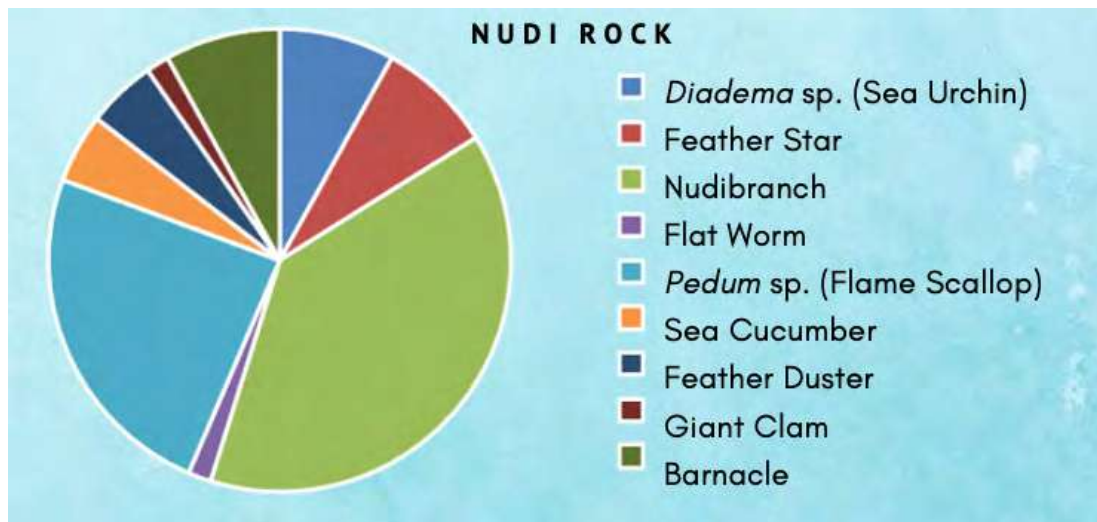


Figure 12.5: Abundance of invertebrates at Nudi Rocks showing the higher occurrence of nudibranch.



Figure 12.6: Some of the species diversity of nudibranch at Pulau Kapas.

Pulau Tenggol

Pedum sp. (flame scallop) represent the highest abundance of invertebrates in all of the surveyed locations, hence mark up the most dominant invertebrate group in Pulau Tenggol. Apart from *Pedum* sp., another commonly spotted invertebrates were feather duster worms and nudibranchs. Among the surveyed location, Seri Nahkota and Lost World recorded with the most diverse group of invertebrates found with a total of 12 species each (Figure 12.7).

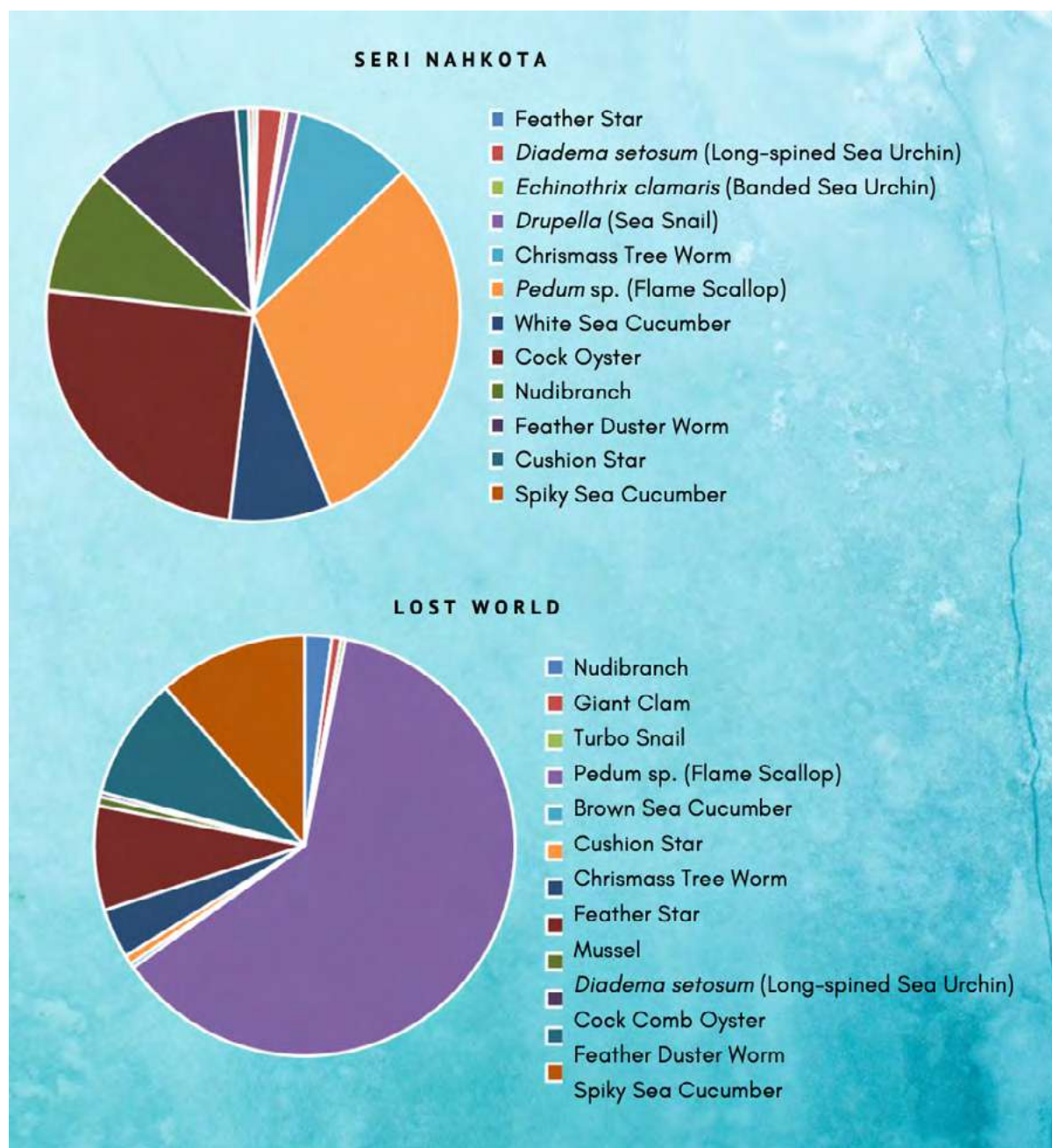


Figure 12.7: Abundance of invertebrates in Seri Nahkota and Lost World with twelve representatives of organisms.

3.4 CONCLUDING REMARKS

Most of the taxa were identified down to genus, with some were only identified in common name unit. Some invertebrates could not be identified due to their small size and distinctive characteristics, but it is worth pointing out their presence in the studied area. Invertebrates communities (in term of diversity) differed significantly among islands, however in term of abundance, several taxa dominated in all islands such as *Pedum* sp. (flame scallop) and feathers duster worms (Polychaete). The least abundance group of invertebrates were represented by several taxa such as *turbo snail*, *Tridacna gigas* (giant clam) and *Cypraea* sp. (Cowrie snail), and *Cassis* sp. (helmet shell).

The health of a reef is greatly influenced by the abundance and diversity of marine invertebrates and disturbance of marine invertebrates can result in negative ecological impacts upon the reef, such as algae blooms and invertebrate plagues. The diversity of coral associated invertebrates may give an indication of community structure because any species groups would serve a function in the community. Overall, this study reported the diversity, abundance and density of associated marine invertebrates in coral reefs area of Pulau Redang, Pulau Perhentian, Pulau Kapas and Pulau Tenggol Marine Park. The overall findings derived from this study are mitigated however by the lack of other analysis such as biomass and productivity of the benthic community and the conclusion may be well improvised in the future.

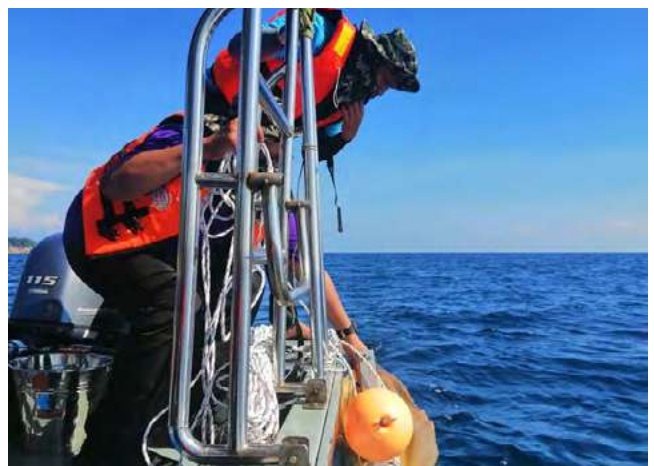
The images data from coral video transect (CVT) survey are still in progress. The analysis involved coral reef community structure, coral cover and condition of coral reef at survey location.

REFERENCES

- DeVantier, L., & Endean, R. (1988). The scallop *Pedum spondyloideum* mitigates the effects of *Acanthaster planci* predation on the host coral *Porites*: Host defence facilitated by exaptation? *Marine Ecology Progress Series*, 47(3), 293-301. Retrieved May 30, 2021, from <http://www.jstor.org/stable/24831586>
- Edmunds, P.J., Mcllroy, S.E., Adjeroud, M., Ang, P., Bergman, J.L., Carpenter, R.C., Coffroth, M.A., Fujimura, A.G., Hench, J.L., Holbrook, S.J., Leichter, J.J., Muko, S., Nakajima, Y., Nakamura, M., Paris, C.B., Schmitt, R.J., Suttacheep, M., Toonen, R.J., Sakai, K., Suzuki, G., Washburn, L., Wyatt, A.S.J., Mitarai, S. (2018) Critical Information Gaps Impeding Understanding of the Role of Larval Connectivity Among Coral Reef Islands in an Era of Global Change. *Front. Mar. Sci.* 5:290.
- Glasl, B., Bourne, D. G., Frade, P. R., & Webster, N. S. (2018). Establishing microbial baselines to identify indicators of coral reef health. *Microbiology Australia*, 39, 42–46
- Kamio M, Derby CD. Finding food: how marine invertebrates use chemical cues to track and select food. *Nat Prod Rep.* 2017 May 10;34(5):514-528. doi: 10.1039/c6np00121a. PMID: 28217773.
- Maynard, J.A., Marshall, P.A., Parker, B., Mcleod, E., Ahmadi, G., van Hooidek, R., Planes, S., Williams, G.J., Raymundo, L., Beeden, R., Tاملندر, J. (2017). *A Guide to Assessing Coral Reef Resilience for Decision Support*. Nairobi, Kenya: UN Environment
- Mazzuco, A.C.A, Stelzer, P.S., Donadia, G., Bernardino, J.V., Joyeux, J.C., Bernardino, A.F. (2019) Lower diversity of recruits in coastal reef assemblages are associated with higher sea temperatures in the tropical South Atlantic 148: 87–98
- Meyer, K.S., Li, Y., Young, C.M. (2018). Oceanographic and biological influences on recruitment of benthic invertebrates to hard substrata on the Oregon shelf. *Estuar. Coast Shelf Sci.* 208, 1–8.
- Neo M.L, Eckman W., Vicentuan K, Teo S.L.-M, Todd P.A (2015). The ecological significance of giant clams in coral reef ecosystems. *Biological Conservation* 181 : 111-123. ScholarBank@NUS Repository.
- Scaps, P. and V. Denis (2007) Association between the scallop, *Pedum spondyloideum*, (Bivalvia: Pteriomorpha: Pectinidae) and scleractinian corals from the Wakatobi Marine National Park (southeastern Sulawesi, Indonesia). *The Raffles Bulletin of Zoology* 55(2):371-380.
- Soo, P., Todd, P.A. The behaviour of giant clams (Bivalvia: Cardiidae: Tridacninae). *Mar Biol* 161, 2699–2717 (2014). <https://doi.org/10.1007/s00227-014-2545-0>

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Kementerian Pertanian dan Industri Asas Tani Malaysia

Aras 1-6, Blok Menara 4G2, Wisma Tani, Presint 4,
Pusat Pentadbiran Kerajaan Persekutuan,
62628 PUTRAJAYA,
MALAYSIA



603-8870 4000



603-8889 5490



hqhelp@dof.gov.my



www.dof.gov.my



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