6.0 EXISTING ENVIRONMENT

6.1 Introduction

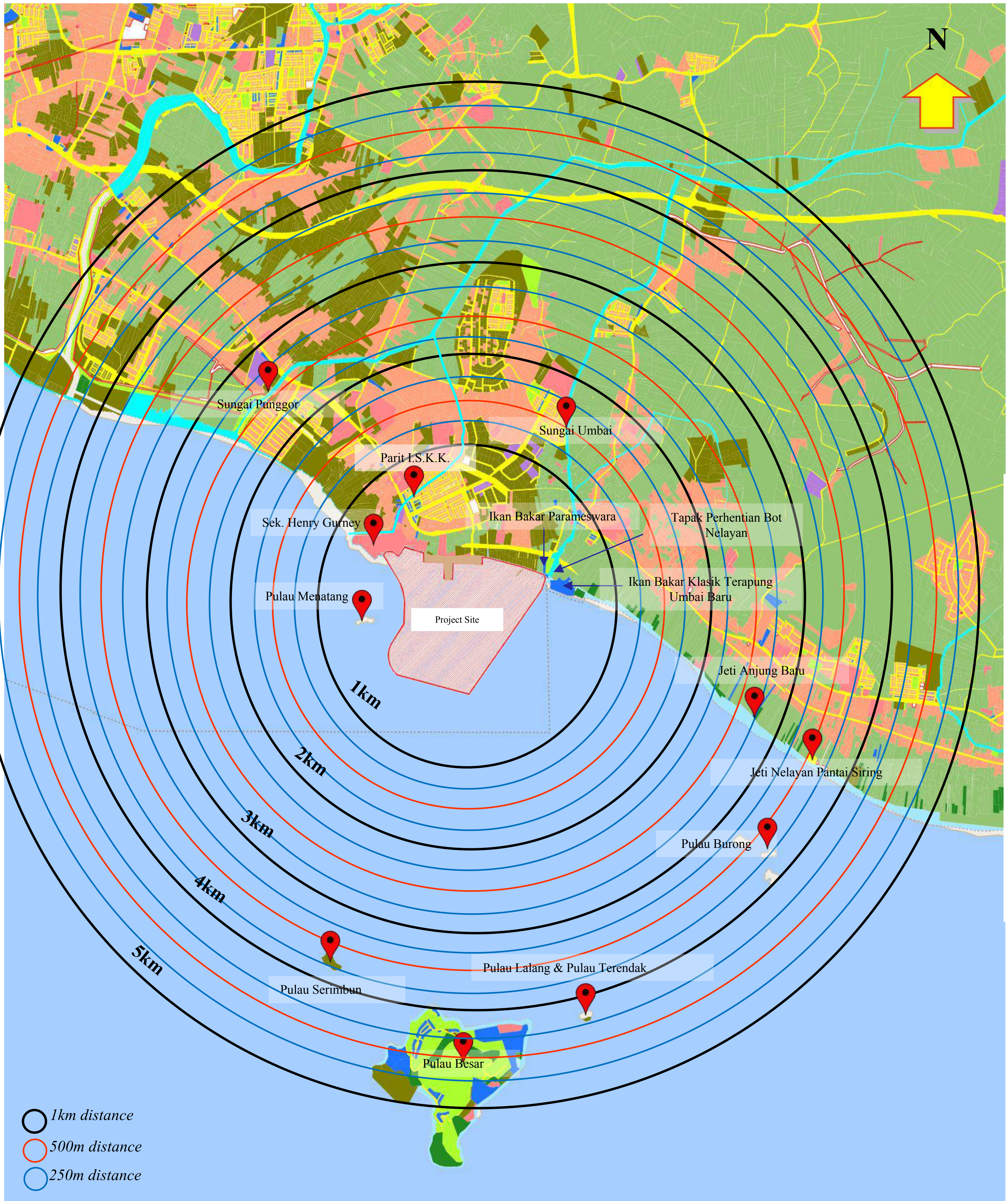
As a prelude to assessing the potential impacts of the Project, the existing environment has been studied and documented in this chapter. Information in this chapter was obtained from field surveys, secondary data sources and approved hydraulic report of this project. Components of the environment described include hydrography, meteorological characteristic, aquatic environment, water quality, ambient air quality and noise level. Landuse and human activities were assessed within a radius of 5 km from the project site.

6.2 Landuse

The project is located at Kawasan Bandar XLVI, District of Melaka Tengah, Melaka. The nearest landmark is Sekolah Henry Gurney, located at the northwest of the site. The location of the Project and its surrounding land use within 5 km distance from its boundary are illustrated in **Figure 6.1**. Other land uses observed from the immediate project boundary to the distance of 5 km from the boundary is tabulated in **Table 6.1**.

Table 6.1: Land Use within 5 km Distance from The Site

Radius (km)	Existing Land Use
0-1	Northwards The nearest landmark here is Sek. Henry Gurney and Restoran Terapung Teluk Mas. Landuse in this region is covered by residential area such as Kg. Ketapang, Kg. Pernu and Taman Seri Telok Emas. Kawasan Perindustrian Telok Mas is also located here. Factories that are available here include Astino Souhern Sdn. Bhd., Mega Printing & Packaging Sdn. Bhd. and Ever Delicious Food Industries Sdn. Bhd.



Petunjuk

- Badan Air
- Hutan
- Industri
- Infrastruktur dan Utiliti
- Institusi dan Kemudahan Masyarakat
- Komersial
- Pantai
- Pembangunan Bercampur
- Pengangkutan
- Pertanian
- Perumahan
- Tanah Kosong
- Tanah Lapang dan Rekreasi
- Sempadan Daerah
- Sempadan Mukim
- Sempadan PBT
- Jalan Raya
- Jalan Keretapi
- Reclaimed Land

CIRI SELASIH SDN. BHD. ENVIRONMENTAL & TRAFFIC CONSULTANT	*Source: iPlan Semenanjung Malaysia*	**Figure 6.1:** Landuse Within 5km Radius	6-1a

Radius (km)	Existing Land Use
	Eastwards Medan Selera Ikan Bakar Pernu-Umbai, Pulau Besar Boat Service, Klinik Desa Telok Mas and Perkampungan Ikan Bakar Terapung Umbai are located here. The rest of this area is covered by Straits of Melaka. Westwards Pulau Menatang is located west of the site.
1-2	Northwards The area mainly consists of residential areas such as Kg. Telok Mas, Kg. Bukit Meta, Taman Emas, Kg. Bukit Larang, Kg. Bukit Tembakau and Taman Alai Perdana. Japerun Telok Mas, Medan Ikan Bakar Crystal Bay, SMKA Sharifah Rodziah Telok Mas, SMK Telok Mas and SMK Pernu are also found here. Eastwards Residential areas eastwards of the site include Kg. Umbai and Kg. Berangan Enam. Facilities such as Klinik Kesihatan Umbai, SK Datuk Haji Baginda and Masjid Al-Kauthar Kg. Umbai are also located in this region.
2-3	Northwards This area is covered mostly with residences such as Taman Bukit Indah Larang, Taman Bukit Tembakau, Kg. Tambak Bugis, Kg. Bukit Tembakau, Kg. Tasek and Kg. Bukit Punggor. Rubber plantation, oil palm plantations and orchards are also located in this region. Eastwards Anjung Batu Jetty, Medan Ikan Bakar Anjung Batu and Sek. Men. Islam Al-Amin are located here. Residential areas that can be found

Radius (km)	Existing Land Use
	here include Kg. Sri Minyak and Kg. Tengah. The rest of this area is covered by Straits of Melaka. Southwards This area is covered by Straits of Melaka. Westwards Sg. Punggor river mouth can be found here. The rest of this region is covered by Straits of Melaka.
3 - 4	Northwards This region is characterised by residential areas, oil palm plantations, rubber plantations and orchards. Residential area that can be found here are Kg. Balik Bukit, Kg. Bakar Batu, Kg. Alai, Taman Balkis and Taman Umbai Setia. Lebuh AMJ stretches across this region. Eastwards Oil palm plantations and residential areas such as Taman Datuk Aziz, Taman Pulai Jaya and Kg. Seri Minyak are located here. SK Pulai and SMK Pulai are also found in this area. Jeti Nelayan Pantai Siring and Pulau Burong (Pulau Burong Kecil & Pulau Burong Besar) are also located here. Southwards Pulau Serimbun, Pulau Lalang, Pulau Terendak and Pulau Besar are located in this region.
4 - 5	Northwards This region consists mostly of residential areas such as Taman Lintang Jaya, Kg. Bukit Lintang, Kg. Bukit Batu, Taman Seri Duyong, Taman Kandang Permai and Kg. Pengkalan Renggam. Sg. Melaka stretches across this region.

Radius (km)	Existing Land Use
	Eastwards This area is covered by oil palm plantations and rubber plantations. Kg. Serkam, Kg. Pulai, Taman Pulai Indah and SK Pulai are also located in this region. Southwards Pulau Besar is located here.

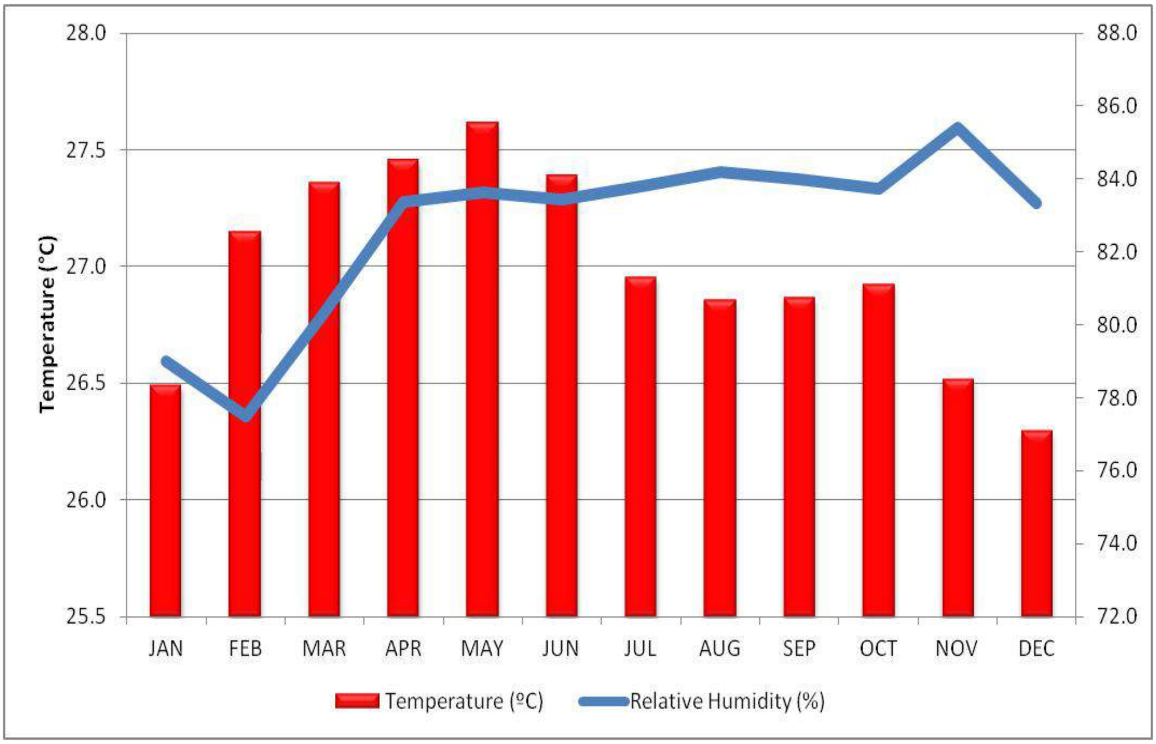
6.3 Meteorology

6.3.1 General

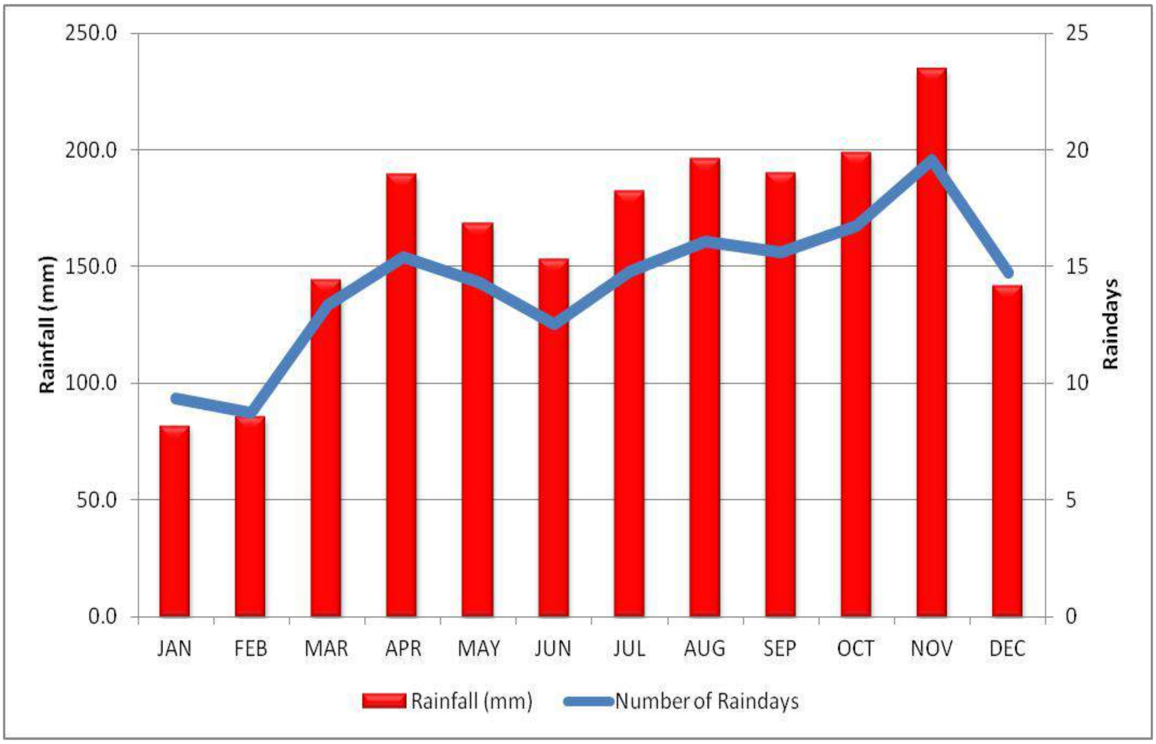
The meteorological description in this section is based on meteorological data from Batu Berendam Airport Principal Station (No. Station: 48665 – N 02°16', E 102°15') obtained from Malaysian Meteorological Service Department. The station is located about 19km (road distance) west from the project boundary and there are no physical barriers between these two locations. Therefore, the meteorological data from the station can be used to describe weather conditions at the Project site.

The summary of the meteorological data for temperature, relative humidity, rainfall and number of raindays at Melaka is as shown in **Table 6.2**. **Figure 6.2** summarises the weather conditions monitored from 1968 to 2014. However, it was observed that there have been some changes to the weather pattern in the past few years. Hence, the latest (2015 to 2018) weather conditions obtained from *World Weather Online Website (https://www.worldweatheronline.com/melaka-weather-averages/melaka/my.aspx)* are highlighted in this report. **Table 6.3** and **Figure 6.3** show the average rainfall amount and the number of rain days from 2015 to 2018. The elaboration of the weather conditions is given in the following paragraphs.

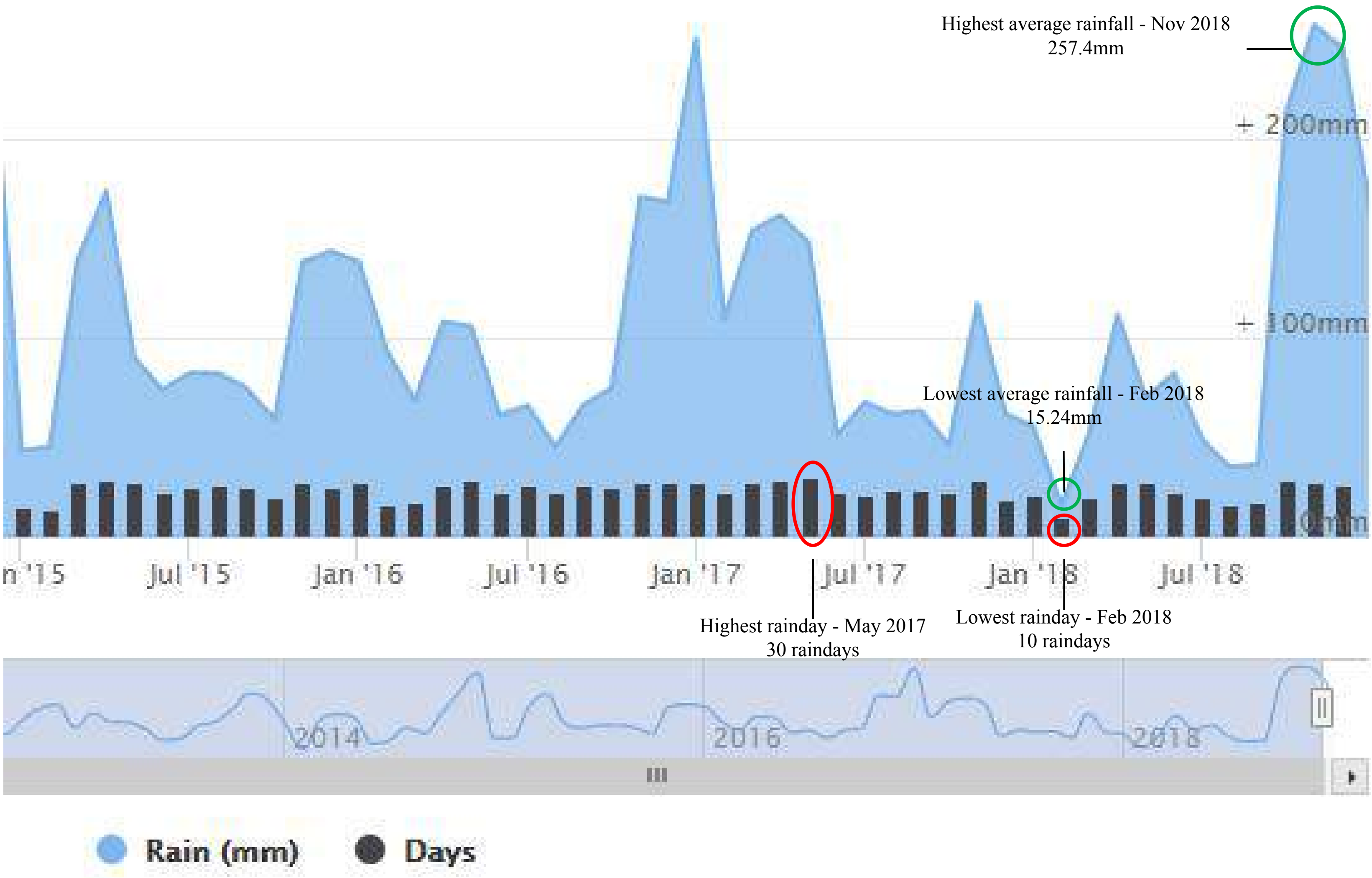
Mean 24-hour Temperature and Relative Humidity for Melaka



Mean Rainfall and No. of Raindays for Melaka



Average Rainfall Amount (mm) and No. of Raindays in Melaka (2015 - 2018)



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Source: World Weather Online

Figure 6.3 : Average Rainfall Amount and No. of Raindays in Melaka (Year 2015-2018)

6.3.2 Rainfall

Based on the rainfall data from 1968 - 2014, the annual mean rainfall for Melaka is about 1,965.6 mm with the annual mean raindays of 171 days. For the period monitored, the wettest month of the year was in November, which recorded a mean value of 234.5 mm with the highest corresponding raindays i.e. 24 days. Meanwhile, the driest month occured in January with an average rainfall of 81.8 mm (9 raindays). For the period monitored, the highest rainfall was in 1984 (of 2,618.2mm) while the lowest rainfall was in 2013 (1,389 mm). The highest recorded raindays was 224 days in y1984 and the lowest recorded raindays was 140 days in 1997.

The meteorological data for the year 2015 to 2018 indicated the highest average rainfall amount was in November 2018 with an average rainfall of 257.4mm, while the lowest average rainfall amount was during February 2018 with an average rainfall amount of 15.24mm. The highest number of rainday was in May 2017 (30 rain days), while the lowest was in February 2018 (10 rain days).

6.3.3 Humidity

It is observed that the annual 24-hour mean relative humidity was about 82.6% with the lowest and highest monthly 24-hour mean relative humidity recorded in the month of February and November with values of 77.5% and 85.4% respectively.

6.3.4 Temperature

The annual average 24-hour mean temperature recorded for Melaka is 27.0 °C with the highest mean 24-hour temperature recorded falls in the month of May with value of 27.6°C. Meanwhile, the lowest mean 24-hour temperature falls in the month of December with value of 26.3°C. The average maximum and minimum mean daily temperature are 31.9°C and 23.5 °C respectively. For the period monitored, the highest maximum temperature recorded was 38.0 °C in year 1998 and the lowest minimum temperature recorded was 19.5°C in year 1981.

Table 6.2: Summary of Meteorological Data For Melaka From 1968 – 2014 (47 years)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)													
• 24-hour Mean	26.5	27.1	27.4	27.5	27.6	27.4	27.0	26.9	26.9	26.9	26.5	26.3	27.0
• Mean Daily Maximum	31.7	32.9	33.1	32.7	32.3	31.9	31.4	31.3	31.4	31.7	31.4	31.1	31.9
• Mean Daily Minimum	23.0	23.4	23.7	23.9	24.0	23.7	23.3	23.2	23.3	23.5	23.4	23.2	23.5
• Highest Maximum	35.2	37.8	37.2	37.3	38.0	35.1	35.7	35.0	34.5	35.6	34.4	34.6	38.0
• Year of Highest Maximum	1998 1985	2005	1990 1998	1998	1998	1986	2004 1998	1986	2001	1998	2014	2002	1998
• Lowest Minimum	20.1	19.7	19.6	21.0	21.0	19.5	20.1	20.4	20.7	20.9	20.6	19.8	19.5
• Year of Lowest Minimum	1991 1972	1992	1971	1981	1986	1981	2014	1982 1990	1974	1973	1976	1973	1981
24-hour Mean Relative Humidity (%)	79.0	77.5	80.4	83.4	83.6	83.4	83.8	84.2	84.0	83.7	85.4	83.3	82.6
Rainfall (mm)													
• Mean	81.8	85.6	144.4	189.5	168.4	152.7	182.1	195.9	190.0	198.9	234.5	141.8	1,965.6
• Highest	270.6	279.0	360.6	391.2	426.7	466.7	471.7	490.6	407.0	347.5	424.6	362.5	2,618.2
• Year of Highest	2011	1984	1984	1968	1994	1979	2002	1998	1995	1981	1969	1992	1984
• Lowest	4.7	0.0	33.8	13.4	25.2	26.7	50.4	75.2	72.8	64.3	98.5	16.1	1,389.8
• Year of Lowest	1974	2014	1972	1998	1972	1991	1972	1981	1997	2002	1983	1979	2013
Number of Raindays (day)													
• Mean	9	9	13	15	14	13	15	16	16	17	20	15	171
• Highest	21	17	21	22	21	22	23	23	20	22	24	25	224
• Year of Highest	1984	1988 1984	1994 2009	1982 2003	1993 1994	1970	1975	1998	2001 1986 1974 1988	1973 2007	1981 1982 2011	1991	1984
• Lowest	2	0	5	5	6	5	10	9	9	10	13	5	140
• Year of Lowest	1976 1982	2014	1972 1983	1998	2000	1985 2012	1997 1972	1997	1997	2002	1992	1979	1997

Source: Malaysian Meteorological Department, 2015

Table 6.3: Average Rainfall Amount and the Number of Raindays from 2015 – 2018

Year / Parameter	Month											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Average Rainfall (mm)												
2015	43.26	45.06	139.17	173.79	90.02	73.86	82.22	81.97	74.75	58.82	138.29	143.51
2016	138.35	93.5	68.38	107.89	105.55	61.04	65.95	45.18	66.22	74.68	170.81	168.28
2017	250.56	108.98	153.84	161.73	147.89	50.97	67.55	61.68	63.16	45.65	117.03	61.62
2018	55.25	15.24	52.39	111.5	69.79	82.05	48.89	34.67	36.25	213.45	257.4	245.7
Number of Raindays (day)												
2015	15	14	28	29	28	22	25	26	25	20	27	25
2016	28	16	17	26	29	23	26	23	26	25	27	28
2017	28	22	28	29	30	22	21	24	24	23	29	19
2018	21	10	20	28	28	22	20	16	18	29	28	26

Source: World Weather Online Website (https://www.worldweatheronline.com/melaka-weather-averages/melaka/my.aspx)

6.3.5 Wind Characteristics

An examination of the annual windrose for Melaka as shown in **Figure 6.4** indicates that the dominant wind is blowing from Northeast (26.9%). The percentage of calm conditions occurrences for Melaka is about 20.2% of the time. Closer examination of the surface wind speed frequency for the identified station indicates that the dominant wind speed range category is from 0.3 m/s to 1.5 m/s with frequency of 33.9%.

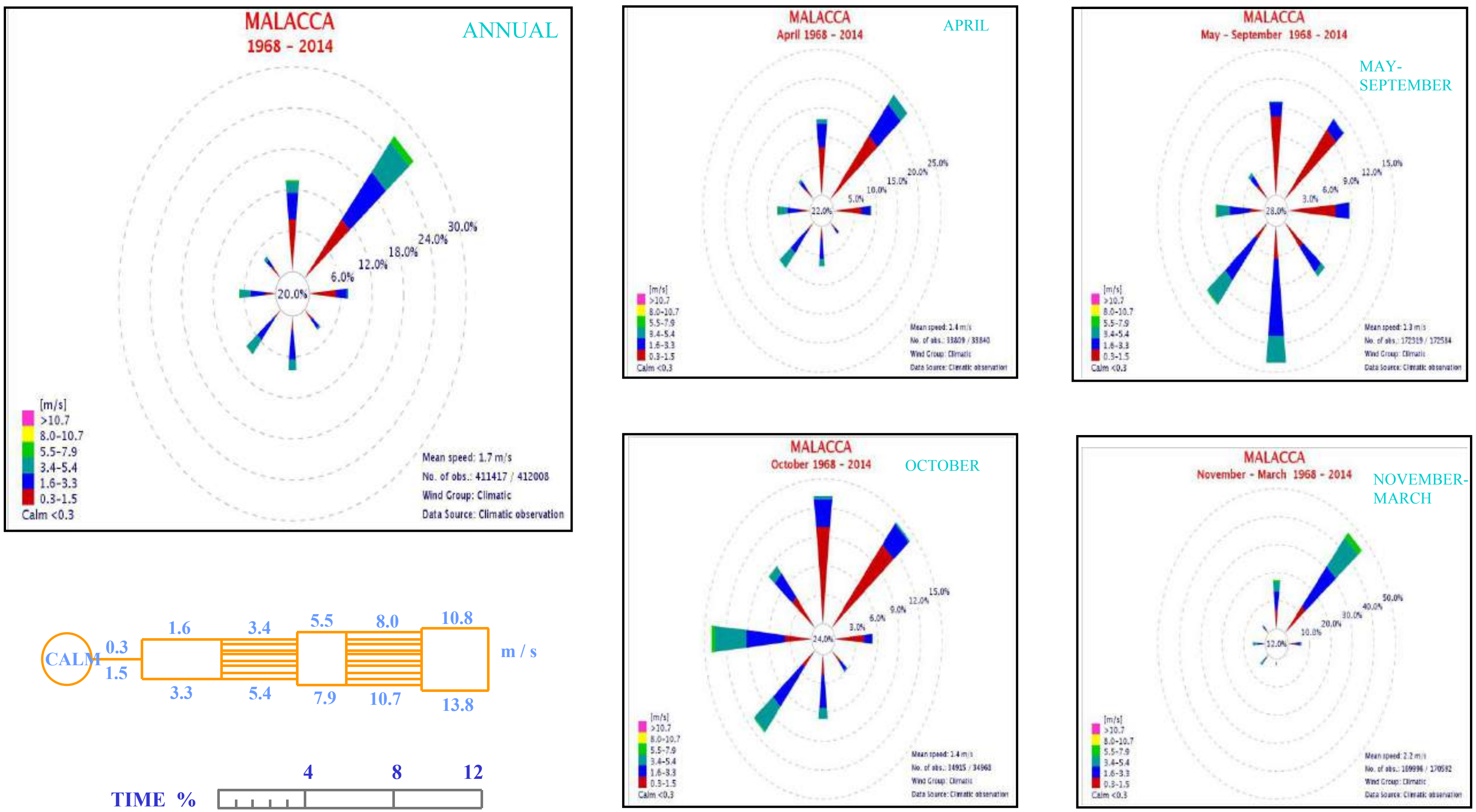
The on-site wind monitoring was conducted on 22nd October 2018 to 27th October 2018 at six (6) sampling locations as shown in **Figure 6.5**. The results of the wind monitoring is summarised in **Figure 6.6.** The full report from the laboratory is attached in **Appendix XII.**

6.4 Coastal Environment

The data for this section is extracted from the approved Hydraulic Study report prepared for this project.

WIND ROSE SUMMARY
M A L A C C A

TIME : 24-HOURS
1968 - 2014



Source : Meteorological Service of Malaysia

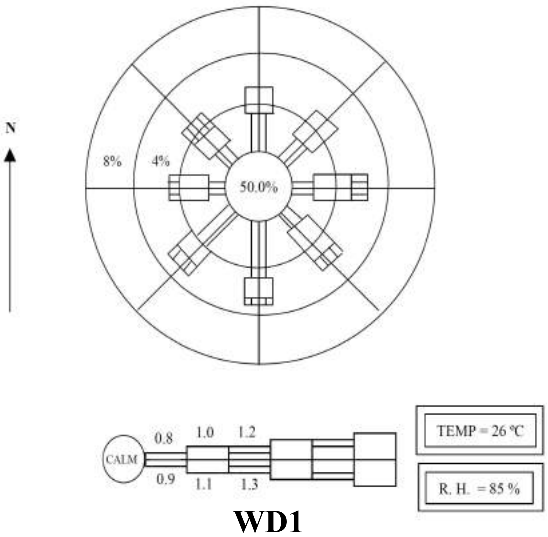
Figure 6.4 : Wind Roses Diagram

Legend

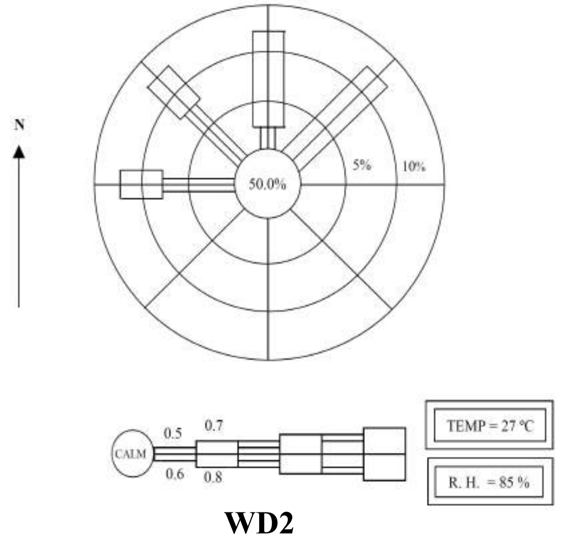
⊗ Wind Direction Sampling Location

Source: iPlan Semenanjung Malaysia

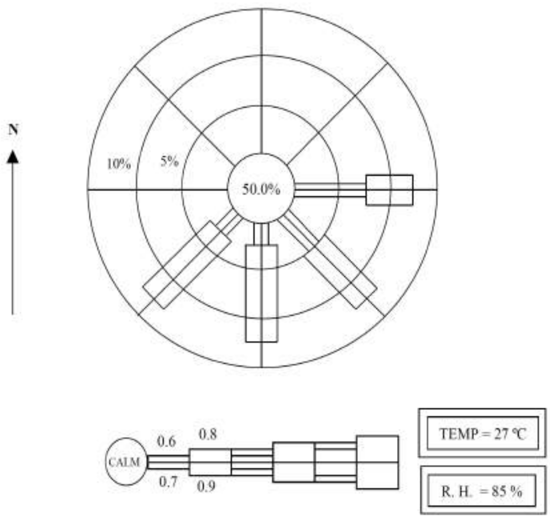
Figure 6.5: Wind Direction Sampling Location



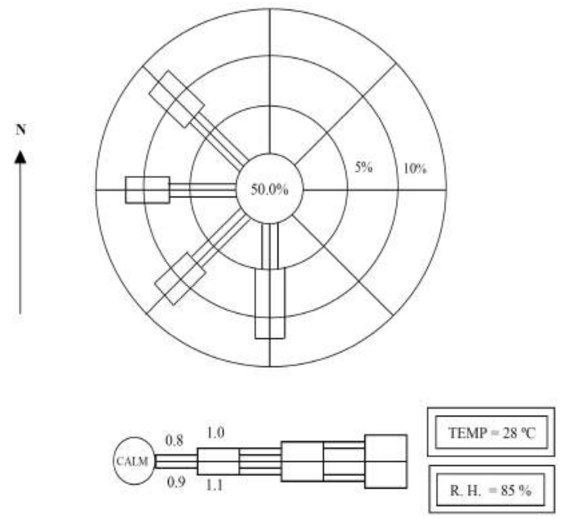
WD1



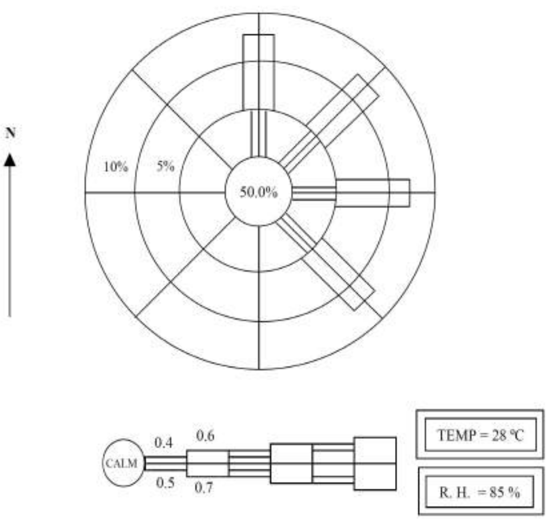
WD2



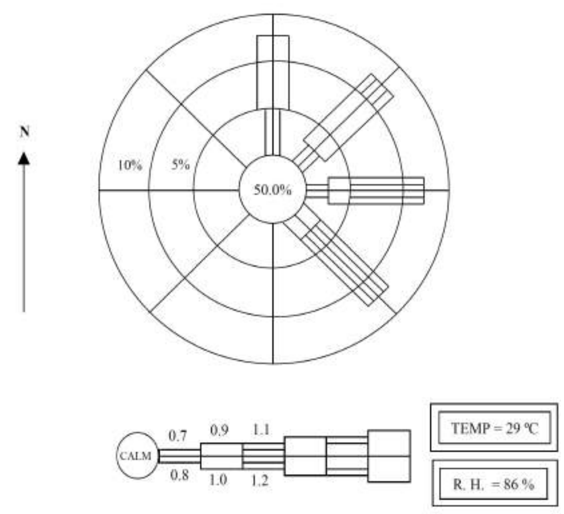
WD3



WD4



WD5



WD6

Figure 6.6: Results of Wind Direction at the Project Site

6.4.1 Bathymetry Survey

The project site is situated at the depth of approximately 0m to 7m. The bathymetry survey is shown in **Appendix XI**.

6.4.2 Wind and Waves

Annual extracted wind and wave data at the project site is illustrated in **Figure 6.7** and **Figure 6.8.** Based on the extracted wind data, two monsoonal scenarios were determined as follows:

a) Northeast monsoon conditions (NE) that represented flows during northeast monsoon periods when wind and tidal currents interacted. This condition has been represented with a local wind of an average of 3.2 m/s blowing as illustrated in **Figure 6.7.**

b) Southwest monsoon conditions (SW) that represented southwest monsoon periods when wind and tidal currents interacted. This condition has been represented with a local wind of an average 2.85 m/s blowing as illustrated in **Figure 6.8**.

The details of the mean annual wind speed and mean annual wave heights is shown in **Table 6.4** and **Table 6.5.**

Table 6.4: Mean Annual Wind Speed

Description	NE	SW
Mean Wind Speed	3.2 m/s	2.85 m/s
Maximum Wind Speed	10 m/s	7.5 m/s
Wind Direction	North West	South

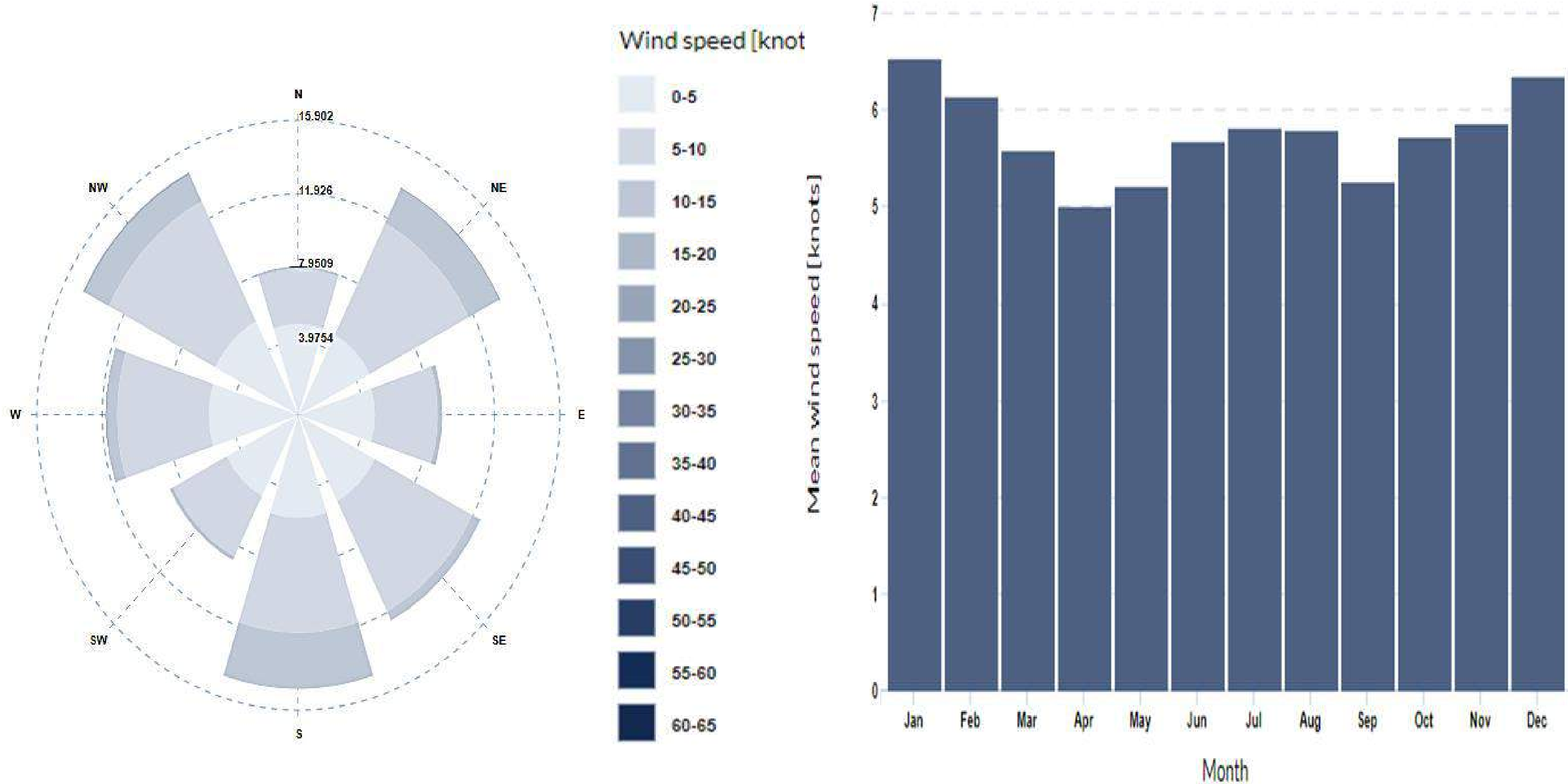
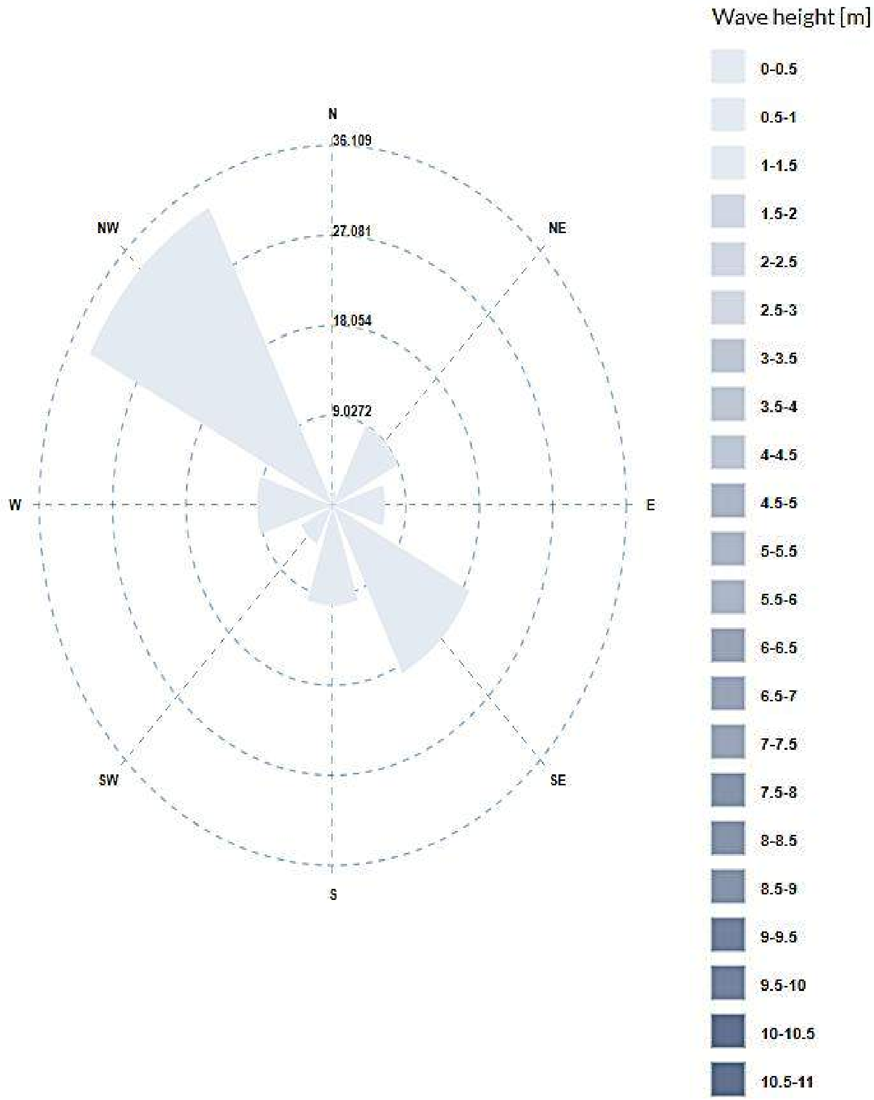


Figure 6.7: Annual Wind Rose Plots at Project Site



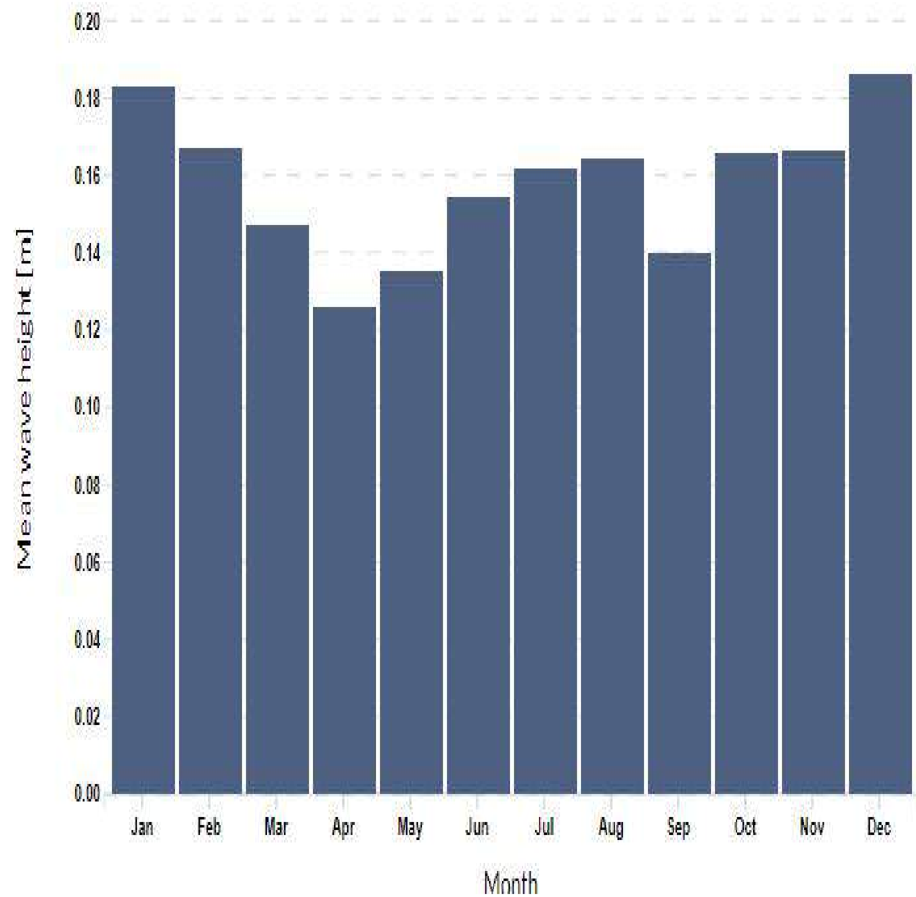


Figure 6.8: Annual Wave Rose Plots at Project Site

Table 6.5: Mean Annual Wave Heights

Description	NE	SW
Mean Wave Height	0.17m	0.14m
Significant Wave Height	0.5 m	0.5 m
Wave Direction	North West	South East

The simulation period of hydrodynamic model includes neap and spring tidal conditions and 1 to 2 days warm-up to avoid any type of instabilities of inaccuracies that could occur during the initial state of the simulations. All scenarios (hydrodynamic and spectral wave) were simulated with the 2D time and domain varying wind fields. Simulation periods for the regional and local hydrodynamic model simulations are illustrated in **Figure 6.9.**

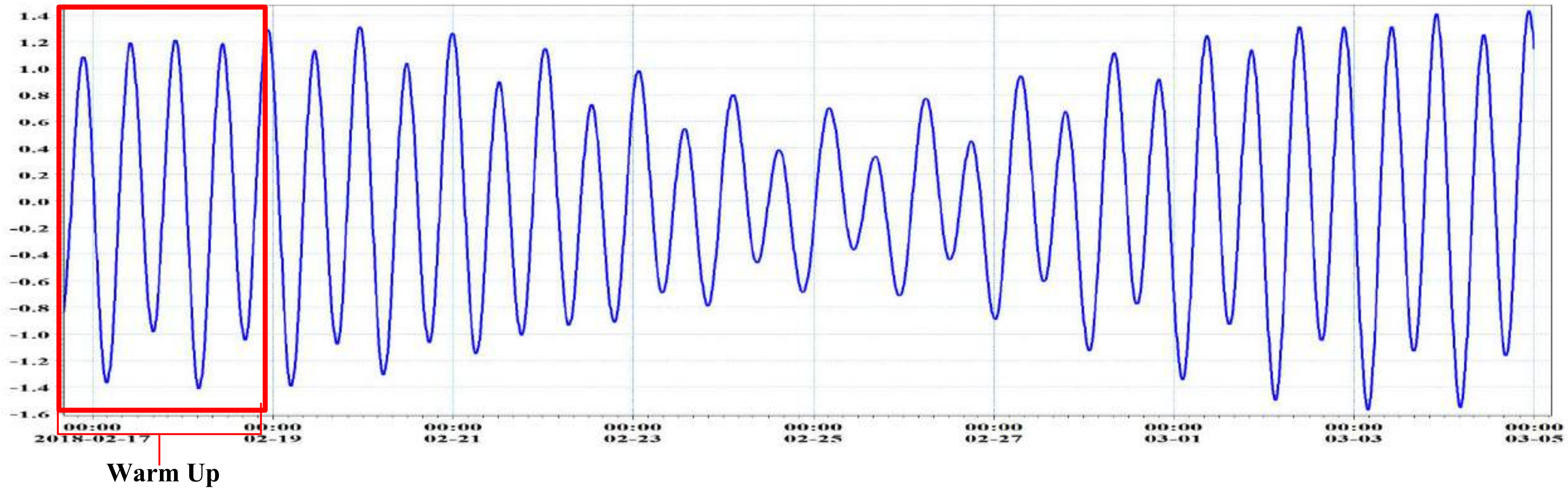
6.4.3 Tides

The tide at the project site is semi-diurnal, i.e. two high water levels and low water levels in a tidal day with comparatively little diurnal inequality. The nearest standard port from the project site is Tanjung Keling. The typical tidal levels published in Tide Tables Malaysia 2017 by National Hydrographic Centre of the Royal Malaysian Navy. Datum differential for Mean Sea Level to Chat Datum is 1.19 meter. All the Datum differential are shown in **Table 6.6.**

Table 6.6: Datum Differential

Tidal Level	Elevation in NGVD (m)	Elevation in CD (m)
Highest Astronomical Tide (HAT)	1.56	2.65
Mean High Water Spring (MHWS)	1.01	2.10
Mean High Water Neap (MHWN)	0.42	1.51
Mean Sea Level (MSL)	0.10	1.19
Land Survey Datum (NGVD)	0.00	1.09
Mean Low Water Neap (MLWN)	-0.21	0.88
Mean Low Water Spring (MLWS)	-0.80	0.29
Lowest Astronomical Tide (Lat)/CD	-1.09	0.00

NE Monsoon Tidal Elevation- (16 February-5 March 2018 – 17days)



SW Monsoon Tidal Elevation (16 February-5 March 2018 – 17days)

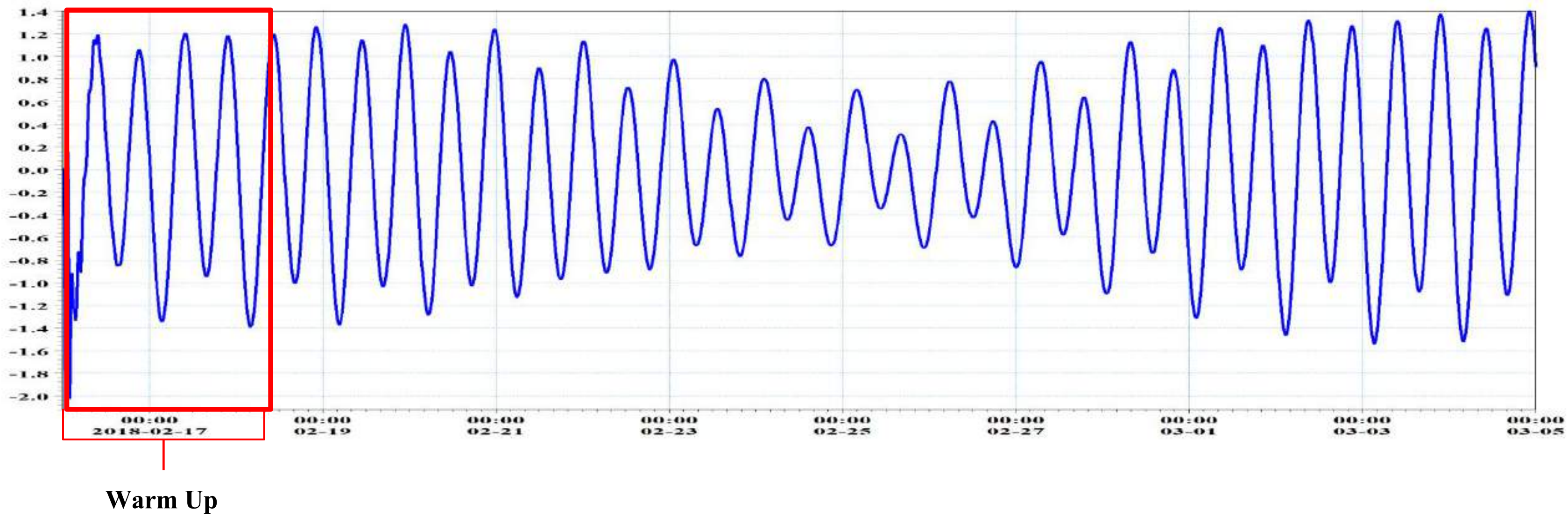


Figure 6.9:Overview of the Tidal Elevation for Simulation Period at Study Area

6.4.4 Current Measurement

The current measurements were performed by two Acoustic Doppler Current Profilers (ADCP) deployed in Station 1 and Station 2 as shown in **Figure 6.10.** The ADCP instrument was used to obtained the data of current speed, current direction and water level.

Figure 6.11 shows the current speed at Station 1 and Station 2. For Station 1, the recorded maximum current speed is around 0.84 m/s, while the maximum current speed in Station 2 has reached up to 0.92 m/s.

Figure 6.12 shows the current direction at Station 1 and Station 2. The current direction recorded shows different variation of direction pattern for spring tide and ebb tide. Station 1 shows current direction of ebb tide at 250º to 320º and flood tide at 70º to 140º. Station 2 shows current direction of ebb tide at 270º to 340º and flood tide at 60º to 130º.

6.4.5 Water Level

Water levels were also measured by using the ADCP. The results of the water level at Station 1 and Station 2 is summarised in **Figure 6.13**.

Based on the **Figure 6.13**, the water level at Station 1 is between -0.96m to 1.14m, while the water level at Station 2 is between -0.99m to 1.14m

6.4.6 Seabed Sediment Sampling

Seabed sampling measurements was taken during the deployment period (15 days) at 30 stations and the stations are well distributed at the location of the proposed reclamation area. **Figure 6.14** and **Table 6.7** shows the location of the sediment collection stations and the grain size distribution around project site. **Figure 6.15** shows the result for spatial analysis of seabed sediment D50, while **Figure 6.16** shows the spatial analysis of seabed sediment composition.

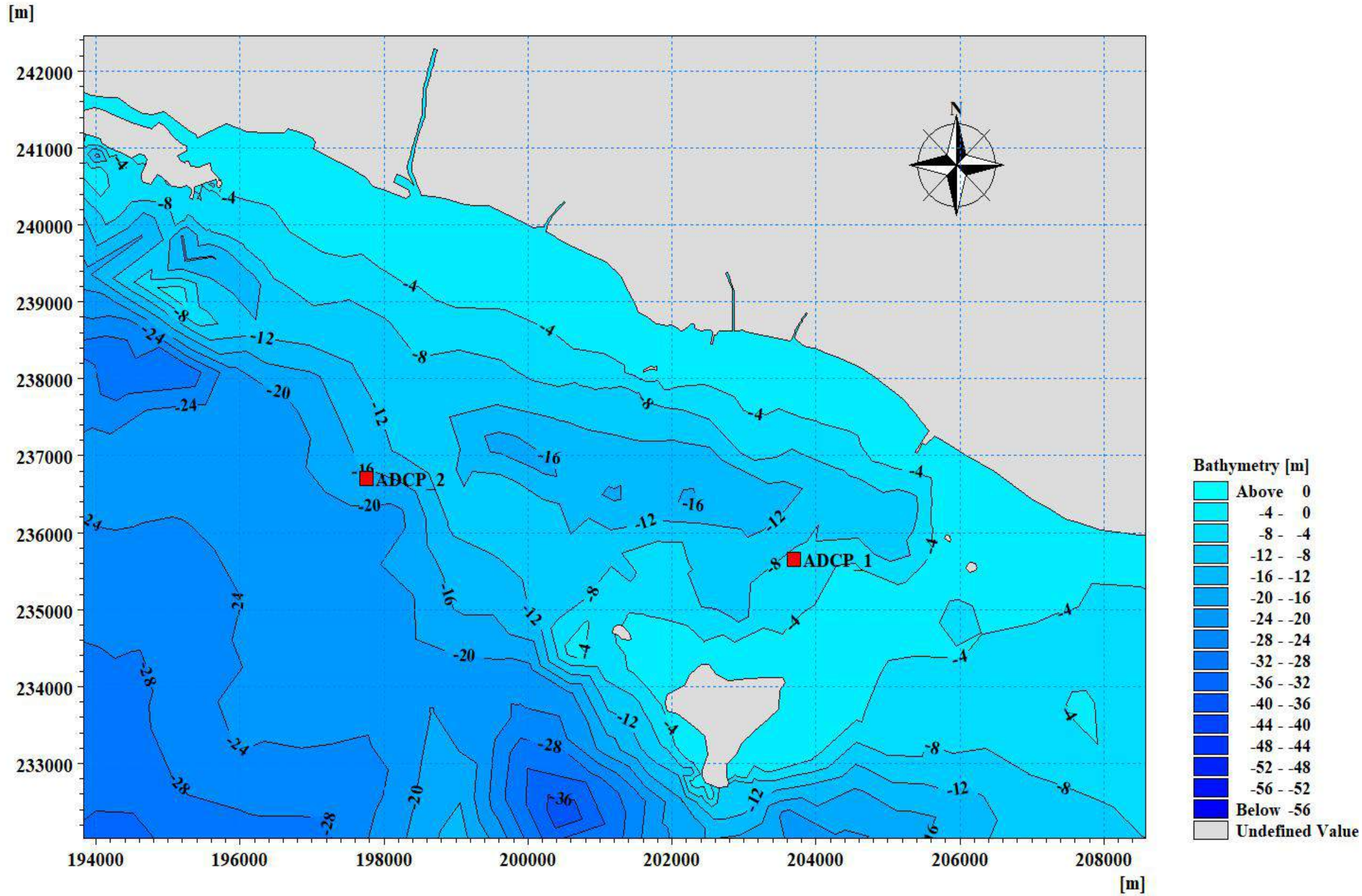


Figure 6.10: Locations of ADCPs Deployment

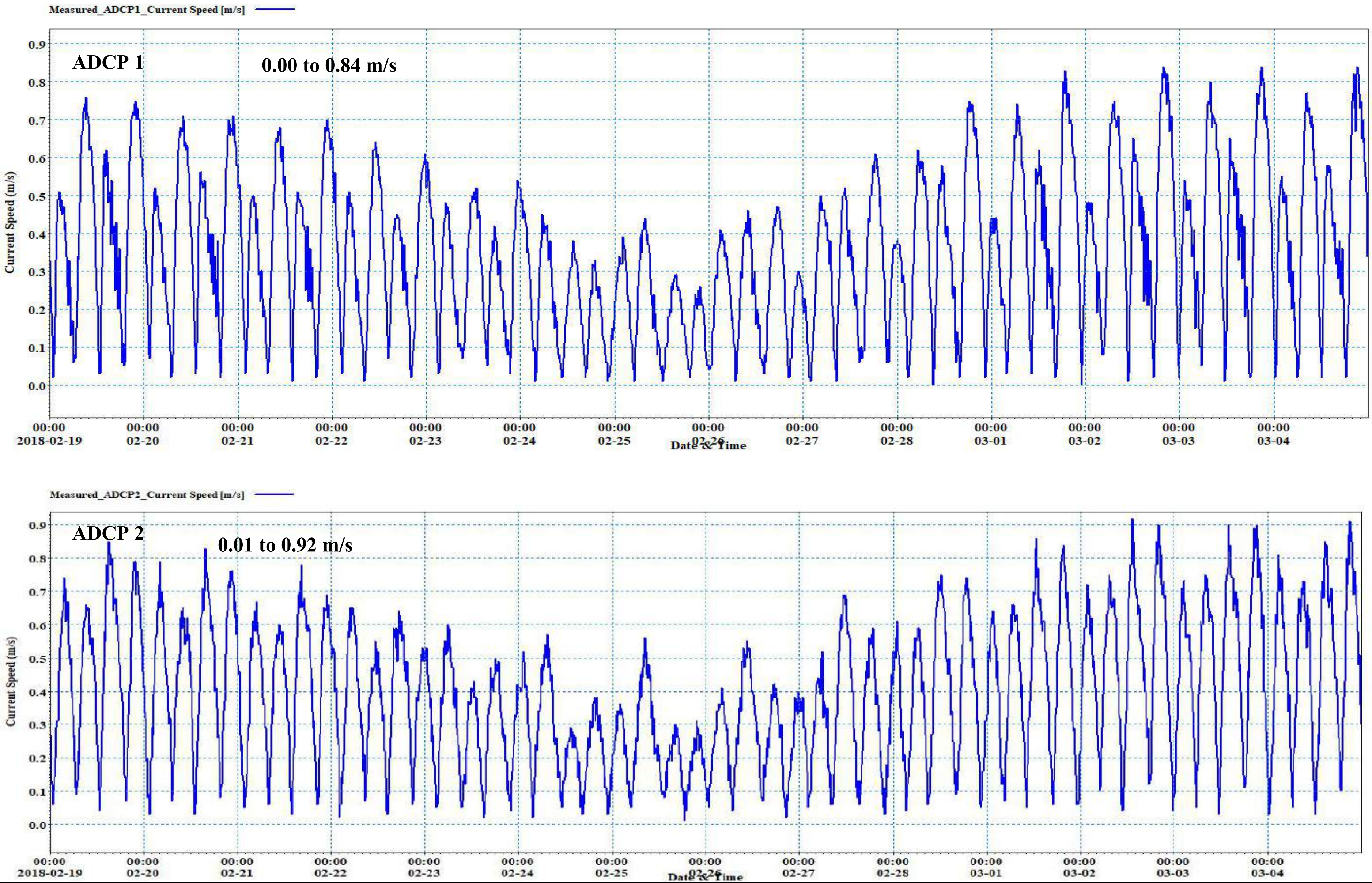


Figure 6.11: Measured Current Speed for Station 1 and Station 2

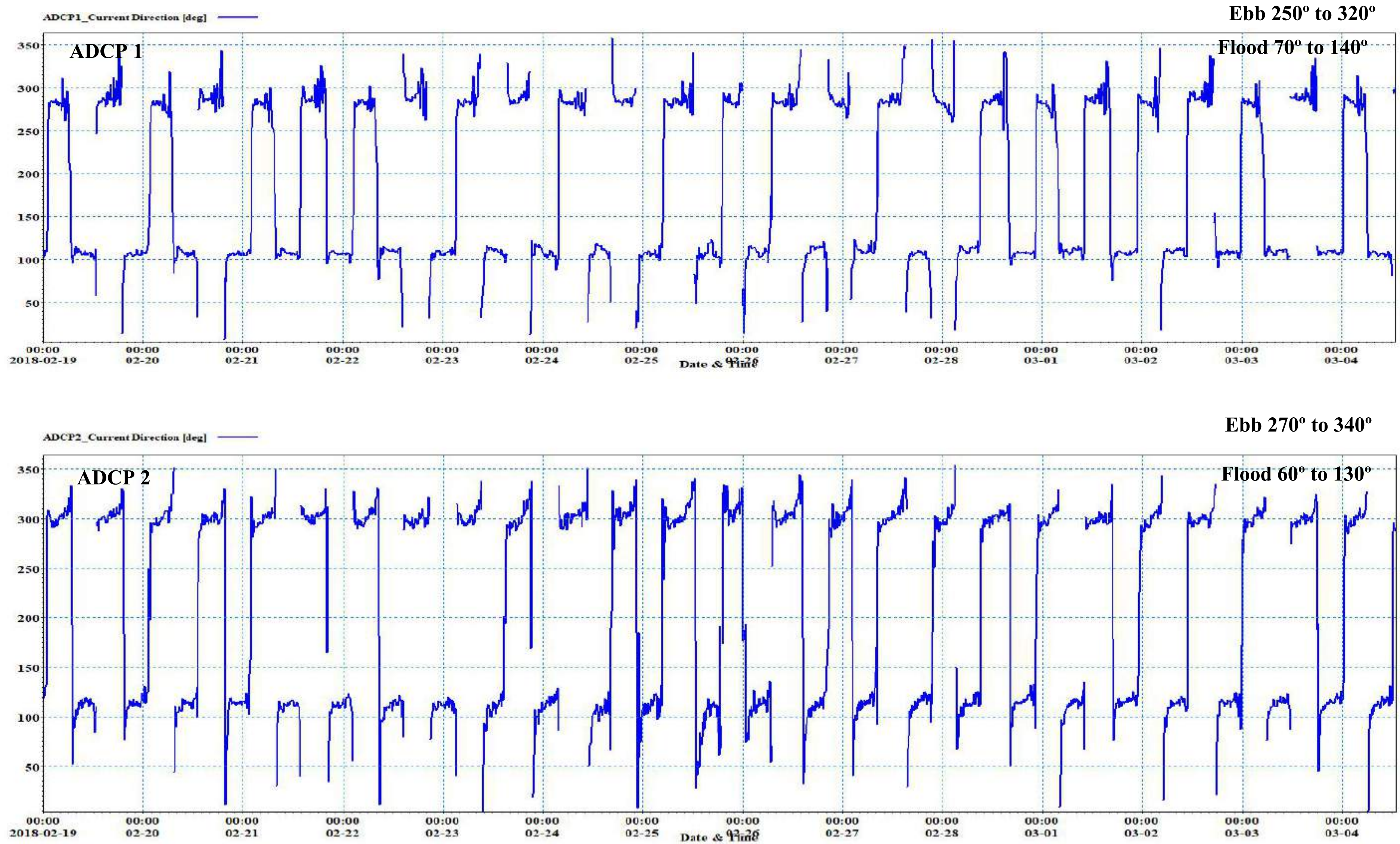
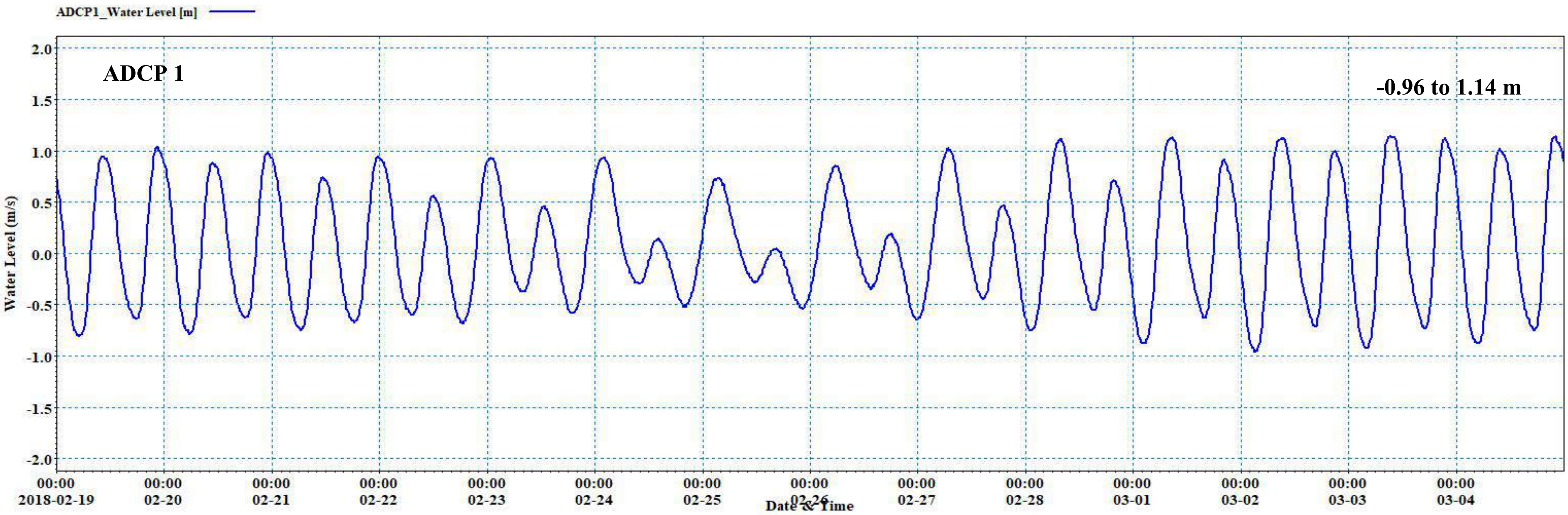


Figure 6.12 : Measured Current Direction for Station 1 and Station 2



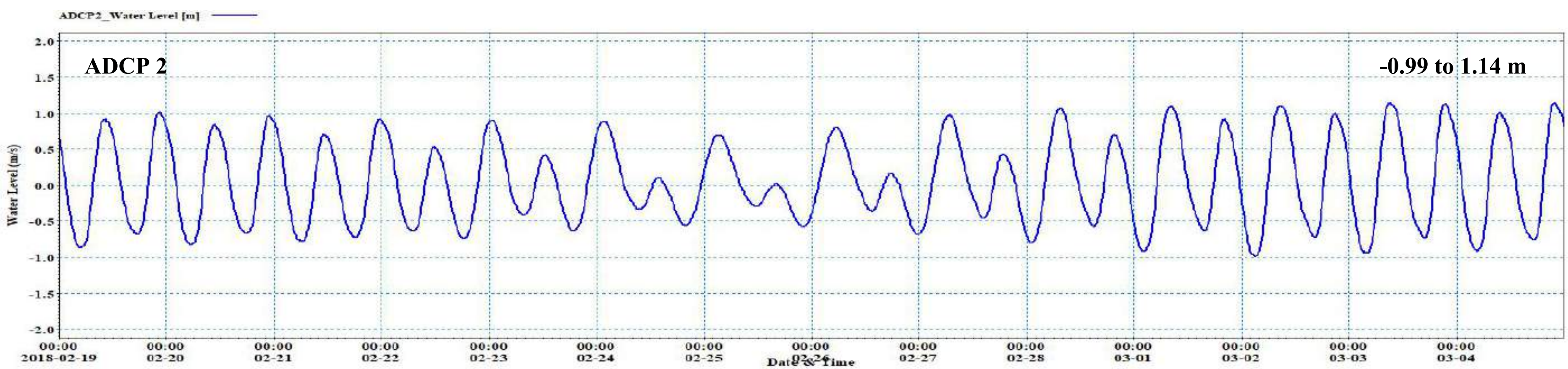


Figure 6.13:Measured Water Level for Station 1 and Station 2

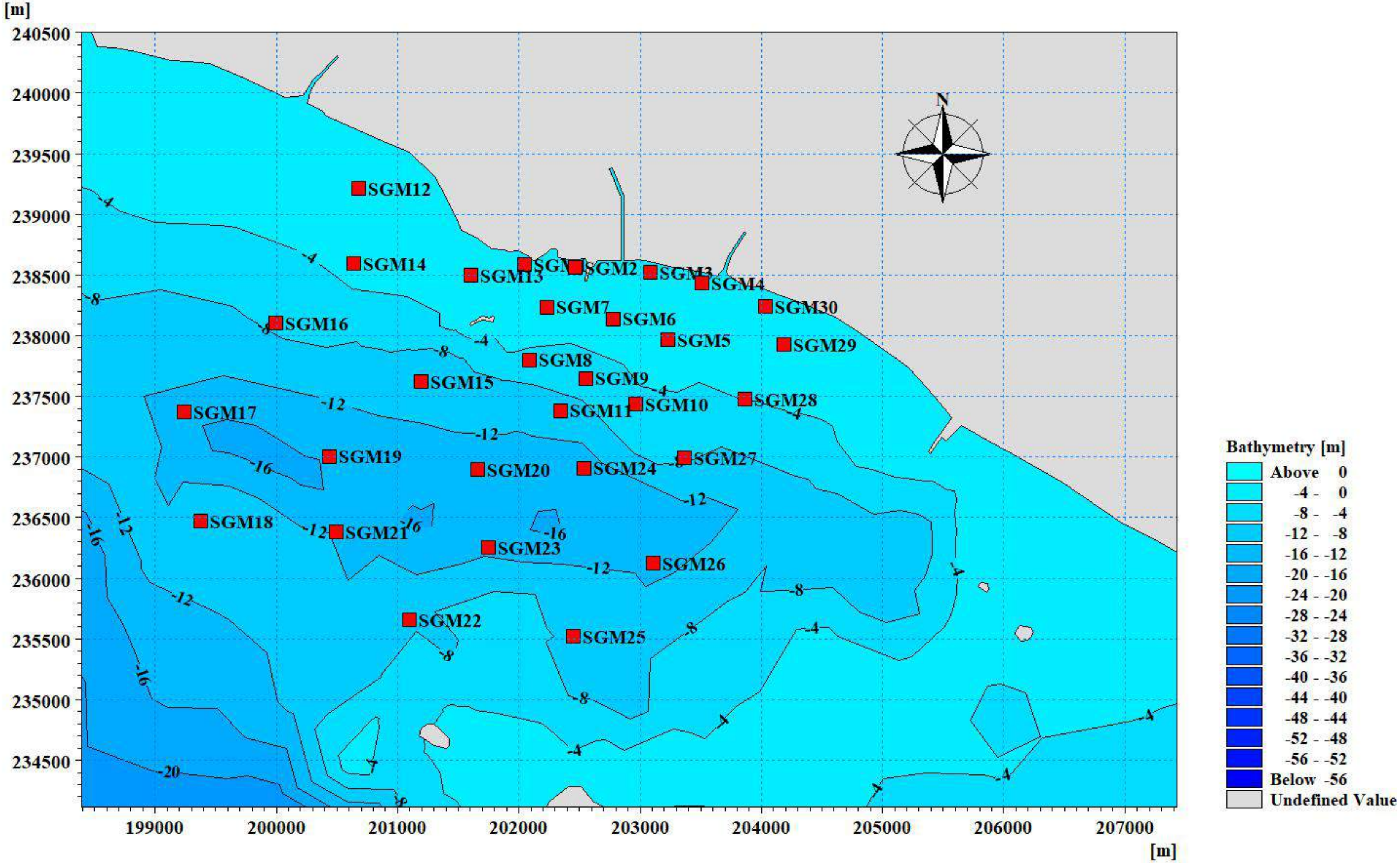


Figure 6.14: Location for Seabed Sediment Collection around Project Area

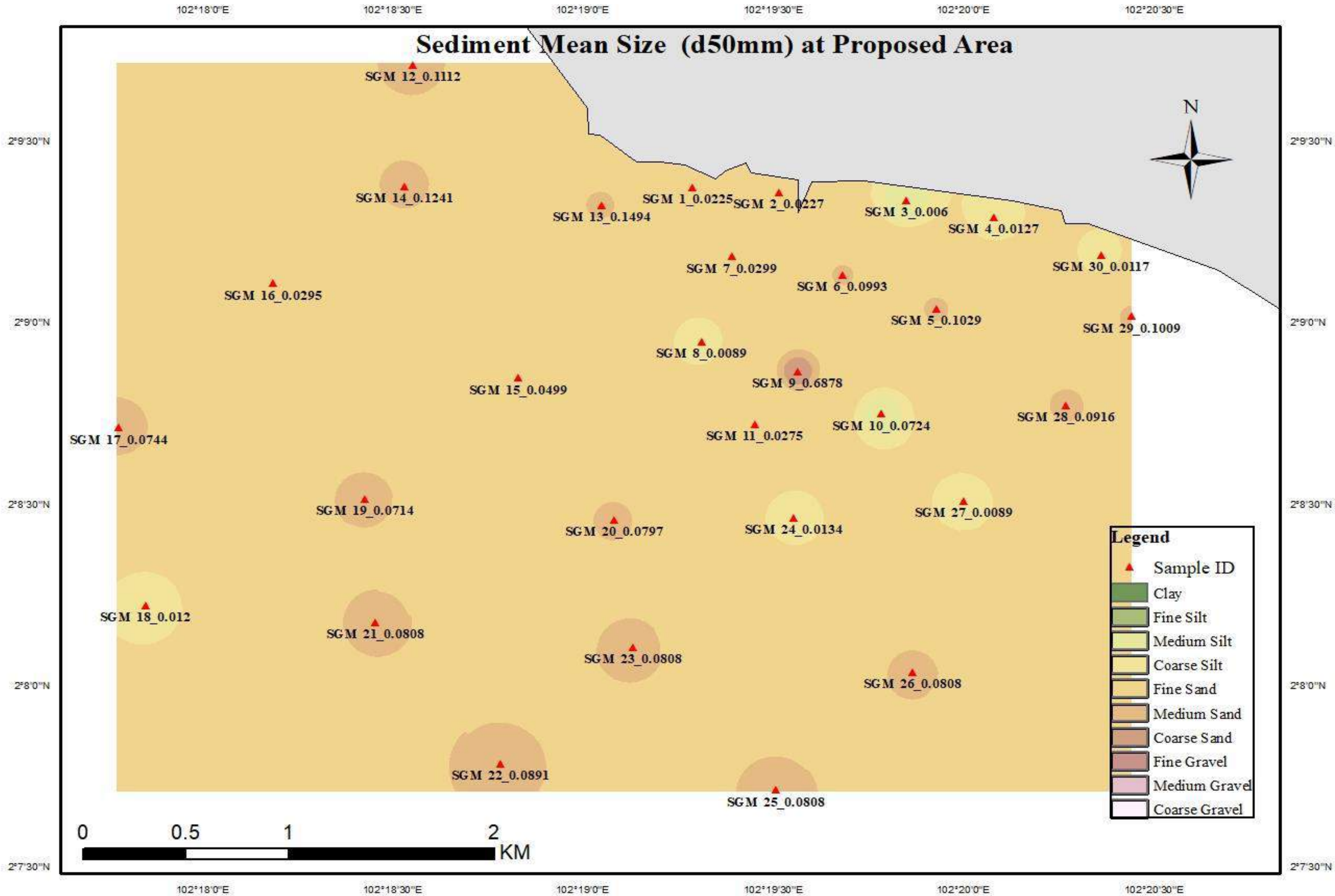


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Figure 6.15: Spatial Analysis of Seabed Sediment D50 Result around Project Area

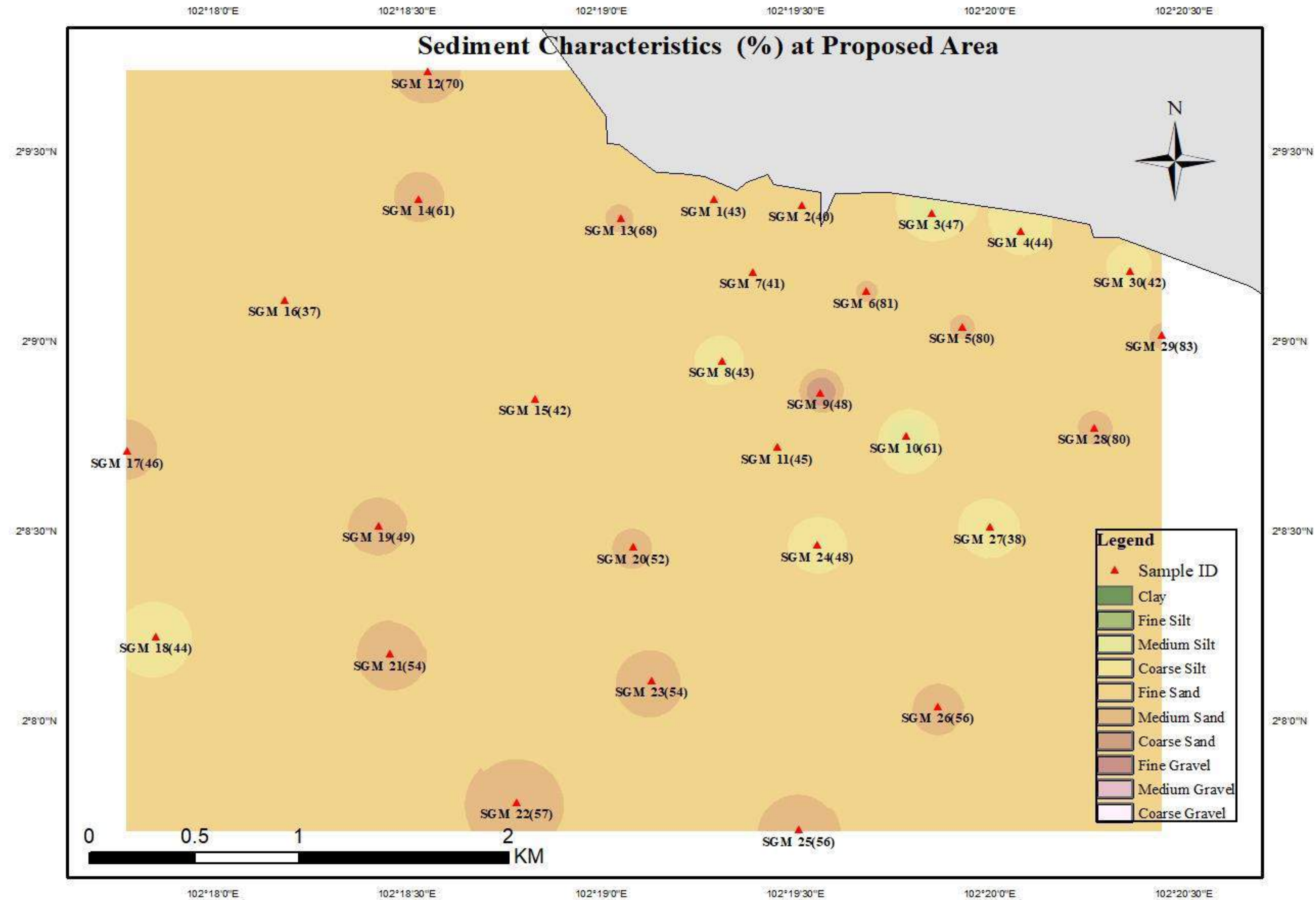

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Figure 6.16: Spatial Analysis of Seabed Sediment Composition around Project Area

Table 6.7: Summary of Particle Size around Proposed Project Area

Sample	Coordinate		Mechanical and Hydrometer Analysis (%)				d50 (mm)	Sediment Characteristics
	Longitude (X)	Latitude (Y)	Clay	Silt	Sand	Gravel		
SGM 1	102.321462	2.156196	25	43	32	0	0.0225	Coarse Silt
SGM 2	102.32524	2.155946	27	40	33	0	0.0227	Coarse Silt
SGM 3	102.330802	2.155594	35	47	18	0	0.0060	Find Silt
SGM 4	102.334653	2.154812	28	44	27	1	0.0127	Medium Silt
SGM 5	102.332126	2.150603	17		80	3	0.1029	Find Silt
SGM 6	102.328034	2.152166	15		81	4	0.0993	Find Silt
SGM 7	102.323159	2.153008	24	41	34	1	0.0299	Coarse Silt
SGM 8	102.321835	2.149099	28	43	27	2	0.0089	Medium Silt
SGM 9	102.326048	2.147716	10	14	48	28	0.6878	Coarse Silt
SGM 10	102.329719	2.145792	13	32	61	4	0.0724	Find Silt
SGM 11	102.324182	2.145311	22	45	33	0	0.0275	Coarse Silt
SGM 12	102.309169	2.161807	7	13	70	10	0.1112	Find Silt
SGM 13	102.317467	2.155355	16		68	16	0.1494	Find Silt
SGM 14	102.308808	2.156225	15		61	24	0.1241	Find Silt
SGM 15	102.313798	2.147434	20	36	42	2	0.0499	Coarse Silt
SGM 16	102.30306	2.151773	26	37	36	1	0.0295	Coarse Silt
SGM 17	102.296288	2.145139	18	28	46	8	0.0744	Find Silt
SGM 18	102.297507	2.136998	27	44	25	4	0.012	Medium Silt
SGM 19	102.307065	2.141873	18	28	49	5	0.0714	Find Silt
SGM 20	102.317995	2.140922	16	28	52	4	0.0797	Find Silt
SGM 21	102.307566	2.136222	15	27	54	4	0.0808	Find Silt
SGM 22	102.313019	2.129712	14	26	57	3	0.0891	Find Silt
SGM 23	102.318818	2.135075	14	28	54	4	0.0808	Find Silt
SGM 24	102.325894	2.14102	25	48	54	3	0.0134	Medium Silt
SGM 25	102.325107	2.128508	12	28	56	4	0.0808	Find Silt
SGM 26	102.331071	2.133934	15	25	56	4	0.0808	Find Silt

Sample	Coordinate		Mechanical and Hydrometer Analysis (%)				d50 (mm)	Sediment Characteristics
	Longitude (X)	Latitude (Y)	Clay	Silt	Sand	Gravel		
SGM 27	102.333345	2.141800	38	36	24	2	0.0089	Medium Silt
SGM 28	102.337797	2.146178	17		80	3	0.0916	Find Silt
SGM 29	102.340706	2.150258	13		83	4	0.1009	Find Silt
SGM 30	102.339345	2.153072	30	42	28	0	0.0117	Medium Silt

6.4.7 Total Suspended Sediment Sampling

Water samples were collected at twenty stations during the survey period shown at **Table 6.8**. Water was sampled at a single depth, which was 0.2D from water depth of water column. A Niskin water sampler was used to collect the samples . The Niskin water sampler was used together with weights to ensure the bottle sampler dropped vertically and a messenger was lowered to trigger the release mechanism. The water sampling locations are shown in **Figure 6.17** and **Table 6.8**. The collected water sample is then stored in 500 ml HDPE bottles which were labelled accordingly and sent to our partner Soil Pro Sdn Bhd for TSS analysis. The result of the TSS shown at **Figure 6.18** with the spatial analysis method.

Table 6.8: Location and the Results of Total Suspended Sediment Sampling

Sample ID	Longitude	Latitude	TSS Result (mg/L)
TSS1	2.15620	102.321	26
TSS2	2.15595	102.325	18
TSS3	2.15559	102.331	58
TSS4	2.15481	102.335	62
TSS5	2.15060	102.332	28
TSS6	2.15301	102.323	28
TSS7	2.14772	102.326	30
TSS8	2.14531	102.324	28
TSS9	2.16181	102.309	20
TSS10	2.15536	102.317	22
TSS11	2.14743	102.314	26
TSS12	2.15177	102.303	22
TSS13	2.14514	102.296	36
TSS14	2.13700	102.298	42
TSS15	2.13508	102.319	14
TSS16	2.12851	102.325	22
TSS17	2.13393	102.331	46
TSS18	2.14180	102.333	30
TSS19	2.14618	102.338	20
TSS20	2.15307	102.339	26

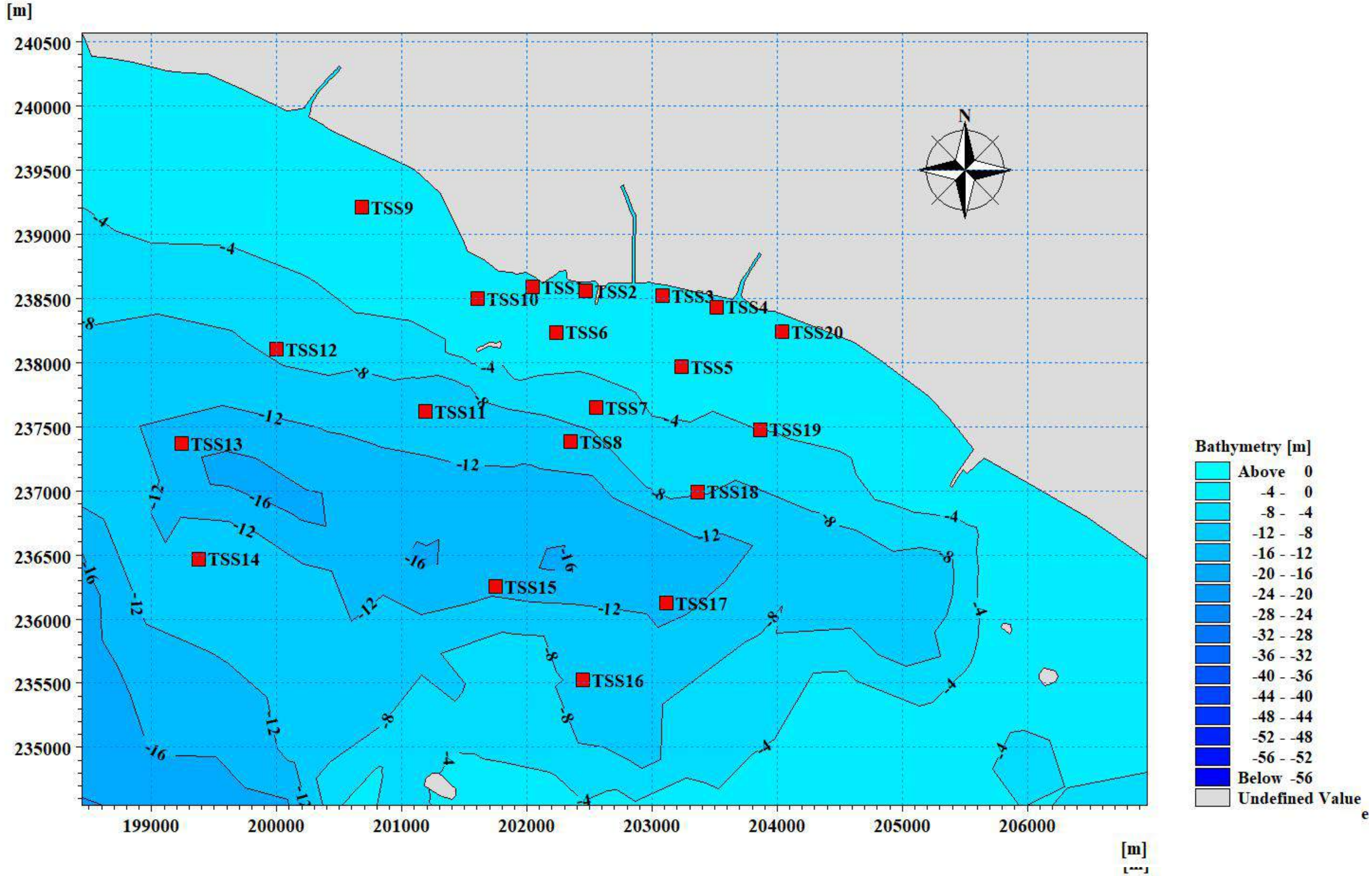

Figure 6.17: Total Suspended Sediment Sampling Points at Project Area

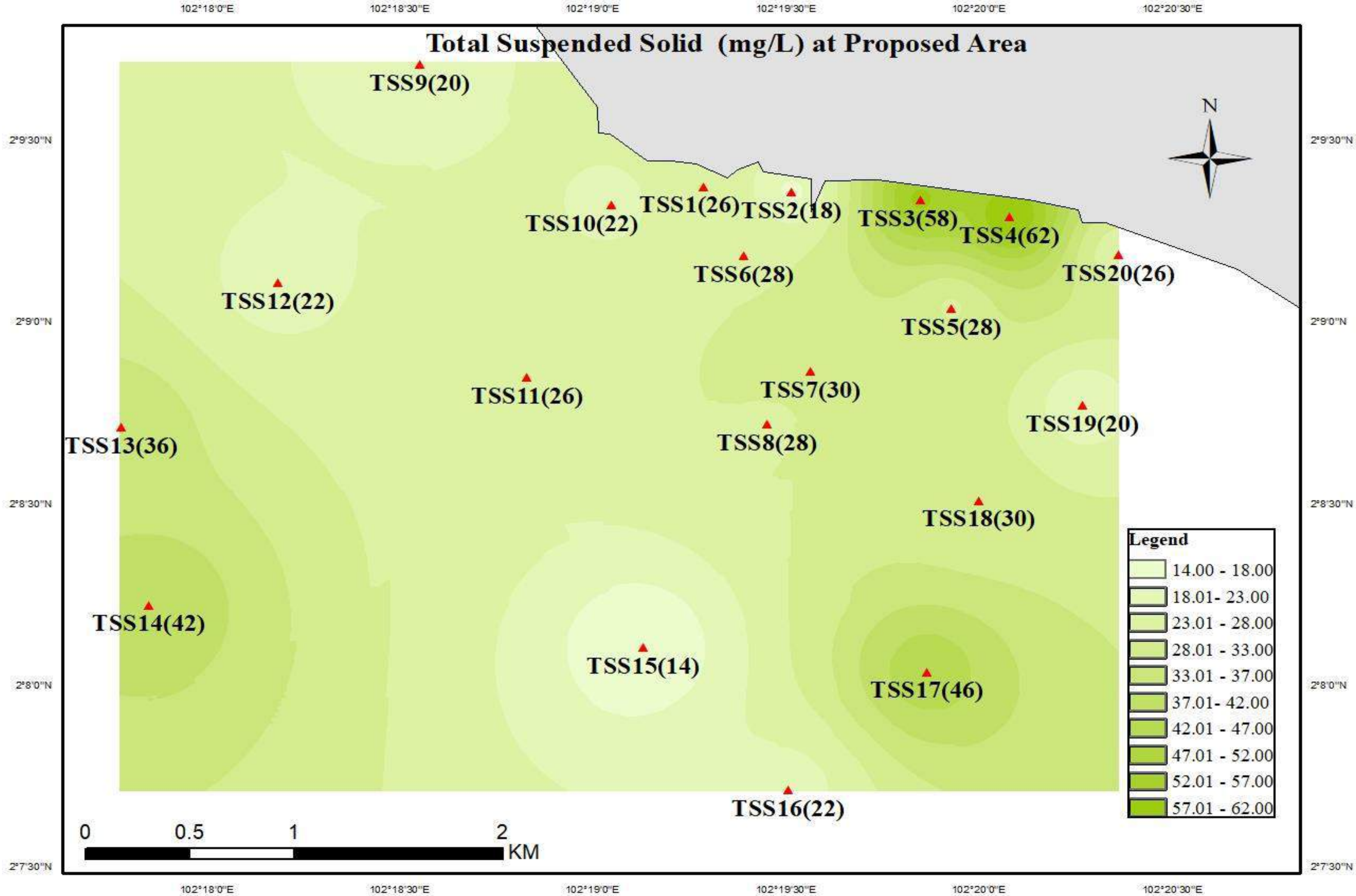

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Figure 6.18: Spatial Analysis of Total Suspended Sediment at Project Area

6.5 Water Quality

Coastal and river field sampling was conducted to collect seawater and river water to determine the existing physico-chemical as well as biological characteristics of the surrounding area of the project site. This sampling and analysis can act as a benchmark / baseline quality to be adhered to in the subsequent monitoring programme.

The field sampling was carried out from 25th to 26th October 2018. A Global Positioning System (GPS) was used to determine the coordinates of the sampling locations. A total of thirteen (13) and six (6) sampling stations was established for seawater and river water monitoring respectively.

The sampling stations for the baseline water quality assessment are described in **Table 6.9** and depicted spatially in **Figure 6.19**. The results of analysis issued by the accredited laboratory are presented in **Table 6.12** and **Table 6.13.**

Table 6.9 : Description of Baseline Sampling Points

Station Site	Description	Coordinates
Seawater		
WM1	Within 3km radius to the northwest of the project site, fronting estuary of Sg. Punggor	N 2°10'01.4" E 102°18'14.2"
WM2	Within 2km radius to the northwest of the project site, offshore of Taman Permatang Pasir Permai	N 2°09'49.1" E 102°18'42.4"
WM3	Within 1km radius to the northwest of the project site, offshore of Sekolah Henry Gurney	N 2°09'29.9" E 102°19'02.5"
WM4	Within 1km radius to the west of the project site, adjacent to Pulau Menatang	N 2°08'53.0" E 102°19'12.6"
WM5	Within 2km radius to the southwest of the project site	N 2°08'31.4" E 102°18'35.5"
WM6	Within 1km radius to the northeast of the project site, fronting estuary of Sg Umbai	N 2°09'07.4" E 102°20'05.8"
WM7	Within 1km radius to the southeast of the project site	N 2°08'44.1" E 102°20'08.6"
WM8	Within 2km radius to the southeast of the project site	N 2°07'52.9"

Legend

(magenta circle)	Marine Water Quality Sampling Station
(green circle)	River Water Quality Sampling Station

Figure 6.19: Baseline Water Quality Monitoring Stations

Station Site	Description	Coordinates
		E 102°20'31.9"
WM9	Within 3km radius to the south of the project site	N 2°07'47.3" E 102°19'30.8"
WM10	Within 4km radius to the south of the project site, offshore of Pulau Besar and adjacent to Pulau Serimbun	N 2°07'03.9" E 102°19'32.0"
WM11	Within 2km radius to the east of the project site, offshore of Umbai	N 2°08'56.1" E 102°20'34.6"
WM12	Within 3km radius to the east of the project site, adjacent to Anjung Batu Jetty	N 2°08'27.0" E 102°21'22.3"
WM13	Within 4km radius to the southeast of the project site, adjacent to Pulau Burong	N 2°07'56.1" E 102°21'31.5"
River Water		
WR1	Upper segment of Sg. Punggor	N 2°10'19.5" E 102°18'29.0"
WR2	Estuary of Sg. Punggor	N 2°10'16.0" E 102°18'24.3"
WR3	Outlet of Parit I.S.K.K.	N 2°09'34.0" E 102°19'02.0"
WR4	Existing earth drain crossing Kg. Pernu	N 2°09'31.0" E 102°19'43.5"
WR5	Estuary of Sg. Umbai	N 2°09'22.4" E 102°20'11.1"
WR6	Upper segment of Sg. Umbai	N 2°09'27.4" E 102°20'14.5"

6.5.1 Water Sampling Methodology

6.5.1.1 Seawater Quality

Seawater samples were collected using grab sampling method at one (1) to three (3) depths according to the bathymetry pattern of the seabed during low tide and high tide (refer **Table 6.12**). The data obtained were generally compared with Class 3 of the Malaysian Marine Water Quality Standards (MMWQS) as the marine water is exposed to direct discharge of effluent from anthropogenic activities. At the estuary of Sg Punggor and Sg Umbai, samples were compared with Class E1 of the Malaysian Marine Water Quality Standards (MMWQS) representing estuary type of coastal plain. Parameters tested for seawater quality is given in **Table 6.11**.

6.5.1.2 Stream Water Quality

River water samples at Sg Punggor (WR1) and Sg Umbai (WR6) were collected during low tide and high tide. While single grab sampling of surface water samples were carried out at the outlet of Parit I.S.K.K (WR3) and earth drain crossing Kg Pernu (WR4) (refer **Table 6.10**). The results were compared with Class III of the National Water Quality Standard (NWQS). Parameters tested for river and surface water quality is given in **Table 6.11.**

Table 6.10: Details of Water Quality Sampling

Sampling Location	Details of Sampling
Seawater	
WM1	1 depth (0-0.3m) during high tide and low tide respectively
WM2	1 depth (0-0.3m) during high tide and low tide respectively
WM3	1 depth (0-0.3m) during high tide and low tide respectively
WM4	3 depths (0-0.3m, 1m & 5m) during high tide and low tide respectively
WM5	3 depths (0-0.3m, 1m & 5m) during high tide and low tide respectively
WM6	1 depth (0-0.3m) during high tide and low tide respectively
WM7	3 depths (0-0.3m, 1m & 5m) during high tide and low tide respectively
WM8	3 depths (0-0.3m, 1m & 5m) during high tide and low tide respectively
WM9	3 depths (0-0.3m, 1m & 5m) during high tide and low tide respectively
WM10	1 depth (0-0.3m) during high tide and low tide respectively
WM11	1 depth (0-0.3m) during high tide and low tide respectively
WM12	1 depth (0-0.3m) during high tide and low tide respectively
WM13	1 depth (0-0.3m) during high tide and low tide respectively
Stream Water	
WR1	1 sample during high tide and low tide respectively
WR2	1 sample during high tide and low tide respectively
WR3	1 sample
WR4	1 sample
WR5	1 sample during high tide and low tide respectively
WR6	1 sample during high tide and low tide respectively

Table 6.11: Parameters Tested for Water Quality

Test Parameters	Test Method
Seawater	
Physical characteristics (pH, temperature, salinity, dissolved oxygen (DO), conductivity and turbidity)	In-situ measurement
Total Suspended Solids (TSS)	APHA 2540 D
Cadmium (Cd)	APHA 3111 B
Chromium VI (Cr^{6+})	APHA 3500-Cr D
Arsenic (As)	APHA 3114 C
Copper (Cu), Lead (Pb) and Zinc (Zn)	APHA 3120 B
Mercury (Hg)	APHA 3112 B
Cyanide (CN)	OSRMA P.456
Ammonia (unionized) (NH_3)	APHA 4500-NH3 B & F
Nitrite (NO_2)	APHA 4500 NO2 H
Nitrate (NO_3)	APHA 4500 NO3 H
Phosphate (PO_4)	APHA 4500 P F
Phenol	APHA 5530 B, C
Oil and grease	APHA 5520 B
Faecal Coliform count	In-House Method-Micro-02 (Based on
Tributyltin	APHA 9222 G
Polycyclic Aromatic Hydrocarbon (PAHs)	USEPA SW846 Jan 1998 or equivalent
Stream Water	
Physical characteristics (pH, temperature, salinity, dissolved oxygen (DO), conductivity and turbidity)	In-situ measurement
Total Suspended Solids (TSS)	APHA 2540 D
BOD_5	APHA 5210 B/APHA 4500-O G
COD	APHA 5220 C
Cadmium (Cd)	APHA 3111 B
Chromium VI (Cr^{6+})	APHA 3500-Cr D
Arsenic (As)	APHA 3114 C
Copper (Cu), Lead (Pb) and Zinc (Zn)	APHA 3120 B
Mercury (Hg)	APHA 3112 B
Cyanide (CN)	OSRMA P.456
Ammoniacal Nitrogen (NH_3-N)	APHA 4500-NH3 B & F
Nitrite (NO_2)	APHA 4500 NO2 H
Nitrate (NO_3)	APHA 4500 NO3 H
Phosphorus (PO_4)	APHA 4500 P F
Oil and grease	APHA 5520 B
Faecal Coliform count	In-House Method-Micro-02

6.5.2 Baseline Water Quality Result

Baseline water quality result are tabulated in **Table 6.12** and **Table 6.13**. The certificates of analysis by accredited laboratory are given in **Appendix XI.**

Water Quality Indices (WQI) for seawater and river water were calculated using formulas below:

Seawater

The formula used in the calculation of Marine Water Quality Index (MWQI) is:

The formula used in the calculation of Malaysian Marine Water Quality Index (MMWQI) is:

$$MMWQI = qi\ DO^{0.18} \times qi\ FC^{0.19} \times qi\ NH_3^{0.15} \times qi\ NO_3^{0.16} \times qi\ PO_4^{0.17} \times qi\ TSS^{0.15}$$

where

qi	-	The subindex of each parameter
DO	-	Dissolved Oxygen
FC	-	Faecal Coliform
NH_3	-	Ammonia (Unionized)
NO_3	-	Nitrate
PO_4	-	Phosphate
TSS	-	Total Suspended Solid

River Water

The formula used in the calculation of the River Water Quality Index (WQI) is:

WQI = 0.22*SI DO + 0.19*SI BOD + 0.16*SI COD + 0.15*SI AN + 0.16*SI SS + 0.12*SI pH

Where,

SI - The subindex of each parameter
DO - Dissolved Oxygen
BOD - Biological Oxygen Demand

COD - Chemical Oxygen Demand

AN - Ammoniacal Nitrogen

SS - Suspended Solid

PH - Acidity/ Alkalinity

Table 6.12: Baseline Seawater Quality Results

Parameter	Unit	WM1		WM2		WM3		Class 3
		Low Tide	Low Tide	High Tide	High Tide	Low Tide	High Tide	
Depth		-	-	-	-	-	-	-
Time of Collection	-	5.39 pm	10.05 am	5.57 pm	10.15 am	6.11 pm	9.45 am	-
pH	-	7.0	6.8	7.1	7.3	7.2	7.4	6.5 – 9.0
Temperature	°C	28	28	28	28	28	28	≤2° increase*
Dissolved Oxygen	mg/l	7.9	8.0	7.8	7.8	7.8	8.0	>3.0
Conductivity	µS/cm	23.5	20.2	19.6	19.3	20.3	19.8	-
Salinity	ppt	29.0	25.1	25.1	18.3	25.1	18.3	-
Total Suspended Solids	mg/l	13	14	15	13	12	10	100
Oil & Grease	mg/l	ND	ND	ND	ND	ND	ND	5
Cyanide as CN	µg/l	ND	ND	ND	ND	ND	ND	14
Ammonia as NH_3	µg/l	ND (<10)	ND (<10)	ND (<10)	ND (<10)	ND (<10)	ND (<10)	320
Nitrite as NO_2	µg/l	45	10	43	14	47	15	-
Nitrate as NO_3	µg/l	200	430	280	360	250	410	700
Phosphate as PO_4	µg/l	**700**	**1,100**	**1,200**	**1,400**	**900**	**1,100**	670
Phenol	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	100
Mercury as Hg	µg/l	ND	ND	ND	ND	ND	ND	0.04
Cadmium as Cd	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	3
Chromium, Hexavalent as Cr^{6+}	µg/l	ND	ND	ND	ND	ND	ND	20
Copper as Cu	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	8
Arsenic as As	µg/l	ND (<10)	ND (<10)	ND (<10)	ND (<10)	ND (<10)	ND (<10)	3
Lead as Pb	µg/l	ND (<6)	ND (<6)	ND (<6)	ND (<6)	ND (<6)	ND (<6)	12
Zinc as Zn	µg/l	26	10	ND (<4)	ND (<4)	ND (<4)	ND (<4)	100
Tributyltin (TBT)	µg/l	ND	ND	ND	ND	ND	ND	0.05
Faecal Coliform count 70	MPN/100ml	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	70
Total Dissolved Solid 50	mg/l	15,050	12,900	12,500	12,350	13,000	12,700	-
Polyaromatic Hydrocarbon	µg/l	ND	ND	ND	ND	ND	ND	1000
Marine Water Quality Index	**-**	**75**	**63**	**64**	**64**	**69**	**64**	**-**
Water Quality Class	**-**	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**-**

Parameter	**Unit**	**WM4**						**Class 3**
		Low Tide	**High Tide**	**Low Tide**	**High Tide**	**Low Tide**	**High Tide**	
Depth		1 m	1 m	4 m	4 m	8 m	8 m	-
Time of Collection	-	4.14 pm	10.10 am	***	10.21 am	***	10.37 am	-
pH	-	7.6	7.7	***	7.8	***	7.9	6.5 – 9.0
Temperature	°C	28	28	***	28	***	28	≤2° increase*
Dissolved Oxygen	mg/l	7.5	7.6	***	7.4	***	7.5	>3.0
Conductivity	µS/cm	24.0	24.7	***	24.3	***	24.2	-
Salinity	ppt	30.4	30.4	***	30.4	***	30.4	-
Total Suspended Solids	mg/l	10	6	***	8	***	6	100
Oil & Grease	mg/l	ND	ND	***	ND	***	ND	5
Cyanide as CN	µg/l	ND	ND	***	ND	***	ND	14
Ammonia as NH_3	µg/l	ND (<10)	ND (<10)	***	ND (<10)	***	ND (<10)	320
Nitrite as NO_2	µg/l	24	72	***	49	***	34	-
Nitrate as NO_3	µg/l	180	120	***	110	***	140	700
Phosphate as PO_4	µg/l	**800**	**1,000**	***	200	***	400	670
Phenol	µg/l	ND (<1)	ND (<1)	***	ND (<1)	***	ND (<1)	100
Mercury as Hg	µg/l	ND	ND	***	ND	***	ND	0.04
Cadmium as Cd	µg/l	ND (<1)	ND (<1)	***	ND (<1)	***	ND (<1)	3
Chromium, Hexavalent as Cr^{6+}	µg/l	ND	ND	***	ND	***	ND	20
Copper as Cu	µg/l	ND (<1)	ND (<1)	***	ND (<1)	***	ND (<1)	8
Arsenic as As	µg/l	ND (<10)	ND (<10)	***	ND (<10)	***	ND (<10)	3
Lead as Pb	µg/l	ND (<6)	ND (<6)	***	ND (<6)	***	ND (<6)	12
Zinc as Zn	µg/l	ND (<4)	ND (<4)	***	ND (<4)	***	ND (<4)	100
Tributyltin (TBT)	µg/l	ND	ND	***	ND	***	ND	0.05
Faecal Coliform count	MPN/100ml	<1.8	<1.8	***	<1.8	***	<1.8	70
Total Dissolved Solid	mg/l	15,350	15,800	***	15,550	***	15,500	-
Polyaromatic Hydrocarbon	µg/l	ND	ND	***	ND	***	ND	1000
Marine Water Quality Index	**-**	**73**	**93**	**-**	**90**	**-**	**84**	**-**
Water Quality Class	**-**	**Moderate**	**Excellent**	**-**	**Good**	**-**	**Good**	**-**

Parameter	Unit	WM5						Class 3
		Low Tide	**High Tide**	**Low Tide**	**High Tide**	**Low Tide**	**High Tide**	
Depth		1 m	1 m	5 m	8 m	10 m	16 m	-
Time of Collection	-	4.24 pm	10.44 am	4.31 pm	10.52 am	4.39 pm	11.00 am	-
pH	-	7.8	7.9	8.3	7.8	8.1	6.5	6.5 – 9.0
Temperature	°C	28	28	28	28	28	28	≤2° increase*
Dissolved Oxygen	mg/l	7.6	7.6	7.2	7.4	7.4	7.5	>3.0
Conductivity	µS/cm	24.8	24.6	24.8	24.3	24.9	24.2	-
Salinity	ppt	29.0	24.6	30.4	28.9	24.9	28.9	-
Total Suspended Solids	mg/l	4	5	3	3	2	3	100
Oil & Grease	mg/l	ND	ND	ND	ND	ND	ND	5
Cyanide as CN	µg/l	ND	ND	ND	ND	ND	ND	14
Ammonia as NH_3	µg/l	ND (<10)	ND (<10)	ND (<10)	ND (<10)	ND (<10)	ND (<10)	320
Nitrite as NO_2	µg/l	28	65	35	70	14	42	-
Nitrate as NO_3	µg/l	120	130	100	130	110	130	700
Phosphate as PO_4	µg/l	**1,000**	600	500	600	600	**1,000**	670
Phenol	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	100
Mercury as Hg	µg/l	ND	ND	ND	ND	ND	ND	0.04
Cadmium as Cd	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	3
Chromium, Hexavalent as Cr^{6+}	µg/l	ND	ND	ND	ND	ND	ND	20
Copper as Cu	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	8
Arsenic as As	µg/l	ND (<10)	ND (<10)	ND (<10)	ND (<10)	ND (<10)	ND (<10)	3
Lead as Pb	µg/l	ND (<6)	ND (<6)	ND (<6)	ND (<6)	ND (<6)	ND (<6)	12
Zinc as Zn	µg/l	ND (<4)	ND (<4)	ND (<4)	ND (<4)	ND (<4)	ND (<4)	100
Tributyltin (TBT)	µg/l	ND	ND	ND	ND	ND	ND	0.05
Faecal Coliform count	MPN/100ml	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	70
Total Dissolved Solid	mg/l	15,850	15,700	15,850	15,550	15,900	15,500	-
Polyaromatic Hydrocarbon	µg/l	ND	ND	ND	ND	ND	ND	1000
Marine Water Quality Index	**-**	**65**	**78**	**82**	**79**	**79**	**66**	**-**
Water Quality Class	**-**	**Moderate**	**Moderate**	**Good**	**Moderate**	**Moderate**	**Moderate**	**-**

Parameter	**Unit**	**WM6**		**WM7**				**Class 3**
		Low Tide	**High Tide**	**Low Tide**	**High Tide**	**Low Tide**	**High Tide**	
Depth		-	-	1 m	1 m	4.2 m	4.2 m	-
Time of Collection	-	2.52 pm	9.20 am	3.28 pm	11.16 am	-	11.34 am	-
pH	-	7.7	7.9	7.7	7.9	***	7.1	6.5 – 9.0
Temperature	°C	28	28	28	28	***	28	≤2° increase*
Dissolved Oxygen	mg/l	7.8	7.5	7.7	7.7	***	7.7	>3.0
Conductivity	µS/cm	24.3	24.2	24.2	24.0	***	24.8	-
Salinity	ppt	31.5	31.5	31.5	30.2	***	30.4	-
Total Suspended Solids	mg/l	4	3	11	10	***	6	100
Oil & Grease	mg/l	ND	ND	ND	ND	***	ND	5
Cyanide as CN	µg/l	ND	ND	ND	ND	***	ND	14
Ammonia as NH_3	µg/l	ND (<10)	ND (<10)	ND (<10)	ND (<10)	***	ND (<10)	320
Nitrite as NO_2	µg/l	31	76	34	38	***	28	-
Nitrate as NO_3	µg/l	170	150	170	190	***	170	700
Phosphate as PO_4	µg/l	**1,100**	ND	500	**800**	***	**700**	670
Phenol	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	***	ND (<1)	100
Mercury as Hg	µg/l	ND	ND	ND	ND	***	ND	0.04
Cadmium as Cd	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	***	ND (<1)	3
Chromium, Hexavalent as Cr^{6+}	µg/l	ND	ND	ND	ND	***	ND	20
Copper as Cu	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	***	ND (<1)	8
Arsenic as As	µg/l	ND (<10)	ND (<10)	ND (<10)	ND (<10)	***	ND (<10)	3
Lead as Pb	µg/l	ND (<6)	ND (<6)	ND (<6)	ND (<6)	***	ND (<6)	12
Zinc as Zn	µg/l	ND (<4)	ND (<4)	ND (<4)	ND (<4)	***	ND (<4)	100
Tributyltin (TBT)	µg/l	ND	ND	ND	ND	***	ND	0.05
Faecal Coliform count	MPN/100ml	<1.8	<1.8	<1.8	<1.8	***	<1.8	70
Total Dissolved Solid	mg/l	15,550	15,550	15,500	15,350	***	15,900	-
Polyaromatic Hydrocarbon	µg/l	ND	ND	ND	ND	***	ND	1000
Marine Water Quality Index	**-**	**65**	**65**	**80**	**72**	**-**	**75**	**-**
Water Quality Class	**-**	**Moderate**	**Moderate**	**Good**	**Moderate**	**-**	**Moderate**	**-**

Parameter	**Unit**	**WM8**						**Class 3**
		Low Tide	**High Tide**	**Low Tide**	**High Tide**	**Low Tide**	**High Tide**	
Depth		1 m	1 m	4 m	6 m	12.5 m	12.5 m	-
Time of Collection	-	3.36 pm	11.55 am	3.50 pm	12.04 am	***	12.13 pm	-
pH	-	7.3	6.6	7.2	7.6	***	7.6	6.5 – 9.0
Temperature	°C	28	28	28	28	***	28	≤2° increase*
Dissolved Oxygen	mg/l	7.5	7.5	7.4	7.7	***	7.7	>3.0
Conductivity	µS/cm	23.9	24.3	24.2	24.8	***	24.6	-
Salinity	ppt	30.4	30.2	31.5	30.2	***	31.5	-
Total Suspended Solids	mg/l	4	8	7	6	***	4	100
Oil & Grease	mg/l	ND	ND	ND	ND	***	ND	5
Cyanide as CN	µg/l	ND	ND	ND	ND	***	ND	14
Ammonia as NH_3	µg/l	ND (<10)	ND (<10)	ND (<10)	ND (<10)	***	ND (<10)	320
Nitrite as NO_2	µg/l	31	33	32	42	***	26	-
Nitrate as NO_3	µg/l	110	140	120	140	***	110	700
Phosphate as PO_4	µg/l	**800**	**700**	**1,500**	**1,200**	***	**500**	670
Phenol	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	***	ND (<1)	100
Mercury as Hg	µg/l	ND	ND	ND	ND	***	ND	0.04
Cadmium as Cd	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	***	ND (<1)	3
Chromium, Hexavalent as Cr^{6+}	µg/l	ND	ND	ND	ND	***	ND	20
Copper as Cu	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	***	ND (<1)	8
Arsenic as As	µg/l	ND (<10)	ND (<10)	ND (<10)	ND (<10)	***	ND (<10)	3
Lead as Pb	µg/l	ND (<6)	ND (<6)	ND (<6)	ND (<6)	***	ND (<6)	12
Zinc as Zn	µg/l	ND (<4)	ND (<4)	ND (<4)	ND (<4)	***	ND (<4)	100
Tributyltin (TBT)	µg/l	ND	ND	ND	ND	***	ND	0.05
Faecal Coliform count	MPN/100ml	<1.8	<1.8	<1.8	<1.8	***	<1.8	70
Total Dissolved Solid	mg/l	15,300	15,500	15,500	15,900	***	15,750	-
Polycyclic Aromatic Hydrocarbon	µg/l	ND	ND	ND	ND	***	ND	1000
Marine Water Quality Index	**-**	**73**	**76**	**66**	**65**	**-**	**81**	**-**
Water Quality Class	**-**	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**-**	**Good**	**-**

Parameter	**Unit**	**WM9**						**Class 3**
		Low Tide	**High Tide**	**Low Tide**	**High Tide**	**Low Tide**	**High Tide**	
Depth		1 m	1 m	4 m	4 m	8.1 m	8.1 m	-
Time of Collection	-	4.40 pm	12.25 pm	***	12.34 pm	***	12.47 am	-
pH	-	7.8	7.9	***	7.8	***	7.9	6.5 – 9.0
Temperature	°C	28	28	***	28	***	28	≤2° increase*
Dissolved Oxygen	mg/l	7.5	7.5	***	7.5	***	7.4	>3.0
Conductivity	µS/cm	24.7	24.6	***	24.2	***	24.3	-
Salinity	ppt	30.4	30.4	***	31.5	***	30.2	-
Total Suspended Solids	mg/l	8	8	***	4	***	6	100
Oil & Grease	mg/l	ND	ND	***	ND	***	ND	5
Cyanide as CN	µg/l	ND	ND	***	ND	***	ND	14
Ammonia as NH_3	µg/l	ND (<10)	ND (<10)	***	ND (<10)	***	ND (<10)	320
Nitrite as NO_2	µg/l	38	30	***	53	***	30	-
Nitrate as NO_3	µg/l	140	130	***	120	***	110	700
Phosphate as PO_4	µg/l	**1,000**	**300**	***	ND	***	**1,000**	670
Phenol	µg/l	ND (<1)	ND (<1)	***	ND (<1)	***	ND (<1)	100
Mercury as Hg	µg/l	ND	ND	***	ND	***	ND	0.04
Cadmium as Cd	µg/l	ND (<1)	ND (<1)	***	ND (<1)	***	ND (<1)	3
Chromium, Hexavalent as Cr^{6+}	µg/l	ND	ND	***	ND	***	ND	20
Copper as Cu	µg/l	ND (<1)	ND (<1)	***	ND (<1)	***	ND (<1)	8
Arsenic as As	µg/l	ND (<10)	ND (<10)	***	ND (<10)	***	ND (<10)	3
Lead as Pb	µg/l	ND (<6)	ND (<6)	***	ND (<6)	***	ND (<6)	12
Zinc as Zn	µg/l	ND (<4)	ND (<4)	***	ND (<4)	***	ND (<4)	100
Tributyltin (TBT)	µg/l	ND	ND	***	ND	***	ND	0.05
Faecal Coliform count	MPN/100ml	<1.8	<1.8	***	<1.8	***	<1.8	70
Total Dissolved Solid	mg/l	15,750	15,750	***	15,500	***	15,550	-
Polyaromatic Hydrocarbon	µg/l	ND	ND	***	ND	***	ND	1000
Marine Water Quality Index	**-**	**65**	**87**	**-**	**96**	**-**	**66**	**-**
Water Quality Class	**-**	**Moderate**	**Good**	**-**	**Excellent**	**-**	**Moderate**	**-**

Parameter	**Unit**	**WM10**		**WM11**		**Class 3**
		Low Tide	**High Tide**	**Low Tide**	**High Tide**	
Depth		-	-	-	-	-
Time of Collection	-	1.09 pm	10.05 am	1.33 pm	9.05 am	-
pH	-	7.8	7.8	7.5	7.2	6.5 – 9.0
Temperature	°C	28	28	28	28	≤2° increase*
Dissolved Oxygen	mg/l	7.5	7.9	7.5	7.7	>3.0
Conductivity	µS/cm	24.3	24.2	24.5	23.9	-
Salinity	ppt	30.4	30.4	31.5	31.5	-
Total Suspended Solids	mg/l	4	5	13	14	100
Oil & Grease	mg/l	ND	ND	ND	ND	5
Cyanide as CN	µg/l	ND	ND	ND	ND	14
Ammonia as NH_3	µg/l	ND (<10)	ND (<10)	ND (<10)	ND (<10)	320
Nitrite as NO_2	µg/l	18	35	73	16	-
Nitrate as NO_3	µg/l	110	120	120	200	700
Phosphate as PO_4	µg/l	200	ND	**800**	400	670
Phenol	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	100
Mercury as Hg	µg/l	ND	ND	ND	ND	0.04
Cadmium as Cd	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	3
Chromium, Hexavalent as Cr^{6+}	µg/l	ND	ND	ND	ND	20
Copper as Cu	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	8
Arsenic as As	µg/l	ND (<10)	ND (<10)	ND (<10)	ND (<10)	3
Lead as Pb	µg/l	ND (<6)	ND (<6)	ND (<6)	ND (<6)	12
Zinc as Zn	µg/l	ND (<4)	ND (<4)	ND (<4)	ND (<4)	100
Tributyltin (TBT)	µg/l	ND	ND	ND	ND	0.05
Faecal Coliform count	MPN/100ml	<1.8	<1.8	<1.8	<1.8	70
Total Dissolved Solid	mg/l	15,050	15,500	15,700	15,300	-
Polyaromatic Hydrocarbon	µg/l	ND	ND	ND	ND	1000
Marine Water Quality Index	**-**	**90**	**95**	**73**	**83**	**-**
Water Quality Class	**-**	**Excellent**	**Excellent**	**Moderate**	**Good**	**-**

Parameter	Unit	WM12		WM13		Class 3
		Low Tide	High Tide	Low Tide	High Tide	
Depth		-	-	-	-	-
Time of Collection	-	2.00 pm	9.15 am	2.23 pm	10.00 am	-
pH	-	7.6	7.6	8.1	7.7	6.5 – 9.0
Temperature	°C	28	28	28	28	≤2° increase*
Dissolved Oxygen	mg/l	7.5	7.5	7.6	7.5	>3.0
Conductivity	µS/cm	24.1	24.3	24.2	24.3	-
Salinity	ppt	31.5	31.5	31.5	31.5	-
Total Suspended Solids	mg/l	12	12	13	14	100
Oil & Grease	mg/l	ND	ND	ND	ND	5
Cyanide as CN	µg/l	ND	ND	ND	ND	14
Ammonia as NH_3	µg/l	ND (<10)	ND (<10)	ND (<10)	ND (<10)	320
Nitrite as NO_2	µg/l	18	31	30	9	-
Nitrate as NO_3	µg/l	110	210	190	130	700
Phosphate as PO_4	µg/l	**1,600**	**1,500**	**700**	**800**	670
Phenol	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	100
Mercury as Hg	µg/l	ND	ND	ND	ND	0.04
Cadmium as Cd	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	3
Chromium, Hexavalent as Cr^{6+}	µg/l	ND	ND	ND	ND	20
Copper as Cu	µg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	8
Arsenic as As	µg/l	ND (<10)	ND (<10)	ND (<10)	ND (<10)	3
Lead as Pb	µg/l	ND (<6)	ND (<6)	ND (<6)	ND (<6)	12
Zinc as Zn	µg/l	ND (<4)	ND (<4)	ND (<4)	ND (<4)	100
Tributyltin (TBT)	µg/l	ND	ND	ND	ND	0.05
Faecal Coliform count	MPN/100ml	<1.8	<1.8	<1.8	<1.8	70
Total Dissolved Solid	mg/l	15,400	15,550	15,450	15,550	-
Polyaromatic Hydrocarbon	ng/g	ND	ND	ND	ND	1000
Marine Water Quality Index	**-**	**65**	**65**	**75**	**73**	**-**
Water Quality Class	**-**	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**-**

Notes - Class 3: Malaysian Marine Water Quality Standards, Class 3

*ND : Not detected ; * : ≤2° increase of maximum ambient ; - : Not available*

Table 6.13: Baseline Stream Water Quality Results

Parameter	Unit	WR1		WR2		WR3	WR4	Class III
		Low Tide	High Tide	Low Tide	High Tide			
Time of Collection	-	8.51 am	9.30 am	9.09 am	9.20 am	8.36 am	8.21 am	-
pH	-	5.5	5.2	5.6	5.3	6.8	7.1	5-9
Temperature	C	28	28	28	28	28	28	Normal +2C
Dissolved Oxygen	mg/l	5.6	5.4	5.6	5.1	**1.4**	5.8	3-5
Conductivity	µS/cm	405	376	371	334	25.0	23.8	-
Chemical Oxygen Demand, COD	mg/l	26	6	6	16	**106**	**61**	50
Biological Oxygen Demand, BOD_5	mg/l	5	1	1	3	**21**	**12**	6
Total Suspended Solids	mg/l	24	10	22	14	33	42	150
Oil & Grease	mg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	N
Ammoniacal Nitrogen as NH_3-N	mg/l	ND(<0.01)	ND(<0.01)	ND(<0.01)	ND(<0.01)	ND(<0.01)	ND(<0.01)	0.9
Nitrite as NO_2	mg/l	0.019	0.006	0.017	0.010	0.017	0.022	0.4 (0.03)
Nitrate as NO_3	mg/l	1.91	1.72	2.03	0.89	0.76	0.83	-
Mercury as Hg	mg/l	ND(<0.001)	ND(<0.001)	ND(<0.001)	ND(<0.001)	ND(<0.001)	ND(<0.001)	0.004 (0.0001)
Chromium, Hexavalent as Cr^{6+}	mg/l	ND(<0.02)	ND(<0.02)	ND(<0.02)	ND(<0.02)	ND(<0.02)	ND(<0.02)	ND (<0.02)
Arsenic as As	mg/l	ND(<0.01)	ND(<0.01)	ND(<0.01)	ND(<0.01)	ND(<0.01)	ND(<0.01)	0.4 (0.05)
Lead as Pb	mg/l	ND(<0.006)	ND(<0.006)	ND(<0.006)	ND(<0.006)	ND(<0.006)	ND(<0.006)	0.02 (0.01)
Copper as Cu	mg/l	0.022	0.019	0.026	0.027	0.032	0.017	-
Zinc as Zn	mg/l	0.071	0.060	0.076	0.203	0.0169	0.166	0.4
Cyanide as CN	mg/l	ND(<0.02)	ND(<0.02)	ND(<0.02)	ND(<0.02)	ND(<0.02)	ND(<0.02)	0.06 (0.02)
Phosphorus as PO_4	mg/l	2.3	1.0	ND(<0.1)	1.0	1.0	1.7	-
Faecal Coliform count	MPN/100ml	17	14	21	9	12	27	5,000 (20,000)
Water Quality Index		**82**	**87**	**89**	**82**	**50**	**73**	
Class		**II**	**II**	**II**		**IV**	**III**	
Water Quality Status		**C**	**C**	**C**	**C**	**P**	**SP**	

Parameter	**Unit**	**WR5**		**WR6**		**Class III**
		Low Tide	**High Tide**	**Low Tide**	**High Tide**	
Time of Collection	-	7.50 am	9.50 am	8.06 am	10.00 am	-
pH	-	6.3	6.1	6.3	5.5	5-9
Temperature	C	28	28	28	28	Normal +2 C
Dissolved Oxygen	mg/l	**2.1**	**2.1**	4.1	4.3	3-5
Conductivity	µS/cm	14.9	18.2	390	368	-
Chemical Oxygen Demand, COD	mg/l	**99**	**83**	13	48	50
Biological Oxygen Demand, BOD_5	mg/l	**19**	**16**	2	**9**	6
Total Suspended Solids	mg/l	24	16	16	50	150
Oil & Grease	mg/l	ND (<1)	ND (<1)	ND (<1)	ND (<1)	N
Ammoniacal Nitrogen as NH_3-N	mg/l	ND(<0.01)	ND(<0.01)	ND(<0.01)	ND(<0.01)	0.9
Nitrite as NO_2	mg/l	0.053	0.032	0.022	0.033	0.4 (0.03)
Nitrate as NO_3	mg/l	0.85	0.66	4.36	0.67	-
Mercury as Hg	mg/l	ND(<0.001)	ND(<0.001)	ND(<0.001)	ND(<0.001)	0.004 (0.0001)
Chromium, Hexavalent as Cr^{6+}	mg/l	ND(<0.02)	ND(<0.02)	ND(<0.02)	ND(<0.02)	ND (<0.02)
Arsenic as As	mg/l	ND(<0.01)	ND(<0.01)	ND(<0.01)	ND(<0.01)	0.4 (0.05)
Lead as Pb	mg/l	ND(<0.006)	ND(<0.006)	ND(<0.006)	ND(<0.006)	0.02 (0.01)
Copper as Cu	mg/l	0.013	0.012	0.022	0.060	-
Zinc as Zn	mg/l	0.036	0.056	0.057	0.071	0.4
Cyanide as CN	mg/l	ND(<0.02)	ND(<0.02)	ND(<0.02)	ND(<0.02)	0.06 (0.02)
Phosphorus as PO_4	mg/l	1.2	0.8	1.1	3.5	-
Faecal Coliform count	MPN/100ml	22	14	26	30	5,000 (20,000)
Water Quality Index		**53**	**56**	**83**	**69**	
Class		**III**	**III**	**II**	**III**	
Water Quality Category		**P**	**P**	**C**	**SP**	

Sources: Spectrum Laboratories Sdn. Bhd. (2018)

Notes: Class III : National Water Quality Standards for Malaysia, Class III ; N : Free from visible film, sheen, discoloration and deposits ; - : Not available ; ND : Not detected ; # : Maximum (unbracketed) and 24-hour average (bracketed) concentrations ; C : Clean ; SP: Slight Polluted ; P : Polluted.

6.5.2.1 Seawater Quality

The Malaysian Marine Water Quality Indices (MMWQI) denoted that the marine water within 5 km radius of the project site were within Classes of Moderate to Excellent under the Malaysian Marine Water Quality Standards (MMWQS). Seawater at the foreshore along the coastline at the northwest and southeast of the project site (WM1, WM2, WM3, WM6, WM11, WM12) showed Moderate water quality except WM11 during high tide which had Good water quality. Seawater quality adjacent to Pulau Menatang (WM4), Pulau Serimbun and Pulau Besar (WM10) were under classes of Good and Excellent. Seawater samples collected within 1 to 2km to the southwest (WM5) and southeast (WM7 & WM8) showed Moderate water quality. Seawater at approximately 3 km south (WM9) of the project site had Moderate to Excellent water quality depending on the water tide and depth of sampling. During high tide, water samples were generally in Good water quality status. During low tide, water sample fell in Moderate class. The classes of seawater quality is greatly affected by the concentration of PO_4.

At the estuary of Sg. Punggor, water quality fell within Good to Moderate classes with MMWQI of 81 to 61 during low tide and high tide respectively. While at the estuary of Sg. Umbai, the water quality was poor with MMWQI between 40-46 at high tide and low tide.

The classification of MMWQS is given in **Table 6.14**.

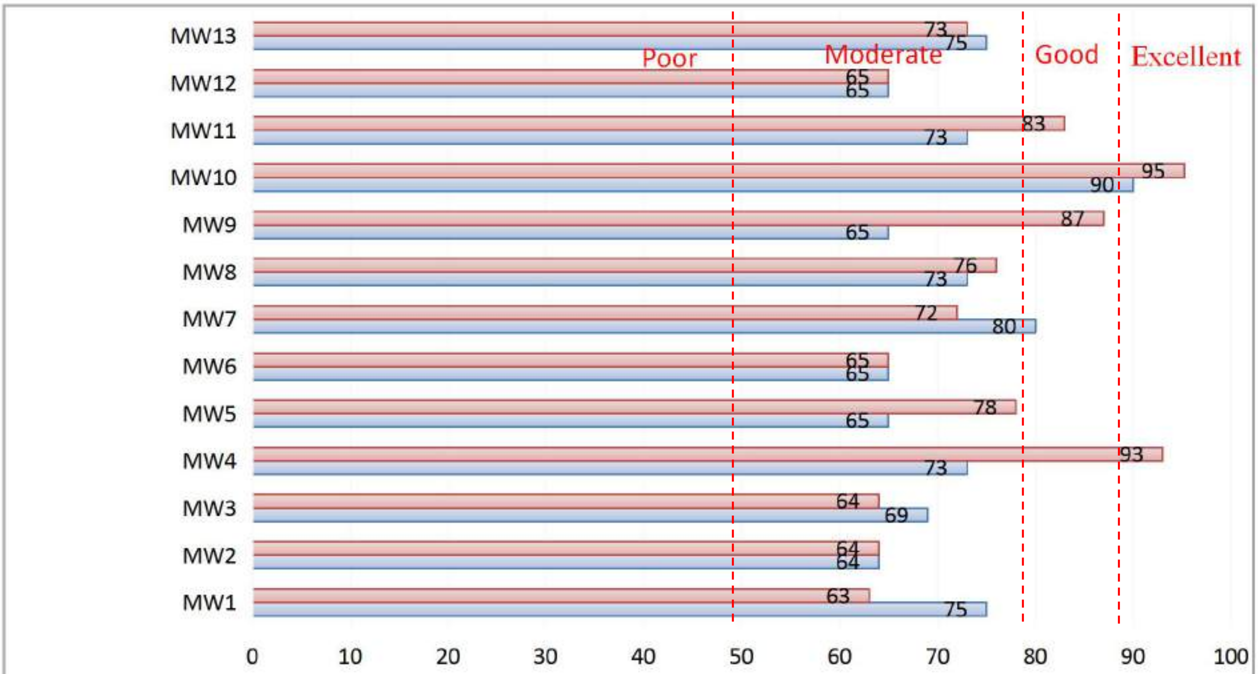
Table 6.14: <u>Classification of Malaysian Marine Water Quality Standards</u>

Class	Uses
I	Sensitive Marine Habitats.
2	Fisheries (including Mariculture).
3	Industry, Commercial Activities & Coastal Settlements.
E (Interim)	Estuaries – E1 : Coastal Plain E2 : Lagoon E3 : Complex Distributary Network
R	Recreation

In comparison, all the parameters tested were well within Class 3 limit of MMWQS except PO_4. Some of the samples showed high levels of PO_4. PO_4 recorded was between 200 µg/l to 1,600 µg/l comparing to the stipulated limit of 670 µg/l. The high concentration of PO_4 are basically associated with sewage pollution as well as discharges from anthropogenic activities. The evidence was observed via the high values of PO_4 detected in the stream water discharging into the sea. The result of river water samples are shown in **Table 6.13.**

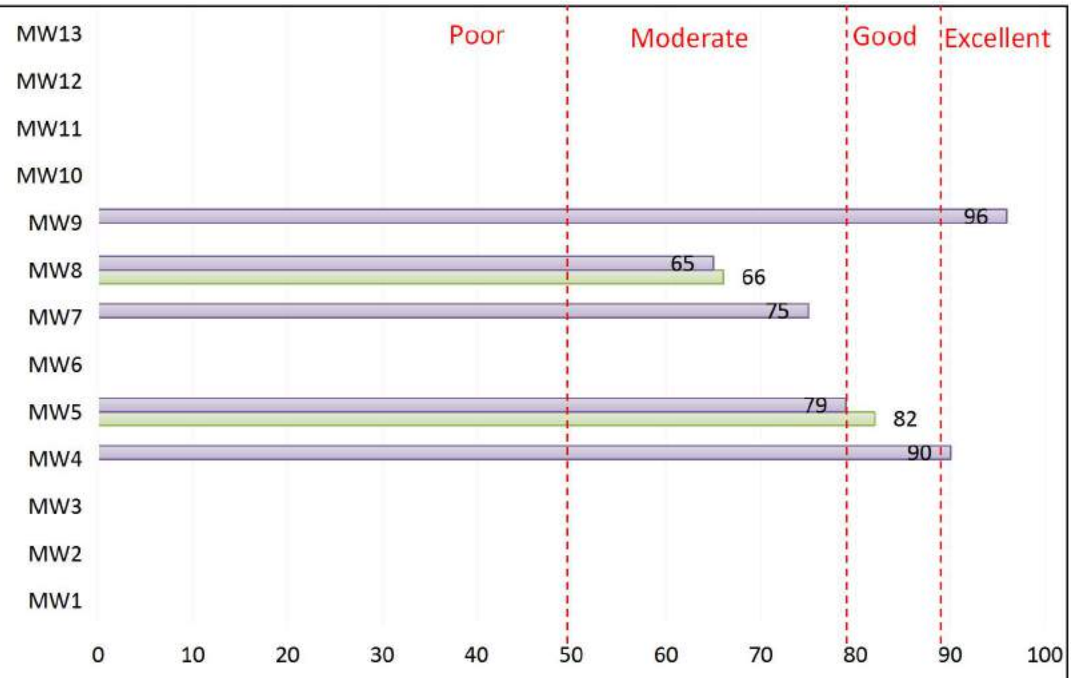
At the estuaries, NO_3, PO_4, Cu and Zn were found to be higher than the Class E1 limit of MMWQS. Besides, DO at the estuary of Sg. Umbai and pH at the estuaries of Sg. Umbai and Sg. Punggor were also exceeding the stipulated limits. DO was lower than 5 mg/l while pH was slightly acidic below 6.5. The estuaries are exposed to direct discharge of effluent from anthropogenic activities including coastal settlement and restaurants. Hence, the water quality is subjected to certain degree of degradation.

Chart 6.1 : <u>Marine Water Quality Index (MWQI) – Top Layer of Seawater</u>



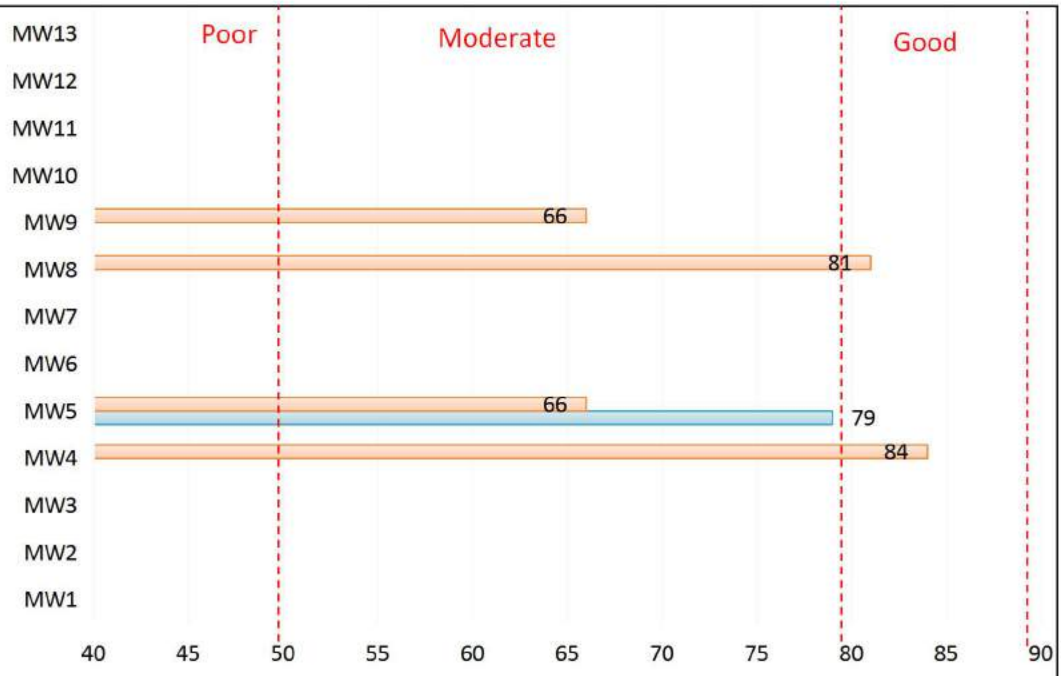
	MW1	MW2	MW3	MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13
High Flow Top Layer	63	64	64	93	78	65	72	76	87	95	83	65	73
Low Flow Top Layer	75	64	69	73	65	65	80	73	65	90	73	65	75

Chart 6.2: Marine Water Quality Index (MWQI) – Middle Layer of Seawater



	MW1	MW2	MW3	MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13
High Flow Middle Layer				90	79		75	65	96				
Low Flow Middle Layer					82			66					

Chart 6.3: Marine Water Quality Index (MWQI) – Bottom Layer of Seawater



	MW1	MW2	MW3	MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13
High Flow Bottom Layer				84	66			81	66				
Low Flow Bottom Layer					79								

The analytical result of the parameters are as follows:

i) pH

The pH levels measured at all stations indicated that the seawater was generally neutral with the highest values of 8.3, lowest of 6.5 and average of 7.6. Differences of readings at all the sampling stations were insignificant. There is no recommended limit stipulated in MWQCS for pH.

ii) Temperature

Generally, surface water of Straits of Melaka is warm with sea surface temperatures ranging from 27°C to 31°C. Temperature readings recorded for this study was 28°C which was comparable with the general range for seawater. The temperature readings at all the sampling stations showed no significant difference. There is no recommended limit stipulated in MWQCS for temperature.

iii) Dissolved Oxygen (DO)

DO concentrations recorded for all stations ranged from 7.2 mg/l to 8.00 mg/l with average of 7.4 mg/l. These values showed no significant difference among all the stations and were higher than the limits for Class 2 and Class E of MWQCS at 5 mg/l and 4 mg/l respectively.

iv) Conductivity

Specific electrical conductivity or simply conductivity is a rough indication of total content of dissolved substances namely those that can dissociate into anions or cations thus exert electrical conductivity. Conductivity values recorded for all sampling stations ranged 19.3 μS/cm to 24.9 μS/cm (average 23.8 μS/cm). Conductivity distribution throughout the stations showed uniformity and there were very little variation between the stations. There is no recommended limit stipulated in MWQCS for conductivity.

v) Salinity

Salinity is the concentration of salts in water. The salinity concentrations recorded at all stations ranged from 18.3 ppt to 31.50 ppt with average of 29.3 ppt. The salinity concentrations recorded were typical for seawater. The salinity values showed no significant difference at the estuaries and the ocean. There is no recommended limit stipulated in MWQCS for salinity.

vi) Total Suspended Solids (TSS)

Total Suspended Solids (TSS) concentrations recorded ranged from 2 mg/l to 15 mg/l (average 8.2 mg/l). The values recorded showed no significant difference for all the sampling stations. According to the MWQCS the stipulated limit for TSS is 50 mg/l and 100 mg/l for Class 2 and Class E respectively. Based on the results obtained, none of the stations had exceeded the stipulated limit of MWQCS. Thus, the values indicated good water quality at the sampling area.

vii) Ammonia (NH_3)

Ammonia (NH_3) in water column takes place when the decomposition of organic matter occurs. Usually, ammonia increases when the dissolve oxygen decreased. The ammonia concentrations recorded were in trace quantities < 10 µg/l. The recommended limit for NH3 stipulated under Class 2 and Class E in MWQCS is 70 µg/l.

viii) Nitrite (NO_2)

The nitrite concentrations recorded for all the stations ranged from 9 µg/l to 76 µg/l (average 37.5 µg/l). The recommended limit for NO_2 stipulated under Class 2 and Class E in MWQCS is 55 µg/l. NO_2 was high at WM6 during high tide (76 mg/l), WM11 during low tide (73 mg/l), WM5 during high tide at the surface and middle layers of the sea (65 & 70 mg/l).

ix) Nitrate (NO_3)

The nitrate concentrations recorded for all the stations ranged from 100 µg/l to 430 µg/L (average 155.9 µg/L). The recommended Class 2 and Class E limit for NO_3 is 60 µg/l. From the result, NO_3 at all the sampling stations exceeded the recommended limit stipulated in MWQCS. Anthropogenic nitrogen source, Sg Punggor and Sg Umbai river plume and riverine nitrogen fluxes are expected to be the contributors to the seawater nitrate.

ix) Phosphate (PO_4)

The phosphate concentrations recorded for all the stations ranged from 200 µg/l to 1,600 µg/l (average 767.6 µg/L). The recommended limit for PO_4 is 75 µg/l. PO_4 at all the stations extremely exceeded the recommended limit. It enters waterways from human and animal waste, phosphorus rich bedrock, domestic and industrial effluents as well as fertilizer runoff. The surrounding landuse and discharges are likely to be the source of phosphate in the sea.

xi) Total Dissolved Solid (TDS)

TDS is a measure of the total ions in solution. Seawater with TDS of 35,000 mg/L is considered standard seawater constitution. The water sampling results showed that TDS was in the range of 12,350 mg/l to 15,900 mg/l with average of 15,199 mg/l. The result indicated that seawater in the vicinity was not polluted with ionic composition. Differences of readings at all the sampling stations were insignificant. There is no recommended limit stipulated in MWQCS for TDS.

xii) Oil and Grease

The oil and grease was not detected at all the sampling stations. Findings of this study indicated that the seawater at the project vicinity was clear with no oil and grease contamination.

xiii) Total Faecal Coliform

Total faecal coliform are bacteria where their presence in the water indicate that the water may be contaminated with human or animal wastes. Total faecal coliform recorded at all the stations were less than 1.8 MPN/100 ml. Recommended limit stipulated is 100 MPN/100ml. Therefore, none of the sampling stations exceeded the recommended limit stipulated in MWQCS.

xiv) Trace Metals & Others

Mercury (Hg), Cadmium (Cd), Chromium (Cr^{6+}), Copper (Cu), Arsenic (As), Lead (Pb) and Zinc (Zn) were tested for trace metals pollution. The results showed that trace metals were not detected at all the sampling stations. Meanwhile, toxic compounds such as Cyanide (CN) and Phenol were also not detected at the project vicinity.

Tributyltin (TBT) is the active ingredient of many products that are used as biocides against a broad range of organisms. In the marine environment, it is primarily used as an antifoulant paint additive on ship and boat hulls, docks, fishnets, and buoys to discourage the growth of marine organisms such as barnacles, bacteria, tubeworms, mussels and algae. The laboratory analysis for TBT showed that all the seawater samples were free from TBT contamination.

Polycyclic Aromatic Hydrocarbon (PAHs) are ubiquitous environmental pollutants generated primarily during the incomplete combustion of organic materials (e.g. coal, oil, petrol, and wood). PAHs in the environment originate from anthropogenic activities and natural sources such as open burning, natural losses or seepage of petroleum or coal deposits etc. Many PAHs have toxic, mutagenic and/or carcinogenic properties. The results indicated that PAHs were not detected in all the water samples.

6.5.2.2 River Water Quality

The River Water Quality Indices (WQI) revealed that downstream of Sg Punggor (WR1 & WR2) and Sg Umbai (WR5 & WR6) were respectively within Class II and Class III denotation of the National Water Quality Standard for Malaysia (NWQS). While the existing drainage system, outlet of Parit I.S.K.K (WR3) and earth drain crossing Kg Pernu (WR4) showed WQI of Class IV and Class III.

In accordance to NWQS, water quality in Class II are suitable for recreational use with body contact, safe for sensitive aquatic species and required conventional treatment. Class III are considered common and safe for tolerant livestock species drinking but extensive treatment are required. While, water quality under Class IV can only use for irrigation. Water Classes and Uses of NWQS is tabulated in **Table 6.15**.

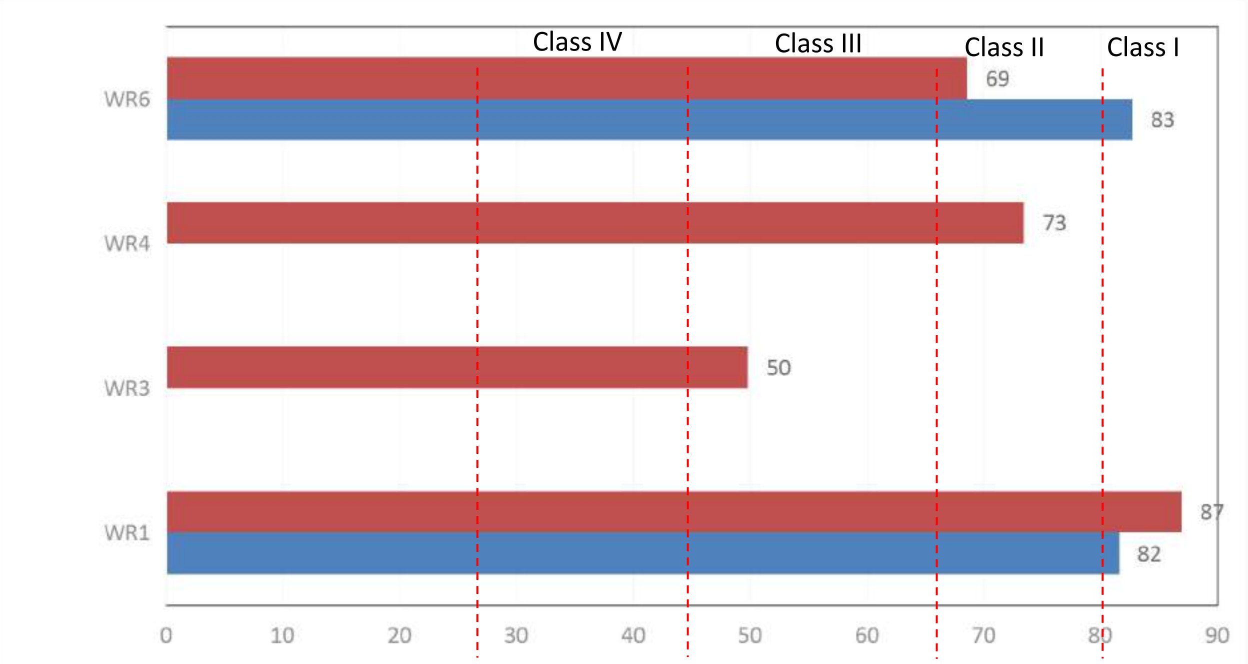
Table 6.15 : Classes and Uses of National Water Quality Standard

Class	Uses
I	- Conservation of natural environment. - Water supply I – Practically no treatment necessary. - Fishery I – Very sensitive aquatic species.
II	- Water Supply II - Conventional treatment. - Fishery II – Sensitive aquatic species. - Recreational use body contact.
III	- Water Supply III – Extensive treatment required. - Fishery III – Common, of economic value and tolerant species; livestock drinking.
IV	- Irrigation
V	- None of the above

In general, the river water quality in the Project vicinity was under the status of clean to slightly polluted except water quality at Parit I.S.K.K (WR3) and estuary of Sg Umbai (WR5) which were polluted.

Among all the parameters tested, BOD_5 and COD were found to be higher than Class III limits of 6 and 50 mg/l respectively at WR3, WR4 and WR5 and WR6. Relatively, DO was also noted to be low at WR3 and WR5. Others parameters complied with Class III limits. **Chart 6.4** shows the river Water Quality Index (WQI).

Chart 6.4: River Water Quality Index (WQI)



	WR1	WR3	WR4	WR6
High Tide	87	50	73	69
Low Tide	82			83

From the analytical results of the parameters, pH in Sg Punggor (WR1) and Sg Umbai (WR6) were slightly acidic between 5.2 to 6.3. Along Parit I.S.K.K (WR3) and earth drain crossing Kg Pernu (WR4), pH were 6.8 and 7.1 respectively.

Overall, temperatures of all sampling stations were constant at 28°C.

For DO, it ranged widely from 1.4 mg/l to 5.8 mg/l. Almost all the samples had DO levels more than the NWQS Class III limit of 3 mg/l except samples WR3 (1.4 mg/l). Parit I.S.K.K (WR3) mainly discharged runoff from a residential area (Taman Seri Teluk Mas). The drain water is anticipated to be polluted with domestic discharges which resulting in low DO.

Conductivity ranged widely from 23.8 µS/cm to 405 µS/cm. Sg Punggor and Sg Umbai showed high conductivity more than 334 µS/cm indicating ionic pollutants from anthropogenic sources. Others stations had conductivity values less than 25 μS/cm. NWQS has no recommendation limit for conductivity.

COD and BOD_5 are measures of organic loading. The results showed COD and BOD_5 levels ranging from 6 mg/l to 106 mg/l and 1 mg/l to 21 mg/l respectively. Sample from Parit I.S.K.K. (WR3) and the earth drain at Kg Pernu (WR4) contained high COD more than 61 mg/l and BOD_5 more than 12 mg/l. Sg Umbai shown higher value of BOD_5 at 9 mg/l. These values exceeding Class III limits of 50 mg/l for COD and 6 mg/l for BOD_5. Primary sources for COD and BOD_5 are surface runoff, point source water pollution discharged from seafood restaurants, anthropogenic activities particularly from Taman Seri Teluk Mas and Kg Pernu.

TSS values ranged from 10 mg/l to 50 mg/l and were well within stipulated limit of 150 mg/l. The amount of suspended particulate matter in the water was low.

Oil and grease was not detected at any of the sampling stations.

Ammoniacal nitrogen was also not detected but NO_2 and NO_3 were found in the ranges of 0.006 mg/l to 0.033 mg/l and 0.67 mg/l to 4.36 mg/l respectively. The Class III limit for NO_2 is 0.4 mg/l while there is no recommended value for NO_3 under the NWQS. The concentration of NO_3 were relatively high compared with Class 3 of MMWQS. The discharge of the stream into the ocean can affect the nitrate concentration of seawater.

Trace metals and cyanide were either not detected or found in trace quantity. Phosphate was detected at 1.0 to 3.5 mg/l. There is no recommended limit stipulated in NWQS for Phosphate but according to Class 3 of MMWQS, the stipulated limit for phosphate is 0.67 mg/l. The discharge with high phosphate is likely to affect the water quality of seawater.
Total faecal coliform recorded at all the stations were between 12 to 30 MPN/100ml. Recommended limit stipulated is 5,000 MPN/100ml. Therefore, none of the sampling stations exceeded the recommended limit..

6.6 Ambient Air Quality

The baseline ambient air quality monitoring was carried out by a [1]SAMM accredited laboratory which is Spectrum Laboratories Sdn. Bhd. (SAMM No.: 062) from 22nd October 2018 to 28th October 2018. The description of the ambient air quality monitoring stations is tabulated in **Table 6.16** and shown in **Figure 6.20.**

The parameter tested is Total Suspended Solid (TSP) and the results of the monitoring exercise is summarised in **Table 6.17.** The details of the exercise is appended in **Appendix XI.**

Table 6.16: Description of Ambient Air Quality Monitoring Stations

Location	Coordinates	Description
A1	N 02° 09' 33.7" E 102° 19' 00.9"	Adjacent to Restoran Terapung, Telok Mas Melaka
A2	N 02° 09' 27.6" E 102° 19' 26.9"	At Jalan Pernu 2
A3	N 02° 09' 32.7" E 102° 19' 31.2"	Adjacent to the access road of the project site
A4	N 02° 09' 30.9" E 102° 19' 44.3"	At Jalan Parit Singkat
A5	N 02° 09' 24.1" E 102° 20' 01.9"	Opposite of a cow shed
A6	N 02° 09' 19.6" E 102° 20' 12.0"	At Sg. Umbai estuary

Table 6.17: Result of Ambient Air Quality Monitoring

Sampling location	Total Suspended Particulate ($\mu g/m^3$)	Malaysian Recommended Air Quality Guidelines
A1	36	260 $\mu g/m^3$ (24 hours averaging time)
A2	37	
A3	40	
A4	43	
A5	41	
A6	39	

[1] *Note: SAMM = Malaysia National Laboratory Accreditation Scheme*

Legend

Air Quality Monitoring Locations

Figure 6.20: Air Quality Monitoring Location

From the monitoring results, the concentration of the TSP monitored at all the monitoring locations are well below the Recommended Malaysian Air Quality Guidelines of 260 $\mu g/m^3$ (refer to **Appendix VII**). Hence, the ambient air quality at the surrounding of the Project site is relatively clean.

6.7 Noise Level

Noise level measurements were carried out at six (6) locations near to the boundary of the Project using the Pre-calibrated Precision Integrating Noise Meter. The frequency of measurement was 24-hours continuously for a specific allotted period, viz., day and night. The measurements were carried out from 22nd October 2018 to 28th October 2018. The locations where the noise levels were measured are shown in **Figure 6.21**. The coordinates and description of the monitoring locations are given in **Table 6.18**.

Table 6.18: The Coordinate and Description of Noise Monitoring Locations

Sample	Coordinates	Description
N1	N 02° 09' 33.7" E 102° 19' 00.9"	Adjacent to Restoran Terapung, Telok Mas Melaka
N2	N 02° 09' 27.6" E 102° 19' 26.9"	At Jalan Pernu 2
N3	N 02° 09' 32.7" E 102° 19' 31.2"	Adjacent to the access road of the project site
N4	N 02° 09' 30.9" E 102° 19' 44.3"	At Jalan Parit Singkat
N5	N 02° 09' 24.1" E 102° 20' 01.9"	Opposite of a cow shed
N6	N 02° 09' 19.6" E 102° 20' 12.0"	At Sg. Umbai estuary

The history graphs of noise level measured are given in the monitoring report prepared by the accredited laboratory as attached in **Appendix XI.** The average readings of LAeq recorded for all allotted period at each monitoring location are summarised in **Table 6.19.**

Legend

⊗ Noise Level Monitoring Locations

Table 6.19: The Summary of Average Readings of LAeq

Location	Date	Period	Time	Average LAeq dB(A)	*Maximum Permissible LAeq dB(A)
N1	22nd – 23rd Oct 2018	Day Time	07:00:14 19:00:52	53.5	≤ 55.0 #
		Evening Time	19:02:12 22:00:12	49.4	≤ 55.0 #
		Night Time	22:02:31 07:00:50	**45.9**	≤ 45.0 #
N2	23rd – 24th Oct 2018	Daytime	07:20:00 19:00:38	53.9	≤ 55.0 #
		Evening Time	19:02:58 22:00:58	52.6	≤ 55.0 #
		Night Time	22:02:18 07:20:40	44.7	≤ 45.0 #
N3	24th - 25th Oct 2018	Day Time	07:23:59 19:00:38	54.2	≤ 55.0 #
		Evening Time	22:02:18 07:15:37	52.3	≤ 55.0 #
		Night Time	22:02:25 08:00:02	44.5	≤ 45.0 #
N4	25th - 26th Oct 2018	Day Time	07:30:29 19:00:07	**55.4**	≤ 55.0 #
		Evening Time	19:02:27 22:00:27	53.7	≤ 55.0 #
		Night Time	22:02:47 08:00:36	**45.2**	≤ 45.0 #
N5	26th - 27th Oct 2018	Day Time	07:30:29 19:00:07	**55.4**	≤ 55.0 #
		Evening Time	19:02:00 22:00:00	55.0	≤ 55.0 #
		Night Time	22:42:20 07:40:40	**45.2**	≤ 45.0 #
N6	27th - 28th Oct 2018	Day Time	08:00:25 19:00:43	52.5	≤ 55.0 #
		Evening Time	19:02:02 22:00:02	52.2	≤ 55.0 #
		Night Time	22:02:42 08:00:01	44.2	≤ 45.0 #

Note:

1.) * means : Maximum Permissible Sound Level (LAeq) By Receiving Land Use For Planning And New Development, Schedule 1; Annex A: Schedule Of Permissible Sound Levels; The Planning Guidelines For Environmental Noise Limits & Control, Department of Environment.

2.) # means: Suburban Residential (Medium Density) Area, Public Spaces, Parks, Recreational Areas.

Based on the results, the current noise level has exceeds the recommended guidelines as stipulated in Annex A: Schedule 1 of the "Planning Guidelines for Environmental Noise Limits and Control" for suburban residential (refer to **Appendix VIII**) at N1 during night time, N4 during day time and night time, and N5 during day time and night time.

Based on the observation annotated by the sampling personnel, the high noise level was caused by the noise of engine boats and sea waves (near to N1), noise of insects, noise of vehicles passing by the monitoring stations, sound of *azan* from the mosque nearby and noise of cows at the cow shed (near to N5).

6.8 Socio-economy

The study was conducted by relying on:

- Analysing secondary data on the socio-economic and demographics of the districts and mukim located within and surrounding the project site
- A general community survey within the 5 km of Zone of Impact (ZOI)
- Detailed interviews with local community leaders and Focus Group Discussion (FGD) with relevant stakeholders.

6.8.1 Socio-economic and Demographics of the Districts and Mukim located Within and Surrounding the Project Site

The above information was obtained from *Data Asas* 2015 (www.melaka.gov.my) where data is at the state level and from the 2010 Population and Housing Census of Malaysia which provides data at the mukim surrounding the project within the ZOI.

6.8.1.1 Population and Ethnic Composition

The information from *Data Asas 2015* (www.melaka.gov.my) indicates that the population in Melaka grew from 852,400 in 2013 to 872,900 in 2015. This represented an annual growth rate of 2.37%. However, there was no demographic information at mukim level. To obtain that information, data was obtained from the 2010 Population and Housing Census of Malaysia.

In 2010, the total population of Melaka Tengah District was 484,855 or 61.37% of the state's total population of 790,136. The project area is within the district of Melaka Tengah but the ZOI, if stretched to its 5km limit, would also cover the district of Jasin. **Table 6.20** provides the population breakdown for Melaka Tengah District and Jasin District in 2010. Melaka Tengah district accounted for a larger proportion of the state population due to Melaka City being located in this district. The mukims that are located within the two districts are also provided in **Table 6.20**.

Table 6.20: Total Population of Melaka State, Melaka Tengah and Jasin Districts and the Mukims within these Districts

State/ District/ Mukim		Population	Percentage (%)
Overall Melaka State Population		**790,136**	**100.00**
District	**Melaka Tengah**	**484,885**	**61.37**
Mukim	*Alai*	8,129	1.68
	Pernu	6,124	1.26
	Telok Mas	7,448	1.54
	Kandang	4,627	0.95
	Bukit Lintang	10,290	2.12
District	**Jasin**	**131,539**	**16.65**
Mukim	*Umbai*	8,989	6.83

Note:

1) = % of total population in Melaka
2) = % of population in the respective district

In general the mukims in Melaka Tengah District that are at or close to the project site are relatively less dense despite being close to Melaka City. The proportion of the district population in these mukims range from 0.95% to 2.12%. Jasin District has a population slightly more than a quarter of that of Melaka Tengah District. Hence, even though the Mukim of Umbai has a population of 8,989 which is almost the same population size of the relevant mukims in Melaka Tengah District, it represented 6.83% of that of Jasin's population.

Table 6.21 shows the racial distribution of Melaka State, Melaka Tengah District and Jasin District and the relevant mukims within these districts as of 2010. As per the Population Distribution By Local Authority Areas and Mukims, 2010, the population of Melaka has 63.02% Malays with Chinese and Indians taking up 25.26% and 5.97% respectively. The racial distribution pattern in Melaka Tengah District was slightly different with Malays at 56.48%, but higher Chinese at 32.76%. The racial pattern in Jasin District indicated a higher Malay population of 72.81% but lower Chinese population of 12.71%. Within all the relevant mukims in both districts, there were much higher Malay populations than at the state and district levels. There were almost similar proportions of Chinese among all the relevant mukims ranging from 3% to 12.36%. There were also smaller populations of Indians, Other Bumiputera and Non-Malaysians in these mukims.

Table 6.21: The Racial Distribution of Melaka State, Melaka Tengah District and Jasin District and the Relevant Mukims Within these Districts

Ethnic	Overall Melaka State	Percentage (%)	District of Melaka Tengah	Percentage (%)	District of Jasin	Percentage (%)
Malay	497,912	63.02	273,844	56.48	95,775	72.81
Other Bumiputera	8,750	1.11	6,492	1.34	871	0.66
Chinese	199,588	25.26	158,828	32.76	16,714	12.71
Indian	47,186	5.97	20,310	4.19	13,551	10.30
Others	3,835	0.49	3,240	0.67	227	0.17
Non-Malaysian Citizens	32,865	4.16	22,171	4.57	4,401	3.35
Total	790,136	100.00	484,885	100.00	131,539	100.00

Ethnic	Relevant Mukims in District of Melaka Tengah										Relevant Mukims in District of Jasin	
	Alai	%	Pernu	%	Telok Mas	%	Kandang	%	Bukit Lintang	%	Umbai	%
Malay	6,774	83.33	5,247	85.68	6,468	86.84	4,357	94.16	9,415	91.50	8,006	89.06
Other Bumiputera	18	0.22	11	0.18	17	0.23	3	0.06	12	0.12	7	0.08
Chinese	1,005	12.36	629	10.27	680	9.13	139	3.00	561	5.45	622	6.92
Indian	98	1.21	70	1.14	149	2.00	65	1.40	189	1.84	246	2.74
Others	70	0.86	16	0.26	34	0.46	7	0.15	4	0.04	14	0.16
Non-Malaysian Citizens	164	2.02	151	2.47	100	1.34	56	1.21	109	1.06	94	1.05
Total	8,129	100.00	6,124	100.00	7,448	100.00	4,627	100.00	10,290	100.00	8,989	100.00

6.8.1.2 Gender Distribution

Table 6.22 shows the gender distribution of the population in Melaka State, Melaka Tengah and Jasin Districts and the relevant mukims within these districts. Overall, the gender distribution at all three levels were almost equal. The male populations in the state and the two districts were slightly larger than females. Only in mukims of Alai, Bukit Lintang and Umbai were there slightly more females than males.

Table 6.22: Population Distribution in Melaka State, Melaka Tengah and Jasin Districts and Relevant Mukims, 2010 by Gender

State/District/Mukim		Male	Female	% Female	Total Population
Overall Melaka State		**397,949**	**392,187**	**49.64**	**790,136**
District	**Melaka Tengah**	**244,611**	**240,274**	**49.55**	**484,885**
Mukim	*Alai*	3,984	4,145	50.99	8,129
	Pernu	3,116	3,008	49.12	6,124
	Telok Mas	3,942	3,506	47.07	7,448
	Kandang	2,334	2,293	49.56	4,627
	Bukit Lintang	4,973	5,317	51.67	10,290
District	**Jasin**	**66,418**	**65,121**	**49.51**	**131,539**
Mukim	*Umbai*	4,275	4,714	52.44	8,989

6.8.1.3 Households and Living Quarters Distribution

Table 6.23 shows the number of households and living quarters in Melaka State, Melaka Tengah and Jasin Districts and the relevant mukims in these districts. Melaka Tengah District and Melaka City within it are densely populated. Hence the district has 62.24% and 62.31% of the state's households and living quarters respectively. The other mukims in the district have lower proportions of the household size and living quarters. The relevant mukims at and close to the project site in Melaka Tengah District tended to have low percentages of households and living quarters ranging from 0.91% to 1.83%, and 0.83% to 1.72% respectively.

The situation in Jasin District is proportionally smaller than the Melaka Tengah District with 16.66% and 13.57% of the state's households and living quarters respectively. Umbai contributed 6.38% and 6.92% of Jasin District's households and living quarters respectively.

Table 6.23: Number of Households and Living Quarters in Melaka State, Melaka Tengah District, Klebang Besar Mukim

State/ District/ Mukim		Household	% Household	Living Quarters	% Living Quarters
Overall Melaka State		**191,393**	**100.00**	**234,930**	**100.00**
District	**Melaka Tengah**	**119,120**	**62.24**	**146,387**	**62.31**
Mukim	*Alai*	1,953	1.64	2,515	1.72
	Pernu	1,494	1.25	1,845	1.26
	Telok Mas	1,720	1.44	2,040	1.39
	Kandang	1,084	0.91	1,215	0.83
	Bukit Lintang	2,174	1.83	2,487	1.70
District	**Jasin**	**31,888**	**16.66**	**31,888**	**13.57**
Mukim	*Umbai*	2,033	6.38	2,206	6.92

6.8.1.4 Population and Age Group

Table 6.24 provides the breakdown of the age groups of the population by state, district and mukim levels. The age structure of a population affects key socioeconomic issues of the district. Households with young populations (high percentage under age 15 years) need to invest more in school education, while households with older populations (high percentage ages 65 and over) need to invest more in health care. The age structure can also be used to help predict potential socioeconomic issues. For example, the rapid growth of a young adult population suggests potential availability of labour force. But if they are unable to find employment it can lead to social problems.

The age distribution of the population are quite similar between the state and district but there were differences among the mukims. The higher population age groups in 15-64 years age group in the two districts as well as the State ranged from 64.25% to 67.54% of the total populations. In contrast, the mukims lower active age group population are found in Pernu (61.71%) and Umbai (62.81%). The population in Umbai mukim has a relatively high proportions of older people. The fact that the elderly populations were high at this mukim, implies that they were no longer active and may have retired from productive activities.

Table 6.24: Distribution of Population Age Group at the State, District and Mukim, 2010

Age Group (years)	Overall Melaka State	Percentage (%)	District of Melaka Tengah	Percentage (%)	District of Jasin	Percentage (%)
<15	207,582	26.27	124,585	25.69	37,204	28.28
15-64	533,687	67.54	333,233	68.72	84,514	64.25
>65	48,867	6.18	27,067	5.58	9,821	7.47
Total	790,136	100.00	484,855	100.00	131,539	100.00

Age Group (years)	Mukims in District of Melaka Tengah										Mukims in District of Jasin	
	Alai	%	Pernu	%	Telok Mas	%	Kandang	%	Bukit Lintang	%	Umbai	%
<15	2,347	28.87	2,039	33.30	2,295	30.81	1,233	26.65	2,864	27.83	2,669	29.69
15-64	5,343	65.73	3,779	61.71	4,877	65.48	3,136	67.78	6,882	66.88	5,646	62.81
>65	439	5.40	306	5.00	276	3.71	258	5.58	544	5.29	674	7.50
Total	8,129	100.00	6,124	100.00	7,448	100.00	4,627	100.00	10,290	100.00	8,989	100.00

6.8.1.5 Dependency Age Ratio

The age dependency ratio for the state, relevant districts and mukims have been computed and provided in **Table 6.25**. The age dependency ratio is calculated by population, using the below formula:

$$\frac{\sum(<15 yearsold)+\sum(>65 yearsold)}{\sum(15-64 yearsold)}\times 100\%$$

The lower the ratio the greater the potential and productive capacity. The results showed that Melaka Tengah District has a ratio of 45.51% which is lower than the overall State and Jasin District. The ratio at the mukim level in the two districts are higher which are also much higher than the Malaysian age dependency ratio of 44.74% (Index Mundi, 2015).

The high dependency ratio suggests that there was higher proportion of dependent members of the population in the mukims relative to what was recorded in the Melaka Tengah District, State and nation. This can add a stress to the productive population.

Table 6.25: <u>Dependency Ratios in the Melaka State, Melaka Tengah and Jasin Districts and Relevant Mukims</u>

State/ District/ Mukim		Dependency Ratio (%)
Overall Melaka State Population		**48.05**
District	**Melaka Tengah**	**45.51**
Mukim	*Alai*	52.14
	Pernu	62.05
	Telok Mas	52.72
	Kandang	47.54
	Bukit Lintang	49.52
District	**Jasin**	**55.64**
Mukim	*Umbai*	59.21

6.8.2 Socio-economic and Demographic Profiles of the Local Communities Surveyed

The demographic, social and economic characteristic profile of the local communities that were surveyed is necessary in discerning the type of population this study is dealing with. It is the make-up of a society that often determines the degree of acceptability and kinds of reaction, impacts and suggested mitigation measures. **Table 6.26** provides the demographic statistics of the local communities.

Table 6.26: Demographic Characteristics of the Local Communities Surveyed

Description		Percentage (%)
Race	Malay	97.93
	Chinese	2.07
Religion	Islam	97.51
	Buddhist	2.07
	Others	0.42
Place of Origin	Local	66.39
	Melaka	27.80
Length of Settlement (years)	≤5	2.49
	5.1 - 10	2.07
	10.1 - 20	8.30
	20.1 - 40	41.49
	>40	45.64
Marital Status	Single	17.01
	Married	78.84
	Widow/er	4.15
Gender	Male	80.08
	Female	19.92
Level of Education	None	0.41
	Primary School	5.39
	Lower Secondary School	14.11
	Upper Secondary School	56.43
	College	4.56
	University	19.09
Age Group (years)	<18	1.66
	19 - 25	4.56
	26 - 40	37.34
	41 - 60	40.66
	61 - 65	7.88
	>65	7.88
Household Size	1	7.08
	2	7.50
	3	12.08
	4	25.83
	5	20.42
	6	13.33
	7	7.50
	8 - 9	2.92
	10 - 13	1.25

Some 97.93% of the local communities surveyed were Malays, with Chinese taking up the rest. Some 97.51% of the local communities surveyed were Muslims, with 2.07% Buddhists and 0.42% other religions. The majority of the respondents (66.39%) were local having been born locally, while the rest were born elsewhere within Melaka. A large majority had settled at the current locations for more than 2 decades. Some 41.49% had settled at the location between 20.1 - 40 years and 45.64% for more than 40 years. A small proportion of the respondents had recently moved into the villages. This suggests the residents at the locations have had their roots in the ZOI.

Of those surveyed, 78.84% were married, 17.01% were single and 4.15% were either widows or widowers. The gender of the respondents were mainly males (80.08%) with the rest being females. The majority (56.43%) of those surveyed attained secondary school education with 14.11% having attended up to lower secondary school, 4.56% attended college and another 19.09% had been to university. A smaller proportion (5.39%) had just completed primary schooling and 0.41% did not attend any formal schooling.

The ranges of respondents' age were wide. The majority of the local community members surveyed (78%) were within the ages of 26 to 60 years. Within these age categories, some 37.34% were within 26 - 40 years old and 40.66% within 41 - 60 years old. Another 15.76% were above 60 years.

Household sizes ranged from individuals to as many as 13 members. Individuals or those who lived alone involved 7.08% of the respondents while those households with 10-13 members involved 1.25%. The majority of the respondents had between 3 to 6 household members. 12.08% had 3 household members (presumably a married couple with a child), 25.83% had 4 household members, 20.42% had 5 household members and 13.33% with 6 household members. The rest had smaller household members. Single occupancy households took up 4.57% while households with two members took up 5.17% and 3 household members only involved 10.29%.

Table 6.27 provides a socio-economic profile of the local communities surveyed. A large percentage (41.49%) of those surveyed were single income earners followed by 31.95% having two income earners in the household. Together these took up 73.44% of the respondents surveyed. The rest had more than two income earners in their households.

Table 6.27: Socio-economics Characteristics of the Local Communities Surveyed

Description		Percentage (%)
Working Household Members	0	0.83
	1	41.49
	2	31.95
	3 - 4	15.35
	5 - 6	6.64
	7 - 8	3.73
Occupation	Fishermen	18.26
	Businessmen	29.46
	Government employee	14.11
	Private sector employee	20.75
	Contractor	0.83
	Own employment	3.32
	Pensioner	7.47
	Children contribution & government / NGO welfare	2.90
	Student	0.41
	Unemployed	2.49
Personal Income Level	<RM500	5.46
	RM501 - RM1,000	7.56
	RM1,001 - RM2,000	26.89
	RM2,001 - RM3,000	30.25
	RM3,001 - RM4,000	18.07
	RM4,001 - RM5,000	7.14
	RM5,001 - RM7,500	2.10
	RM7,501 - RM10,000	0.84
	RM10,001 - RM15,000	1.68
Household Income Level	<RM500	1.24
	RM501 - RM1,000	1.66
	RM1,001 - RM2,000	11.20
	RM2,001 - RM3,000	22.41
	RM3,001 - RM4,000	26.14
	RM4,001 - RM5,000	17.01
	RM5,001 - RM7,500	12.03
	RM7,501 - RM10,000	5.81
	RM10,001 - RM15,000	1.66
	RM15,001 - RM20,000	0.00
	RM20,001 - RM30,000	0.83

Description		**Percentage (%)**
Type of House Ownership	Own Home	75.10
	Rental Home	18.26
	Living in Family Home	2.07
	Government Quarters	4.56
Type of House Living In	Single house / bungalow	75.10
	Terrace	18.26
	Shop Lot	2.07
	Government Quarters	4.56
Housing Materials	Brick and cement	71.78
	Wood and cement	20.75
	Wood	7.47
Vehicle Ownership	Car	47.14
	Motorcycle	47.80
	Bicycle	3.96
	Trishaw	1.10

The main occupations of the respondents were as fishermen (18.26%), businessmen (29.46%), private sector employees (20.75%) and government employees (14.11%). Given the variety of occupations involved, the personal incomes of the respondents ranged from as low as <RM500/month to as high RM10,001-15,000/month. There are higher proportions of those surveyed that earned RM1,001-2,000/month (26.89%), RM2,001-3,000/month (30.25%), and RM3,001-4,000 (18.07%). Since a high proportion of the communities also had double or more income earners per household, the true picture of purchasing power for the family would be the household incomes. Household incomes could be significantly greater than personal incomes, with the highest range reaching RM20,000-30,000/month. There was a high proportion of household monthly incomes from RM1,001-2,000 (11.20%), RM2,001-3,000 (22.41%), RM3,001-4,000 (26.14%), RM4,001-5,000 (17.01%) and RM5,001-7,500 (12.03%).

Assets owned or rented by the local communities were mainly houses and vehicles. The majority of the respondents surrounding the project site lived in their own homes (69.58%), with 16.25% renting and another 7.50% and 5.00% living in their family homes and government quarters. A high proportion lived in single detached or bungalow houses (75.10%), 18.26% with terrace housing and another 2.07% lived in shophouses. The homes were made of brick and cement (71.78%) while wood and cement took up 20.75%. Wholly wood houses only took up 7.47%. Considering Malaysian weather and high prices of quality timber and wooden materials, it is not surprising that brick and cement combination was the popular construction material of choice.

Transportation means are essential for residents. The majority of residents owned and used cars (47.14%) and motorcycles (47.80%) as their two main means of transport with a minority using bicycles.

6.8.3 Health Data of the Surrounding Community

The disease vector data at the surrounding of the project site is obtained from Pejabat Kesihatan Daerah Melaka Tengah. The only disease vector recorded is dengue.

Table 6.28: Dengue Cases at the Surrounding of the Project Site

No.	Locality	Case No.	Case Admission Date
1	Jalan Sri Emas 1-20	3	1/3/18, 1/3/18, 24/6/18
2	Jalan Sri Emas 52-29	1	17/1/18
3	Taman Seri Telok Mas	1	10/11/18

Source: Pejabat Kesihatan Daerah Melaka Tengah

6.9 Marine Traffic and Navigation

6.9.1 Existing Marine Traffic Procedures and Safety Rules

6.9.1.1 Mandatory Ship Reporting System (STRAITREP)

Established in the Straits of Melaka and Singapore (SOMS), STRAITREP is the International Maritime Organisation (IMO)-adopted Mandatory Ship Reporting System which proposed by Indonesia, Malaysia and Singapore to enhance navigational safety, protect the marine environment, and facilitate the movements of vessels. STRAITREP provides information to ships about specific and critical situations which could cause conflicting traffic movements as well as other information concerning safety of navigation. Under STRAITREP, every ship should maintain a VHF radio telephone listening watch to appropriate VHF Channel depending on which sector the ship is in. Information of general interest to ships is broadcast on VHF Channel 16 and any other as may be specified by the appropriate VTS Authority (**Table 6.29**).

Table 6.29: Assigned VHF Channels for Sectors in STRAITREP

Sector	VHF Channels	VTS Authorities
Sector 1	VHF Channel 66	Klang VTS
Sector 2	VHF Channel 88	Klang VTS
Sector 3	VHF Channel 84	Klang VTS
Sector 4	VHF Channel 61	Klang VTS
Sector 5	VHF Channel 88	Klang VTS
Sector 6	VHF Channel 88	Johor VTS
Sector 7	VHF Channel 73	Singapore VTS
Sector 8	VHF Channel 14	Singapore VTS
Sector 9	VHF Channel 10	Singapore VTS

Source: Mandatory Ship Reporting Systems, IMO, 1998

The Proposed Project area is located on the outside of Traffic Separation Scheme (TSS) east of the northbound traffic lane. However it is still within the inshore traffic zone in the vicinity of **Sector 4** of the STRAITREP (**Figure 6.22**). Thus, any voyage that pass through this access must be obliged to follow STRAITREP rules by using **VHF Channel 61** under Klang VTS Authorities.

All vessels must report the name of ship, call sign, IMO identification number (if available), position, and hazardous cargo, class if applicable. It is essential for the vessels to report any breakdown, damage and/or deficiencies affecting the structure, cargo or equipment of the ship or any other circumstances affecting normal navigation. **Table 6.30** shows the format of ship report that is derived from the Standard Reporting Format given in paragraph 2 of the IMO resolution A.851 (20).

Table 6.30: Format of Ship Report

Designation	Function	Information Required
A*	Ship	Name and call sign
C*	Position	A 4-digit giving latitudes in degrees and minutes suffixed with N (north) and S (south) and a 5-digit group giving longitudes in degrees and minutes suffixed with E (east) or W (west); or
D*	Position	True bearing (first 3 digits) and distance given in nautical miles from a clearly identifiable point

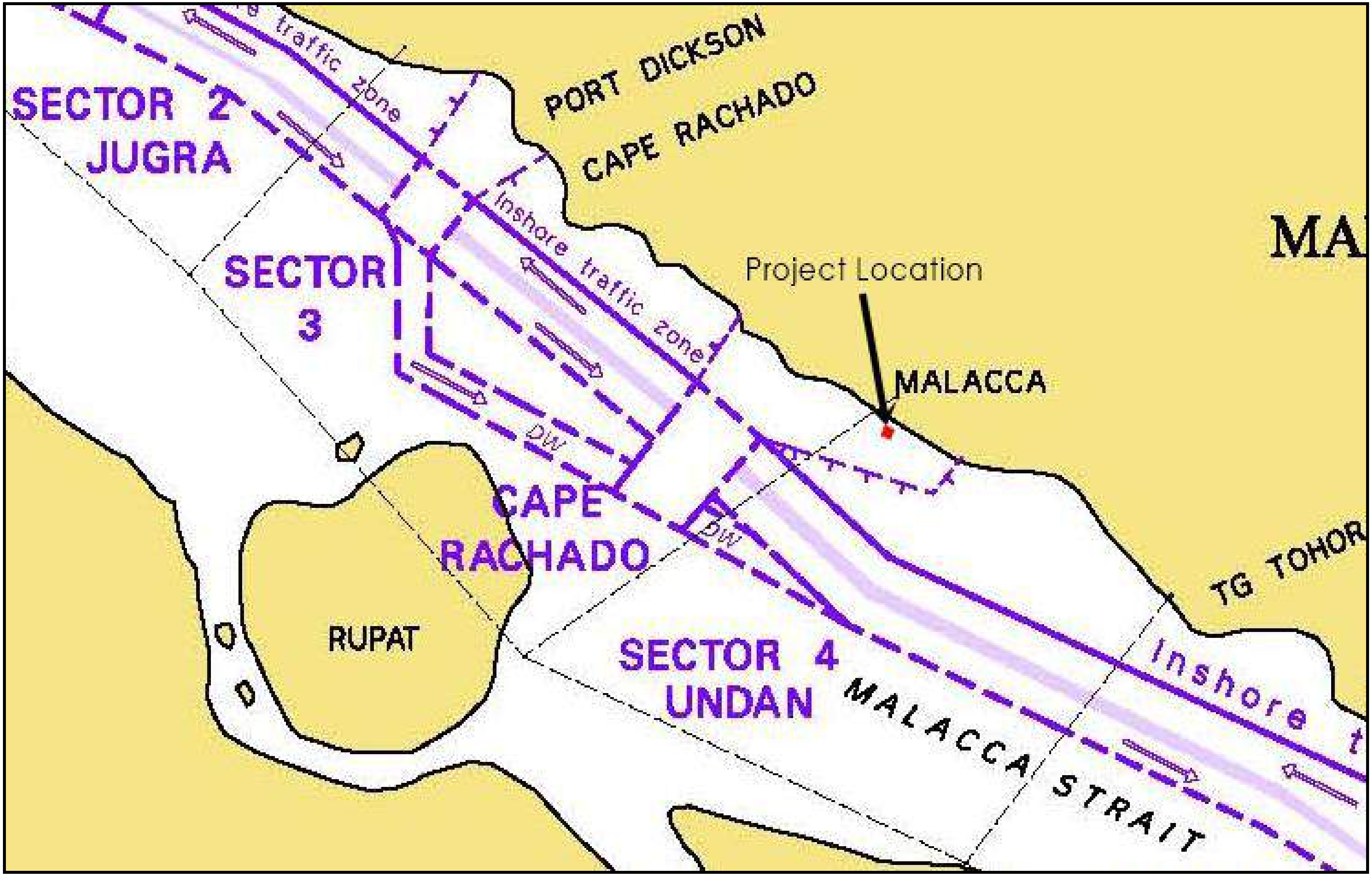


Figure 6.22: Location of Proposed Project area in the vicinity of Sector 4 of STRAITREP

Designation	Function	Information Required
		(state landmark)
E	True course	A 3-digit group
F	Speed in knots and tenths of knots	A 3-digit group
P*	Hazardous cargo on board	Indicate "Yes" or "No" to whether vessel is carrying hazardous cargo. If "Yes" the class if applicable
Q*	Defects/ damage/ deficiencies/ other limitations	Brief detail of defects, deficiencies or other limitations
R*	Description of pollution or dangerous goods lost overboard	Brief detail or type of pollution (oil, chemicals, etc.) or dangerous goods lost overboard; position expressed as in (C) or (D)

*Considered necessary by VTS

Source: Mandatory Ship Reporting Systems, IMO, 1998

6.9.1.2 Existing Navigation of Nearby Port: Melaka Port

Melaka Port or also known as Tanjung Bruas Port is located on the west coast of Peninsular Malaysia, approximately 25 km from Proposed Project area. The general directions, rules and regulations pertaining to safety of navigation are in accordance to Port Authorities Act, Merchant Shipping Ordinance and Regulations, Melaka Port Authority By-Laws, Pilotage By-Laws, International Regulations for Prevention of Collisions at Sea 1972 and IALA Buoyage System A (Melaka Port Authority, 2014). In addition, special provisions are also issued from time to time by the port officer, Marine Department Central Region and General Manager of the Port Authority to enhance the safety of navigation within the port.

In accordance with the latest Declaration of alteration of Port Limits for Melaka Port, of 22 December 2016, the port limit of the Malacca Port are the areas enclosed by the following imaginary lines (**Figure 6.23**):

a) From a point of the coast at Latitude 02^0 14.18' N, Longitude 102^0 08.44'E, directly to;
b) Latitude 02^0 11.0' N, Longitude 102^0 07.0' E, to;
c) Latitude 02^0 01.2' N, Longitude 102^0 25.2' E, to;

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Figure 6.23: Melaka Port Limit and location of Proposed Project Area

d) A point of the coast at Latitude 02^0 06.18' N, Longitude 102^0 29.3' E and returning to position (A) following the coast.

The Proposed Project area is within the port limits. Thus, any vessels that pass through this area must be obliged to follow Melaka Port rules and regulations to ensure the safety of navigation within the port. The anchorages area located 1 – 1.5 nm off Melaka Port with the depth of between 5.5 m to 11 m within the port limits. In case of emergency situation, the place to anchor is at 02° 11.7' N, 102° 09.0'E, which is about 1.2 nm south of the jetty.

Location for pilot boarding ground is at 02° 12.0'N, 102° 09.0'E, which is about 1 nm south of Tanjung Bruas jetty. Pilotage is compulsory for all vessels berthing/unberthing at the wharf side. However, there is exemption for vessels arriving and leaving the port's anchorage subject to conditions and imposition of a fee. The pilot usually boards by tugboat and radio communication is through VHF **Channel 12**. Pilot ladders and other pilot transfer arrangements for all vessels entering or departing Melaka Port shall be rigged in strict accordance with SOLAS regulations, IMO Resolution A. 889 (21) and recommendations of the International Maritime Pilots Association.

Any vessels departing from berths shall request for pilot at least 1 hour prior to departure by contacting Melaka Port Authority (MPA). And no vessel is allowed to leave port without a valid port clearance issued by Royal Malaysia Customs Department.

6.9.2 Information of Nearby Jetties/Ports

6.9.2.1 Melaka Port

Melaka Port or also known as Tanjung Bruas Port located on the West Coast of Peninsular Malaysia, facing the Straits of Malacca. The port has a "T"-shaped jetty with capability of accommodating ocean going vessels of up to 150 – 160m LOA and up to 15,000 dwt capacity (**Table 6.31**). Approaches to the wharf, has a minimum depth 12m and the minimum depth alongside the berth is 8.5m. Inner berth can be used for smaller vessels of below 65m LOA. A 450m long bridge capable of loads up to 30 tonnes linked the wharves to the mainland.

Table 6.31: Melaka Port Facilities

Type	Number of Berths	Length (m)	Depth (m)	Maximum Ship Size
General Cargo/Barge, Dry & Liquid Bulk	1 (outer berth)	160	8.5	15,000 dwt
General Cargo/Barge, Supply & Service Vessels	1 (inner berth)	70	5.0 (with tidal restriction)	2,000 dwt

Source: Melaka Port Authority, 2014

There are seven (7) hectares of total backup area and it is fully occupied. **Table 6.32** shows storage and warehousing at Melaka Port. A warehouse and several open yards are operated by port authority, while the rest consists of 3 warehouses and 1 liquid storage facility are operated by private sector. **Table 6.33** shows the cargo throughput of Melaka port. In the import sector, the cargo throughput has slightly dropped from 2012 to 2014, which 304 FWT in 2012, 301 FWT in 2013 and 299 FWT in 2014. However, towards 2016, the number increased from 479 FWT in 2015 to 561 FWT in 2016 by 17%. While in export sector, the number of cargo throughput shows fluctuating pattern; decreasing from 177 FWT in 2013, and then to 82 FWT in 2016.

Table 6.32: Storage and Warehousing at Melaka Port

Warehouse/ Installation	Capacity	Type of Cargo
Malacca Port Authority (MPA)	21, 600 sf	General Cargo
	98, 78 sf (open yard)	Minerals / Ore
Sinn Kian Hin (SKH)	150,000 sf	General Cargo
Perkhidmatan Kargo Tumpatan (PKT)	46,000 sf	General Cargo
Syarikat Fujun	62, 675 sf	General Cargo
Petronas	7, 000 mt	Lubrication Oil

Source: Melaka Port Authority, 2014

Table 6.33: Total Cargo Throughput (FWT) in Melaka Port, 2012 - 2016

Export/ Import	Year				
	2012	2013	2014	2015	2016
Export	115	177	144	44	82
Import	304	301	299	479	561
Total	**419**	**478**	**443**	**523**	**643**

Source: Ministry of Transport, 2016

Several types of ships called at Melaka port i.e. barge, bulk carrier, chemical tanker, general cargo, LNG and LPG carrier, oil tanker, passenger ship, tugboat and others. **Table 6.34** shows the total number of ship calling by types at Melaka Port from 2013 until May 2017. The highest number was in 2014, with 1124 ship calling recorded. Since 2015, the number had dropped to 880 in 2015 to 775 in 2016.

Table 6.34: Total Number of Ship Calling by Types at Melaka Port, 2013 to May 2017

Category	Year				
	2013	2014	2015	2016	2017
Barge	19	1	40	39	45
Bulk Carrier	3	9	18	22	1
Chemical Tanker	20	16	30	13	11
General Cargo	10	4	14	15	10
LNG Carrier	6	7	3	3	0
LNG Carrier	0	0	6	5	8
Oil Tanker	455	368	219	319	102
Others	83	23	18	31	11
Passenger Ship	395	648	449	286	203
Tugboat	67	48	63	53	60
Total	**1,058**	**1,124**	**880**	**775**	**451**

Source: Melaka Port, 2019-unpublished

6.9.2.2 Umbai Jetty

Located within Proposed Project area, this jetty provides services of daily private speed boats run to and from Pulau Besar which is around 2.5 nm from Umbai Jetty. This marine transport services are operated depending on tidal and requested by clients. Moreover, this jetty is a hub for fishing activities as it is one of fishing jetty in Melaka as well as famous for its *ikan bakar* restaurants and other seafood restaurants.

6.9.2.3 Anjung Batu Jetty

Anjung Batu Jetty is situated less than 2 km from south of the Proposed Project area. This jetty provides services of daily ferries run to and from Pulau Besar, Melaka. The ferries can have 50 passengers on board, normally. **Table 6.35** shows schedule of marine transport services at Anjung Batu Jetty.

Table 6.35: Schedule of Marine Transport Services at Anjung Batu Jetty

Schedule Boat (Anjung Batu - Pulau Besar)	
From Anjung Batu Jetty	From Pulau Besar Jetty
8:00 am	8:30 am
10:00 am	10:30 am
12:00 pm	12:30 pm
Closed: 1:00pm – 2:00pm	
2:30 pm	3:30 pm
5:00 pm	5:30 pm
6:30 pm	7:00 pm
8:30 pm	9:00 pm

6.9.3 Other Pertinent Information

6.9.3.1 Jeti Nelayan Pantai Siring

Located approximately 3 km south of the Proposed Project area, this jetty is developed for fishermen in order to shelter from storms that happened regularly during the Southwest Monsoon and causing damage to fishing vessels. Also, fish landing and trading activities at this jetty has attracted more people to visit and purchase fresh marine products.

6.9.3.2 Present Traffic Scenario in the Proposed Project Area

During the site visit on the 12th and 13th December 2017, there is little marine traffic encountered in the Proposed Project area. This is clearly shown in the real-time image taken on the 14th September 2018 (**Figure 6.24**) which no underway or anchorage vessel spotted within reclamation area. **Figure 6.25** shows the traffic density image in 2017.

The main traffic movement in the area consist of fishing vessels and ferries. The reclamation work is close to shore in shallow waters thereby will cause little interference with inshore traffic. However this area is used by fishermen as a track and sometimes as fishing grounds for fishermen in search of fish school.

Figure 6.24: Real-time Image of Reclamation Area Taken on 14th September 2018.

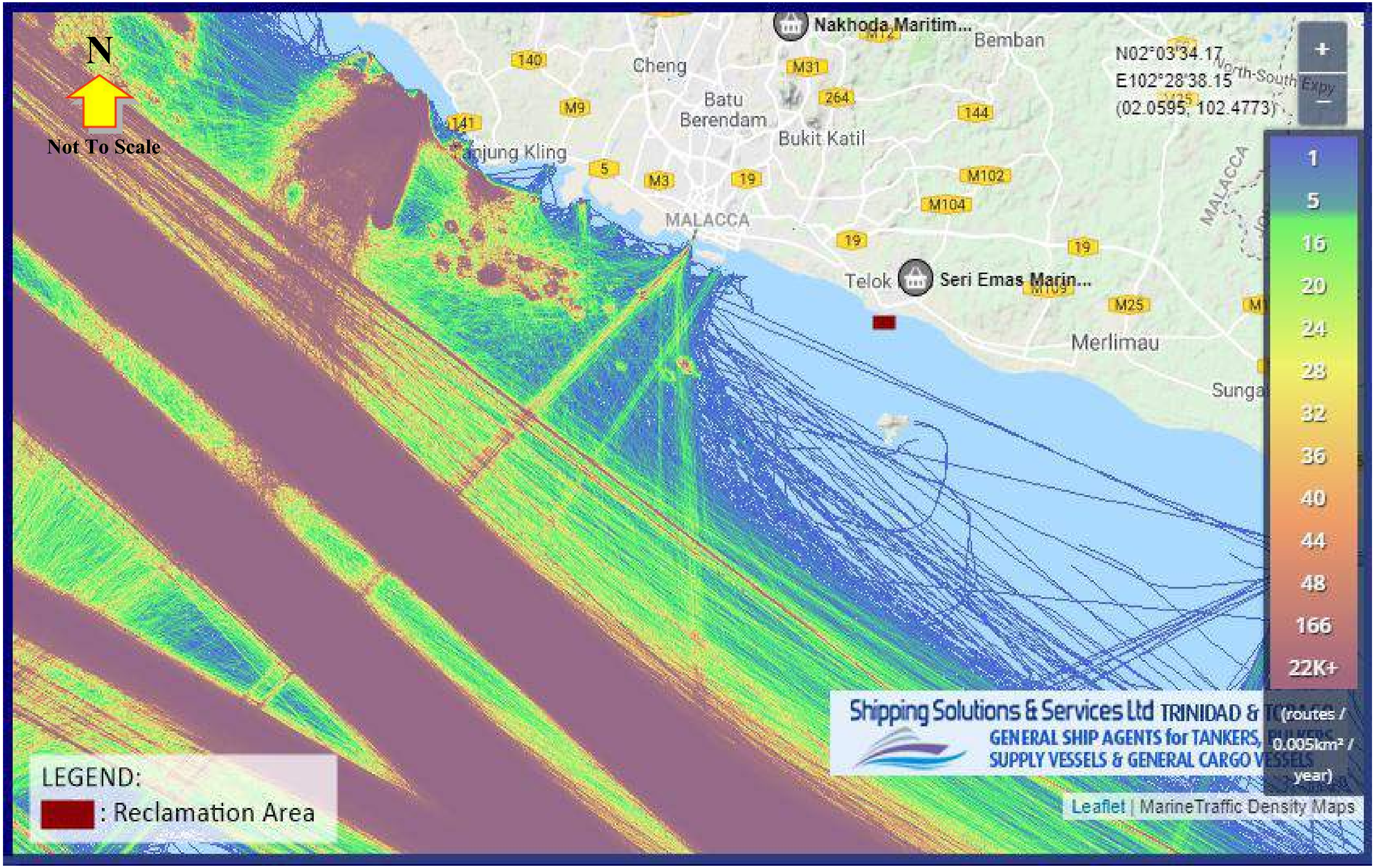

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Figure 6.25: Traffic density image of the proposed project area in 2017

According to Melaka Tengah Department of Fisheries, most of the fishermen using small boats with outboard engine and some of them are using sampan. As the project area situated close to shore which is Zone A, fishery activities in this zone (1 to 8 nm from shore) is reserved solely for small-scale fishers using traditional fishing gear and owner-operated vessels (Dept. of Fisheries Malaysia, 2014).

Besides fishing activities, daily services of ferries and private speed boats from nearby jetties i.e. Umbai and Anjung Batu Jetty to Pulau Besar also play a part in traffic movement in the vicinity of reclamation area. Discussion with the Marine Department officers of Melaka do not foresee any disruption to the normal maritime traffic in the area, only the adding up of vessels during reclamation work may cause small congestion to the vicinity of Proposed Project area. Strict adherence to the COLREG1972 besides these small boats are manoeuvrable will ensure that the risk of collision can be averted.

A meeting with officers of the Marine Department Melaka and Marine Officer of Melaka Port indicated that there will not be any impact of the project activities to their daily operation since the Proposed Project area is located some 20 km south of the Melaka Port. However, since it is situated within Melaka Port Limit, any vessels that operate in this area must be obliged to follow Melaka Port rules and regulations to ensure the safety of navigation within the port.

6.10 Marine Ecology, Fisheries and Aquaculture

6.10.1 Scope of Work

The work scope encompassed the following:

- Reconnaissance assessment of the marine biological resources (plankton, macrobenthos, fish fauna) and marine habitats (mangrove and coral reefs) within the impact zone (5km radius) of the proposed project sites.
- Collection and appraisal of relevant baseline information on fisheries and aquaculture activities within the impact zone (5km radius) of the proposed project sites.
- Identification of significant and major environmental impacts, including source of impacts and type of impacts.
- Proposed mitigation measures, including physical measures and monitoring.

6.10.2 Methodology

The study involved the collection of both primary as well as secondary data based on the following methodologies.

6.10.2.1 Biological Productivity

This involved the following:

- Sampling and identification of phytoplankton found in and adjacent the project area.
- Sampling and identification of zooplankton found in and adjacent the project area.
- Sampling and identification of benthic macrofauna found in and adjacent the project area.

The field investigation involved the collection of water and sediment samples for plankton and macrobenthic density and diversity assays. The sampling were undertaken on 26th – 27th April 2018 at 20 sampling stations i.e:

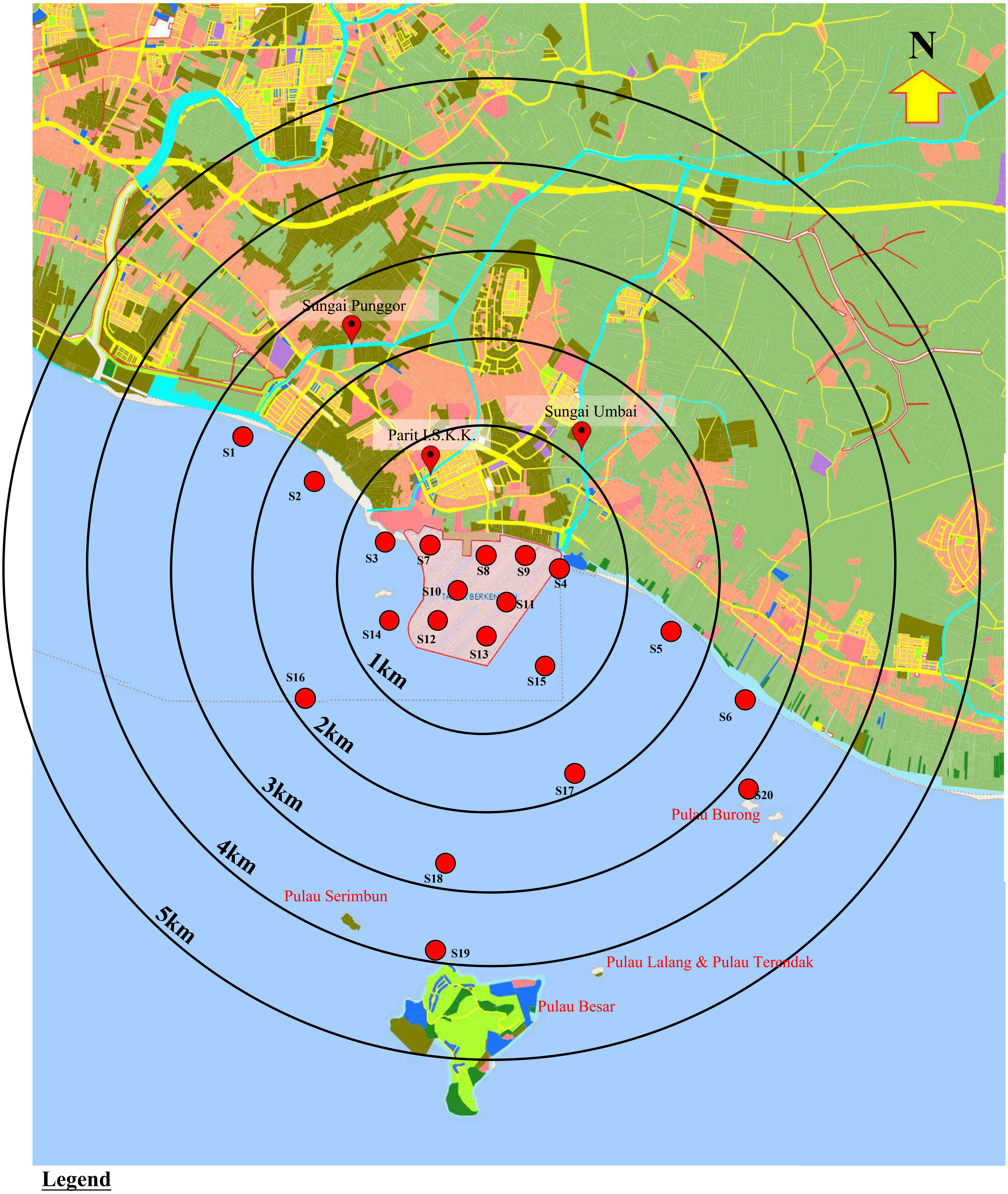
- 6 stations (S1 - S6) at foreshore area
- 7 stations (S7 - S13) within reclamation footprint
- 5 stations (S14 – S18) outside reclamation footprint
- 2 stations (S19 & S20) off Pulau Besar and Pulau Burong

The location and description of the sampling stations are provided in **Table 6.36** and shown graphically in **Figure 6.26.**

Details of the sampling and analytical regimes are provided below.

Table 6.36: Description of Sampling Stations for Phytoplankton, Zooplankton and Macrobenthos Assessment (S1 – S20)

Station	Coordinate		Description				
	Latitude	Longitude	Date	Time	Tide	Water Depth (m)	Sediment Type
Foreshore Area							
S1	02° 09. 966'	102° 18.211'	260418	0910	High neap tide	1.0	Muddy shell
S2	02° 09.674'	102° 18.709'	260418	0920	High neap tide	1.0	Muddy shell
S3	02° 09.364'	102° 19.028'	260418	0930	High neap tide	1.5	Muddy sand
S4	02° 09.071'	102° 20.116'	270418	0905	High neap tide	1.0	muddy
S5	02° 08.782'	102° 20.698'	270418	0920	High neap tide	2.0	Muddy
S6	02° 08.556'	102° 21.204'	270418	0935	High neap tide	1.5	Muddy
Within Reclamation Footprint							
S7	02° 09.236'	102° 19.360'	260418	0940	High neap tide	1.0	Muddy
S8	02° 09.231'	102° 19.655'	260418	1000	High neap tide	2.5	muddy
S9	02° 09.170'	102° 19.913'	260418	1005	High neap tide	2.0	muddy
S10	02° 08.990'	102° 19.483'	260418	0950	High neap tide	3.0	Muddy
S11	02° 08.928'	102° 19.835'	260418	1010	High neap tide	3.5	Muddy
S12	02° 08.744'	102° 19.419'	260418	1025	High neap tide	6.5	Muddy
S13	02° 08.685'	102° 19.734'	260418	1015	High neap tide	6.0	Muddy shell
Outside Reclamation Footprint							
S14	02° 08.817'	102° 19.065'	260418	1045	High neap tide	3.0	Muddy
S15	02° 08.553'	102° 20.129'	270418	0930	High neap tide	7.5	Sandy shell
S16	02° 08.450'	102° 18.739'	260418	1030	High neap tide	17.0	Muddy
S17	02° 08.127'	102° 20.336'	270418	0840	High neap tide	14.0	Sandy shell
S18	02° 07.684'	102° 19.494'	270418	0810	High neap tide	8.0	Sandy shell
Off Pulau Besar and Pulau Burong							
S19	02° 07.148'	102° 19.572'	270418	0820	High neap tide	6.0	Sandy
S20	02° 08.145	102° 21.335'	270418	0950	High neap tide	13.0	Muddy



Legend

● Sampling Station

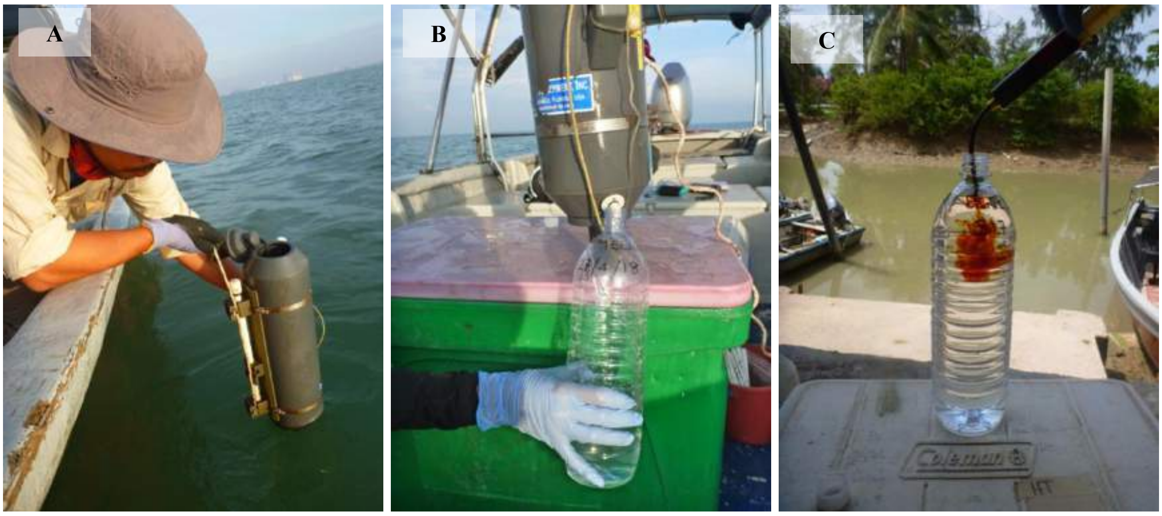
Figure 6.26: Location of Sampling Station for Plankton and Macrobenthos (S1 – S20)

a) Phytoplankton Assessment

Sampling involved the collection of surface water samples. The standard procedures implemented at each station were as follows.

- Water samples were collected using Niskin Water Sampler (**Plate 6.1A**).
- 1,500 mL of a mixture of surface, middle and bottom water of the water column was transferred into the labelled polyethylene terephthalate (PET) plastic bottles (**Plate 6.1B**).
- Phytoplankton samples were preserved immediately using Lugol's iodine solution (**Plate 6.1C**) and moved to the laboratory.

Plate 6.1: <u>Phytoplankton Assessment. A: Sample Collected using a Niskin Water Sampler, B: Plankton Samples Transferred into PET Bottles, C: Samples Preserved with Lugol's Iodin Solution</u>



At the laboratory:

- Phytoplankton composition and diversity were determined by first concentrating, then sub-sampling and counting using an inverted microscope. Plankton samples were identified at family and genus/species levels using a high magnification compound microscope.
- Phytoplankton was enumerated in terms of number of cells per milliliter (cells/ml).

- Species diversity was also assessed based on the Shannon-Weiner Diversity Index (H'), which provides information about rarity and commonness of the species in a community. A high H' value indicates that the community has a high level of species diversity or that many equally abundant species are present. The index was calculated based on the following formula:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

Where,

H' = Index of species diversity

s = Number of species

p_i = Proportion of the i th species in the total sample of S species

b) Zooplankton Assessment

Sampling involved the collection of surface water samples.

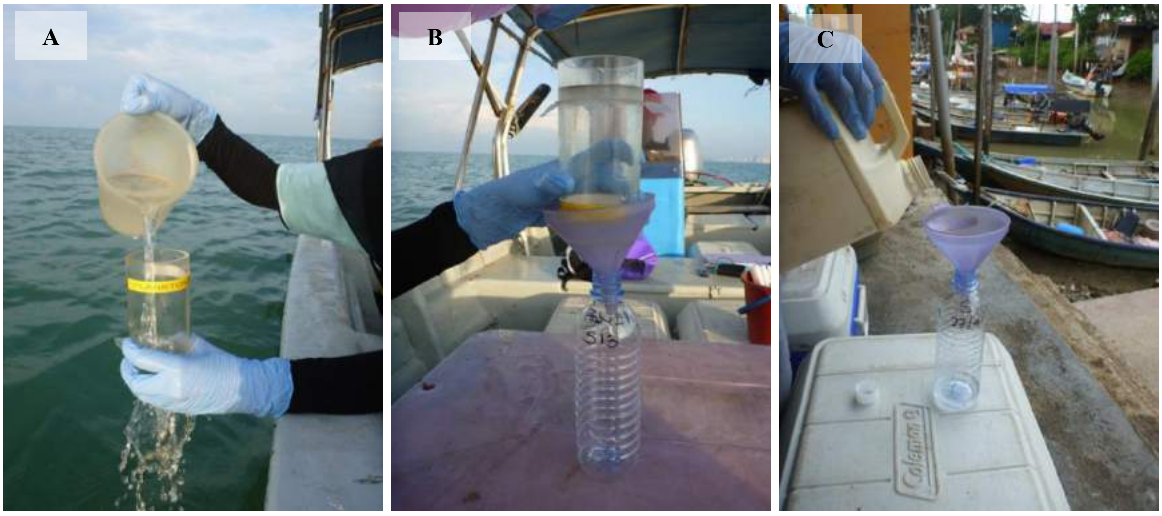
At each sampling station:

- 20 litres of a mixture of surface, middle and bottom water of the water column was collected and filtered through 140 µm plankton net (**Plate 6.2A**).
- Zooplankton samples retained on the plankton net were washed into a 500 mL bottle and labelled (**Plate 6.2B**).
- 10% formaldehyde was added as preservatives (**Plate 6.2C**).

At the laboratory:

- Zooplankton composition and diversity were determined by first concentrating, then sub-sampling and counting using an inverted microscope.
- Samples were identified at the family and genus/species levels using a high power compound microscope.
- Zooplankton was enumerated in terms of individuals per litre (ind./l).
- Zooplankton diversity was assessed based on the Shannon-Weiner Diversity Index (H').

Plate 6.2: Zooplankton Assessment. A: Water Filtered through a 140 µm Plankton Net, B: Retained Plankton Samples Washed into a PET Plastic Bottle, C: Samples Preserved with 10% Seawater Buffered Formalin Solution



c) Macrobenthos Assessment

The sampling involved collection of bottom sediment.

At each sampling station:

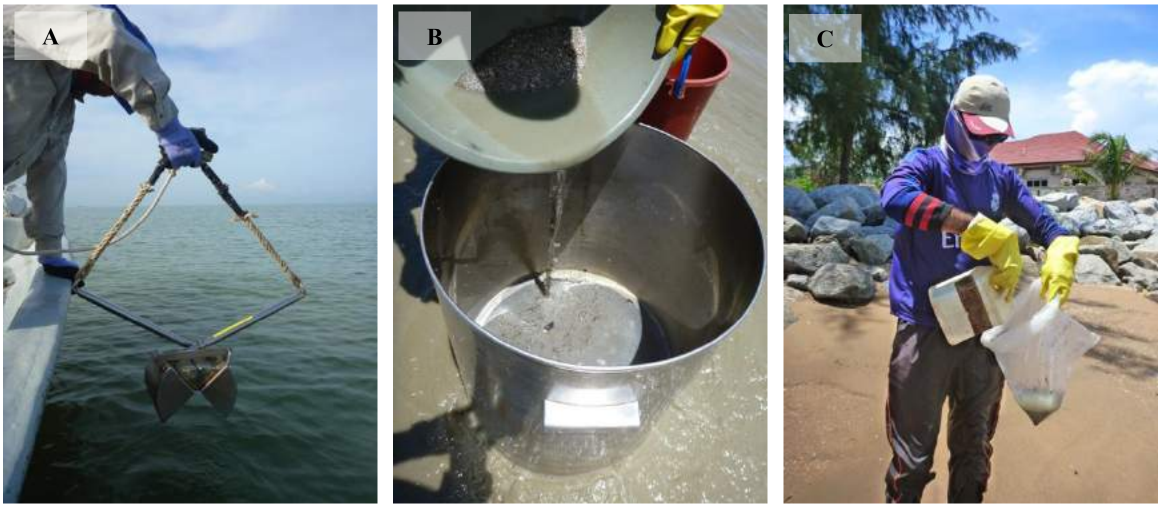
- Benthic organisms were sampled using a Van Veen Grab (**Plate 6.3A**).
- The samples were collected in double-layered plastic bags and labelled.
- On shore, the sediment was slowly washed through a sieve with a mesh size of 500µm (**Plate 6.3B**).
- Specimens and coarse sediment that were retained in the sieve were collected in a plastic bag, preserved in 10% seawater buffered formalin solution (**Plate 6.3C**) and moved to the laboratory.

At the laboratory, the sieved specimens were:

- Sorted and identified at the family and genus/species levels using a stereomicroscope and a high power compound microscope.
- Density was calculated in terms of number of individuals per square meter (ind./m^2).

- Macrobenthos diversity was assessed based on the Shannon-Weiner Diversity Index (H').

Plate 6.3: Macrobenthos Assessment: A: Samples Collected using a Van Veen Grab, B: Sediment Slowly Washed through a 500µm Sieve, C: Samples Preserved with 10% Seawater Buffered Formalin

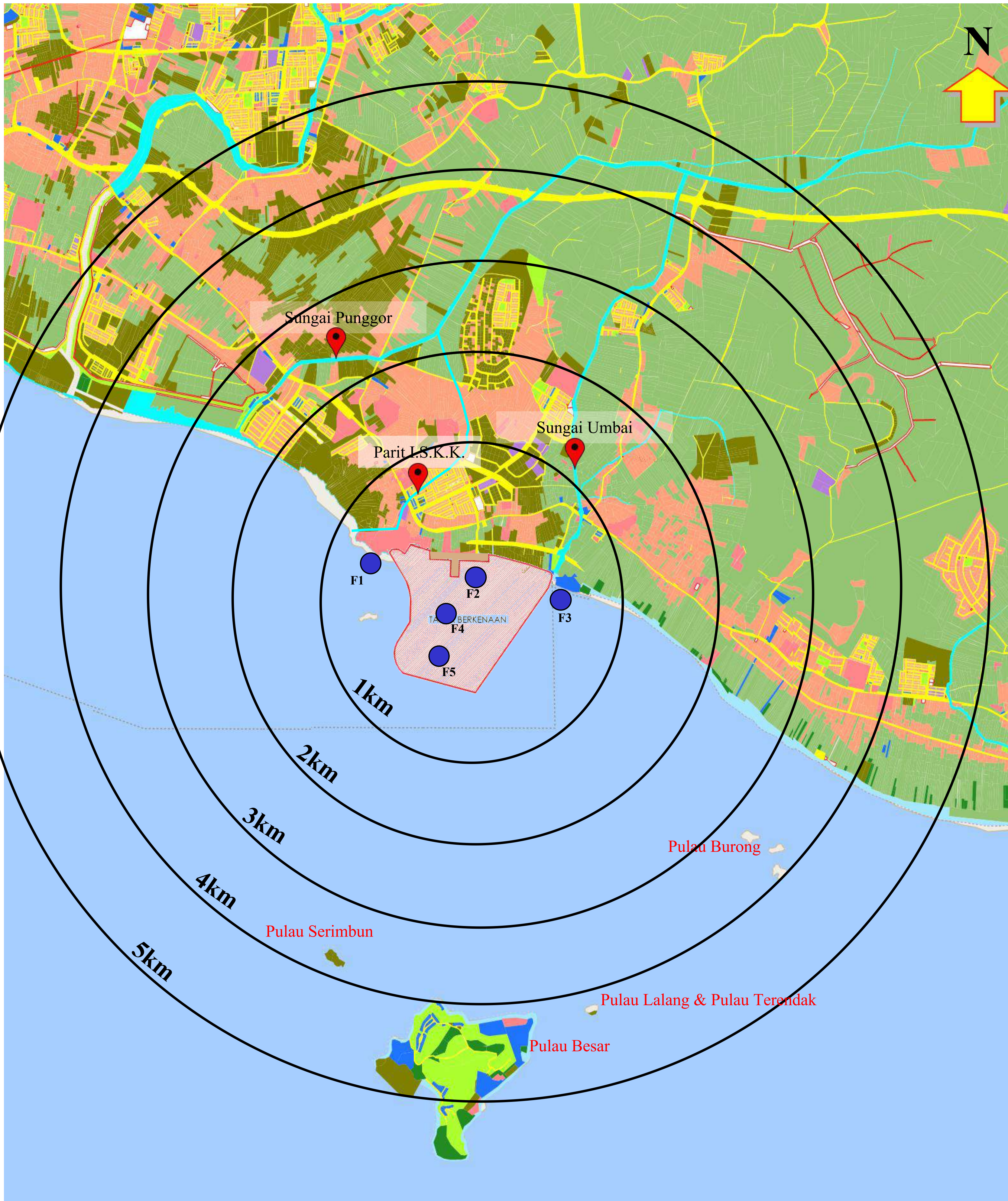


6.10.2.2 Fish Fauna Assessment

Fish sampling was taken at five locations i.e two outside the proposed reclamation and three within proposed reclamation area. The location and description of the each sampling stations are provided in **Table 6.37; Figure 6.27.** Sampling was only undertaken using gill net. Beam trawl was not employed during the survey due to unsuitable seabed conditions at study area.

Table 6.37: Description of the Sampling Points for Fish Fauna Assessment

Station	Coordinates		Description			
	Latitude	Longitude	Date	Time	Tide	Location
F1	02° 09.364'	102° 19.028'	070319	0900	High neap tide	Outside Proposed reclamation (north)
F2	02° 09.231'	102° 19.655'	070319	0930	High neap tide	Within proposed reclamation (nearshore)
F3	02° 09.071'	102° 20.116'	060319	1030	High neap tide	Outside Proposed reclamation (south)
F4	02° 08.990'	102° 19.483'	070319	0830	High neap tide	Within proposed reclamation (middle)
F5	02° 08.744'	102° 19.419'	060319	1000	High neap tide	Within proposed reclamation (end of boundary)



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Sampling Station

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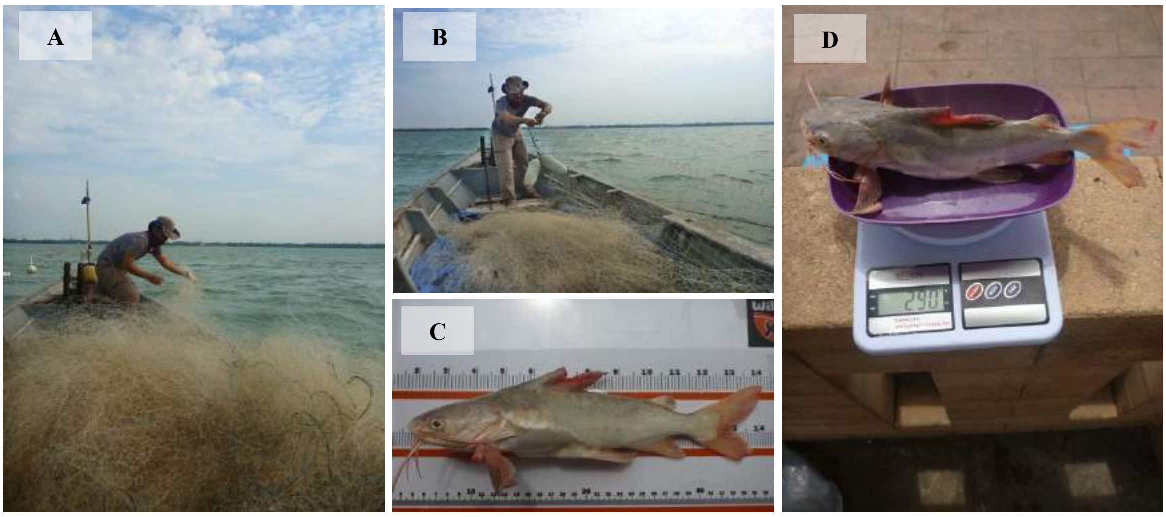
ENVIRONMENTAL & TRAFFIC CONSULTANT

Figure 6.27: Location of the Sampling Stations for Fish Fauna Assessment (F1-F5)

At each sampling stations the following procedure was employed:

- Sampling was undertaken using gill net. The net was employed as barrier nets, with both ends affixed to anchor or stakes (**Plate 6.4**). Two mesh size of net were employed i.e:
  - 3.81 cm with a total length and width at 70 m and 1.5 m, respectively.
  - 10.16 cm with a total length and width at 60 m and 3.0 m, respectively.
- The net was affixed for a standard time of two (2) hours.
- Fish caught was collected, separated and identified up to the genus or species level based on keys in De Bruin *et al*. (1995), Mohsin *et al.* (1993), Kong (1998) and Fishbase website.
- The weight and length measurements were recorded for all the fish collected. The total length (TL) of the fish was measured from the snout until the outer tip of the tail using measuring tape. A portable weighing scale was used for weight measurement (**Plate 6.4**).
- Photographs of the representative fish specimens will be taken. Some fish specimens were preserved in 10% seawater buffered formalin solution for documentation and record purposes.
- The data that was gathered covered speciation and catch per unit (CPUE) effort of fish fauna.

Plate 6.4: <u>Fish Fauna Assessment. A-B: Gill Nets Employed at the Study Area, C: Length (cm) Measurement of Fish Specimen, D: Weight (g) Measurement of Fish Specimen</u>



6.10.2.3 Marine Habitat

Habitat assessment involved the following:

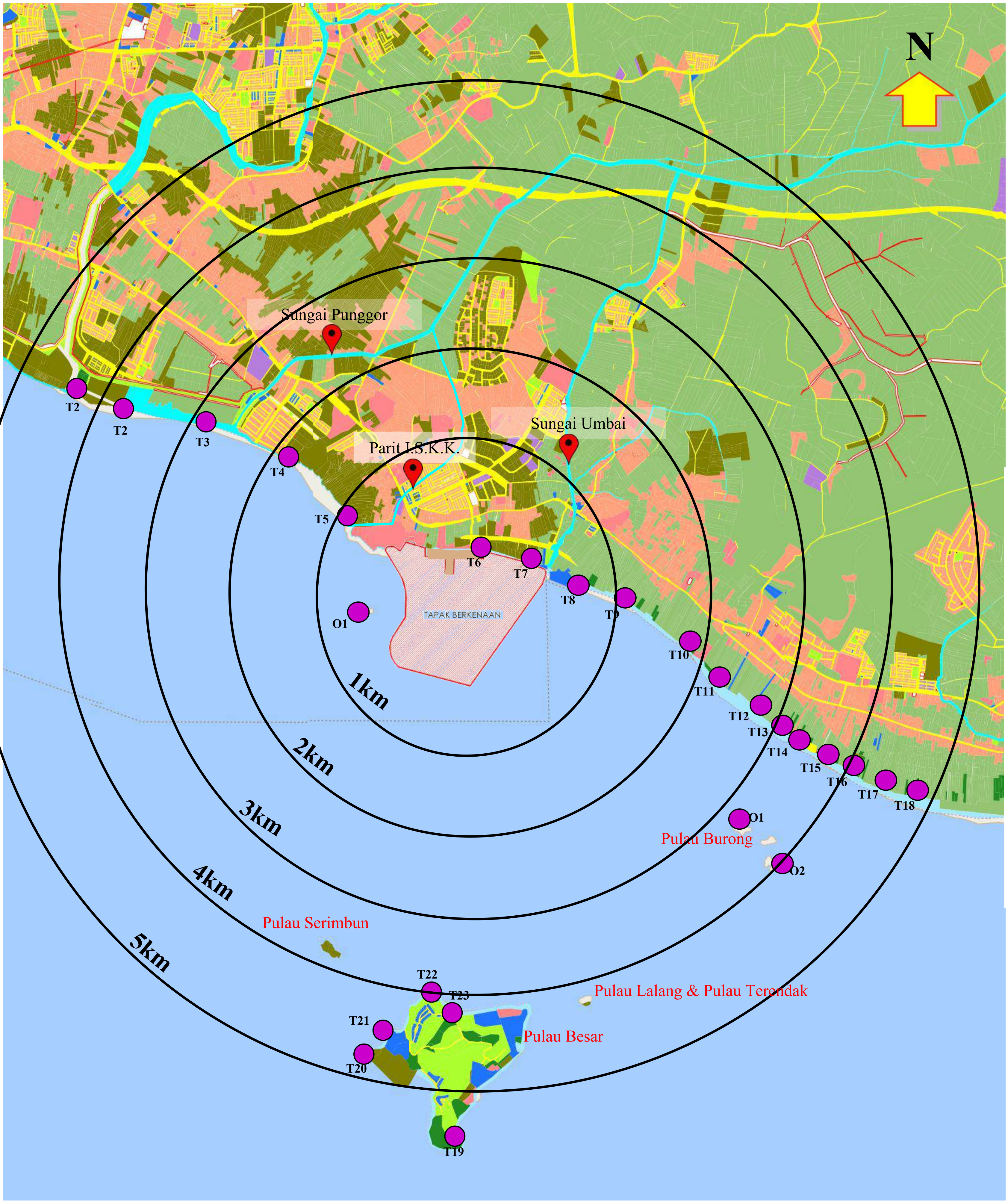
- The coastal forest and vegetation types at and adjacent to the project site. Focus was on mangroves found along the shoreline and rivers astride the proposed project area as well as Pulau Besar, Pulau Burung Kecil, Pulau Burung Besar and Pulau Menatang.
- Coral reef status and health at Pulau Burung Besar, Pulau Burung Kecil, Pulau Lalang, Pulau Serimbun and Pulau Besar.

a) Mangrove Assessment

The health and status of the mangroves found at and within the project site was undertaken using line-transect sampling. A total of 23 transects (T1-T23) were involved. Of the 23, five (5) transects (T1-T1) located along coastal area of Sg. Duyong to Telok Mas, two (2) transects (T6 – T7) fronting the reclamation footprint, 11 transects (T8- T18) located along coastal area of Umbai to Kg. Serkam and five (5) transects in Pulau Besar (T19-T23). Visual assessment of mangroves was also undertaken for Pulau Burung Kecil, Pulau Burung Besar and Pulau Menatang (O1-O3). The location and description of the sampling stations are provided in **Table 6.38**; **Figure 6.28**.

At each transect line:

- A pole starting at the edge of a mangrove forest marked the first point. It was important to ensure that transect line is long enough to cover the habitat particularly the succession line.
- The transect tape was laid until it reached the other end of the mangrove forest in a straight line, and the end point was also marked by a pole (**Plate 6.5A**).
- Quadrates (10.0 m x 10.0 m) were marked off against the transect line (**Plate 6.5B**).
- Major characteristics within the line such as sediment type, number of trees, mangrove speciation, girth sizes, height and epifauna type were recorded (**Plate 6.5C**).



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● Mangrove Transect Line

Figure 6.28: Location of the Transects for Mangrove Assessment

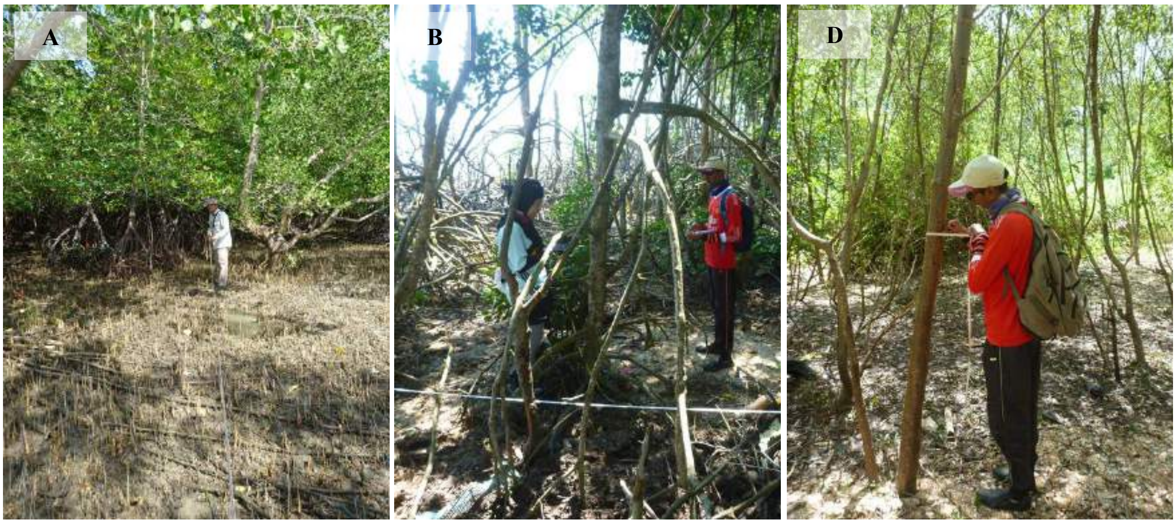
Table 6.38: Description of the Transects for Mangrove Assessment

Transect	Date	Coordinate				Transect Line (m)	Quadrate	Location
		Latitude	Longitude	Latitude	Longitude			
		Start		End				
T1	280418	02°10.311'	102°17.648'	02°10.335'	102°17.660'	50	5	Sg. Duyong
T2	280418	02°10.272'	102°17.825'	02°10.242'	102°18.030'	380	38	Sg. Duyong
T3	100119	02°10.212'	102°18.174'	02°10.239'	102°18.178'	50	5	Sg. Punggur
T4	100119	02°09.873'	102°18.790'	02°09.893'	102°18.808'	40	4	Next to Taman Alai Perdana
T5	100119	02°09.621'	102°18.981'	02°09.633'	102°18.999'	40	4	Telok Mas
T6	100119	02°09.397'	102°19.623'	02°09.360'	102°19.724'	180	18	Pernu
T7	100119	02°09.360'	102°19.952'	02°09.381'	102°19.964'	50	5	Pernu
T8	100119	02°09.215'	102°20.477'	02°09.237'	102°20.490'	50	5	Umbai
T9	100119	02°09.157'	102°20.644'	02°09.175'	102°20.658'	40	4	Umbai
T10	100119	02°08.958'	102°20.934'	02°08.967'	102°20.943'	30	3	Anjung Batu
T11	090119	02°08.752'	102°21.145'	02°08.765'	102°21.157'	30	3	Anjung Batu
T12	121118	02°08.624'	102°21.295'	02°08.647'	102°21.307'	50	5	Anjung Batu
T13	121118	02°08.546'	102°21.432'	02°08.566'	102°21.448'	50	5	Pantai Siring
T14	121118	02°08.427'	102°21.646'	02°08.401'	102°21.678'	70	7	Pantai Siring
T15	280418	02°08.291'	102°21.837'	02°08.311'	102°21.849'	40	4	Kg. Pulai
T16	280418	02°08.240'	102°21.927'	02°08.261'	102°21.935'	40	4	Kg. Pulai
T17	151118	02°08.099'	102°22.180'	02°08.119'	102°22.192'	30	3	Kg. Serkam
T18	151118	02°08.045'	102°22.293'	02°08.072'	102°22.305'	50	5	Kg. Serkam
T19	131118	02°06.322'	102°19.670'	02°06.270'	102°19.661'	80	8	Pulau Besar

Transect	Date	Coordinate				Transect Line (m)	Quadrate	Location
		Latitude	Longitude	Latitude	Longitude			
		Start		End				
T20	141118	02°06.833'	102°19.293'	02°06.817'	102°19.309'	40	4	Pulau Besar
T21	141118	02°06.726'	102°19.194'	02°06.730'	102°19.216'	50	5	Pulau Besar
T22	141118	02°06.992'	102°19.576'	02°06.984'	102°19.563'	30	3	Pulau Besar
T23	141118	02°06.982'	102°19.618'	02°06.972'	102°19.632'	30	3	Pulau Besar
O1	151118	02°07.934' N, 102°21.323' E				-	-	Pulau Burung Kecil
O2	151118	02°07.728' N, 102°21.514' E				-	-	Pulau Burung Besar
O3	151118	02°09.123' N, 102°19.098' E				-	-	Pulau Menatang

- Identification of trees (up to genus or species level) was undertaken mainly using form and root type, bark mottling patterns, leaf characteristics and bole and bough shape. The mangroves were identified based on the several books, such as by Primavera *et al* (2004) and Rusila Noor *et al*. (1999).

Plate 6.5: Mangrove Assessment. A: Employed Line Transect, B: Marked 10.0 m x 10.0m Quadrate Against the Transect Line, C: Measure the Girth Size of Mangrove Tree



b) Coral Reef Assessment

For the coral reef assessment, diving surveys was undertaken at Pulau Besar, Pulau Lalang, Pulau Serimbun Pulau Burung Kecil and Pulau Burung Besar. The survey was undertaken on and 13th – 15th November 2018.

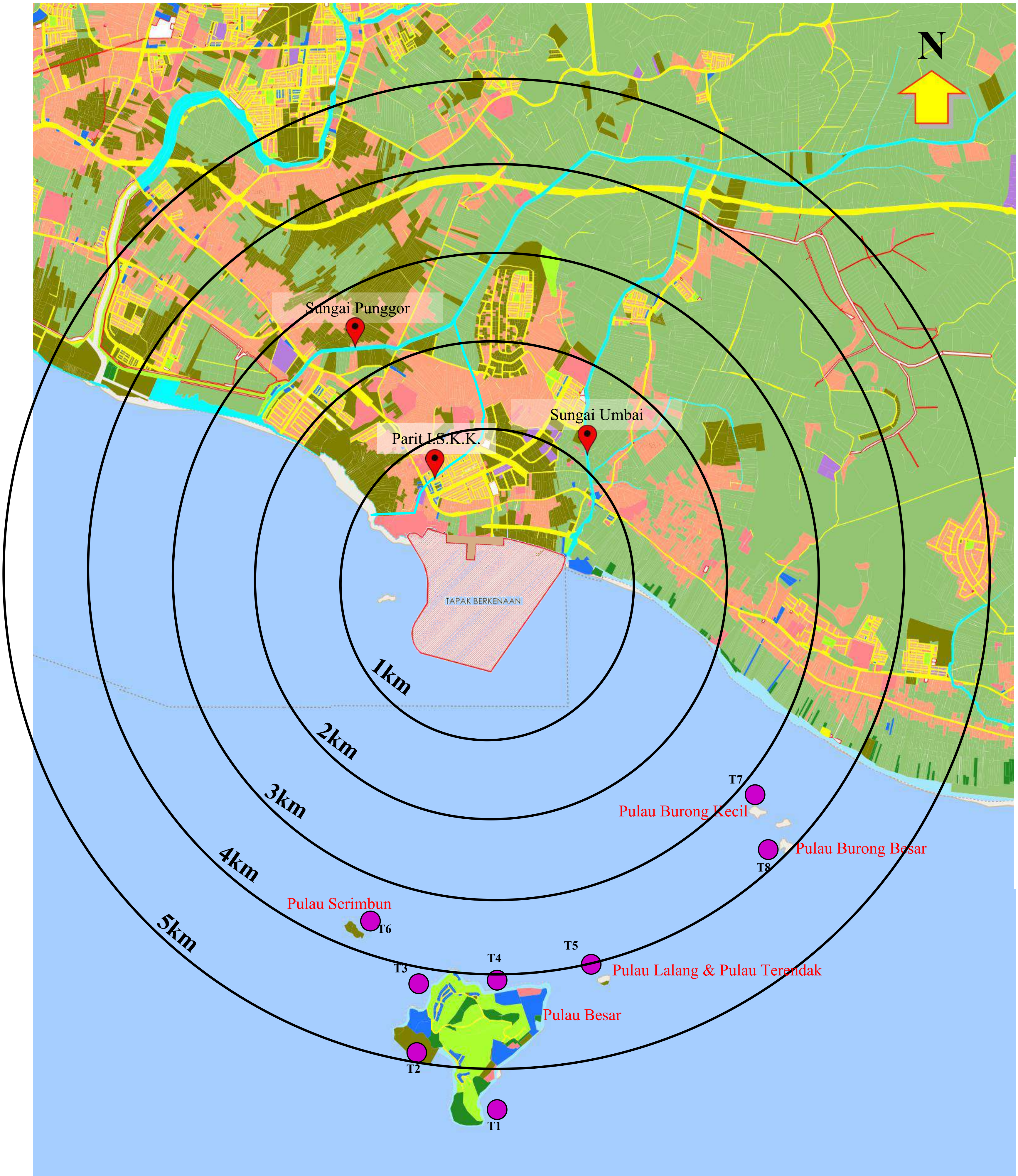
A total of eight (8) dive sites were involved i.e. four at Pulau Besar (T1-T4), and one dive site each for Pulau Lalang (T5), Pulau Serimbun (T6), Pulau Burung Kecil (T7) and Pulau Burung Besar (T8). The durations of diving at each station ranged from 45 – 60 minutes. The weather during the dive survey was sunny, sea conditions were characterized by moderate currents and poor (0.3 - 0.5 m) to moderate visibility (1-2 m).

A cell-based method was used to assess the sessile benthic community of the reefs and establish the diversity, density and health status of reefs at each islands. The survey method used was a variation of the Bohsack and Bannerot method (1986) and Line Intercept Transect (LIT) method by English *et al.* (1994) with minor modifications were undertaken to conform to the cell-based layout. Cells were arranged in parallel rows, stretching from the coastline to the outermost seaward limit of the project. The location and description of the each sampling stations are provided in **Table 6.39; Figure 6.29.**

The general procedure employed at each site was as follows:

- The positions of each cell or line were established and respective positions were plotted by GPS. Once these positions were established, a team of divers laid transect lines started from coastal area to the coral edge (further offshore), approximately 100m long (depending on the coral areas) using a measuring tape.
- Afterwards, the divers left the survey area for 10 minutes to allow normal fish activity to resume.
- When the divers returned, they recorded species of coral/fish/other organisms on the polyester data sheet along the transect line.
- The coral species were identified up to genera/species level where possible in the field or after the dive were completed using field guidebooks. Among the references that provided background material for the identification of species but not limited to were Kelley (2009), Veron (2000), Janes and Lee (2007), Fabricius and Alderslade (2001), Allen and Steen (1999), van Ofwegen *et al.* (2000), Tullock (1997), Delbeek and Sprung (1994), Chou (1988), van Ofwegen (1987), Millis (1985) and Searle (1980).

As for Pulau Menatang, only visual observation of coral reefs was undertaken due to strong winds, shallower water (<0.5 m) and high turbidity (poor visibility <10 cm) (**Plate 6.6G-H**) that restricted accessibility to the island. Further, there were no proper areas to moor the boat near the island to allow the divers to undertake the survey.



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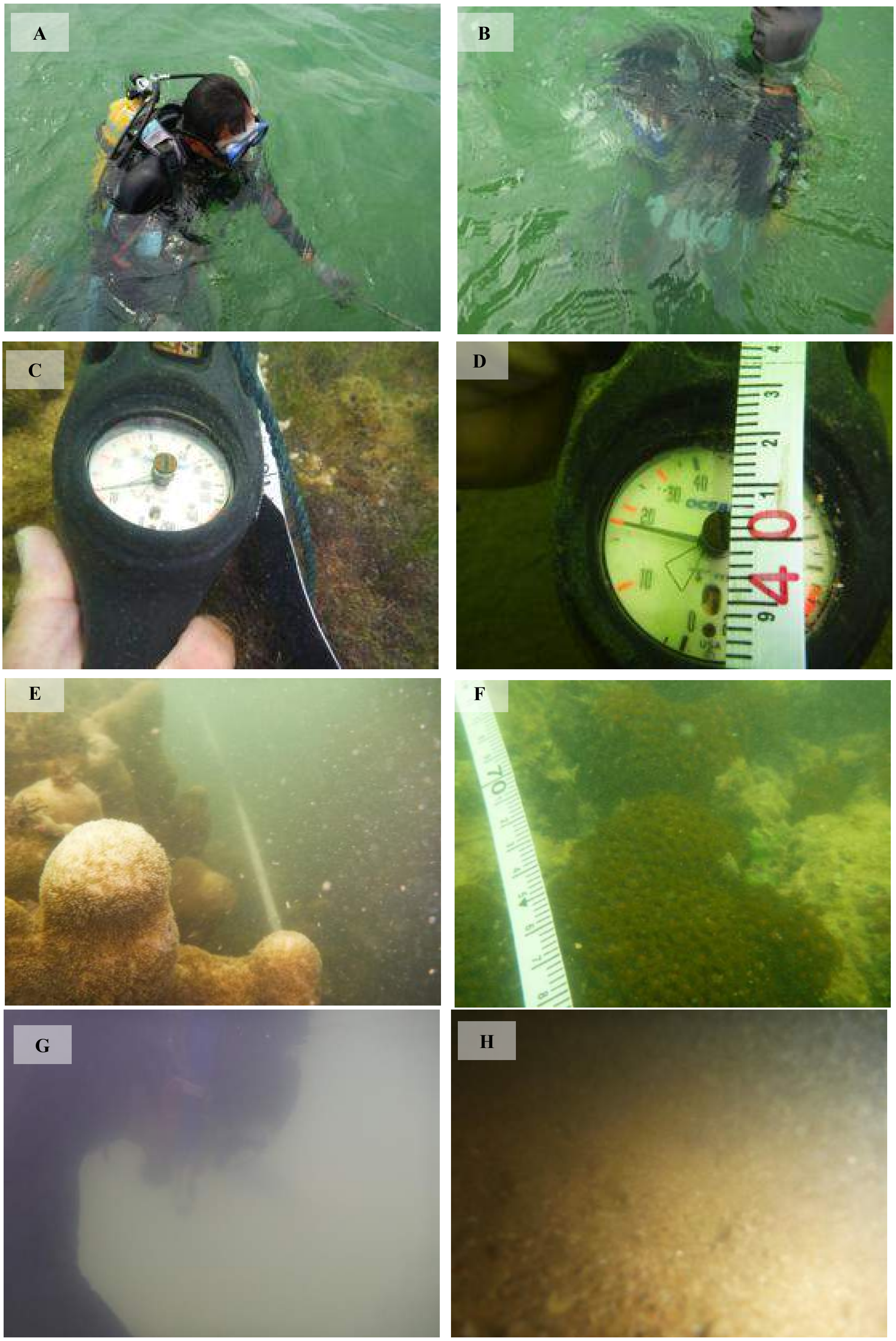
Coral Divie Site

Figure 6.29: Location of the Dive Sites at the Study Area

Table 6.39: Description of the Dive Sites for Coral Reef Assessment

Transect	Coordinate				Description					
	Latitude	Longitude	Latitude	Longitude	Date	Time	Weather	Transect Line (m)	Depth (m)	Visibility (cm)
	Start		End							
Pulau Besar										
T1	2° 06.263'	102° 19.699'	2° 06.229'	102° 19.740'	131118	1100	Sunny	100	10	1.5
T2	2° 06.607'	102° 19.358'	2° 06.565'	102° 19.319'	131118	1300	Sunny	100	6	0.5
T3	2° 06.977'	102° 19.372'	2° 07.019'	102° 19.334'	131118	1200	Cloudy	100	3	1.2
T4	2° 06.974'	102° 19.742'	2° 07.015'	102° 19.741'	141118	1000	Cloudy	100	2	0.3
Pulau Lalang										
T5	2° 06.999'	102° 20.428'	2° 07.018'	102° 20.377'	141118	1100	Cloudy	100	6	1.2
Pulau Serimbun										
T6	2° 07.280'	102° 18.951'	2° 07.335'	102° 18.975'	141118	1230	Sunny	100	3	1.8
Pulau Burung Kecil										
T7	2° 07.955'	102° 21.308'	2° 07.965'	102° 21.253'	151118	1300	Sunny	100	3	1.2
Pulau Burung Besar										
T8	2° 07.729'	102° 21.445'	2° 07.773'	102° 21.415'	151118	1400	Sunny	100	5	1.0

Plate 6.6: <u>Coral Reef Assessment. A-F: Coral Reef Survey undertake at T1 -T8, G-H: Poor Visibility at Pulau Menatang</u>



c) Marine Turtle Assessment

There are no marine parks and fisheries prohibited areas located within the impact zone of the study area. However, marine turtle landing sites have been recorded. Marine turtle assessment at Melaka is based on secondary data from Department of Fisheries, Melaka and other secondary data (reports, journals).

6.10.2.4 Fisheries and Aquaculture Assessment

The assessment covered major fish landing points and aquaculture activities within the impact zone at the study area.

a) Marine Capture Fisheries

Capture fisheries and recreational fisheries assessment was undertaken on 26th - 28 April 2018 based on the following:

- Discussion and interviews with sample fishing populations (fishermen) at Sg. Duyong, Punggur, Telok Mas, Umbai, Najung Batu, Pengkalan Siring and Serkam (**Table 6.40**).
- Visual appraisal of fish catch/landings at the major fish landing points located within the impact zone at the study area.
- Capture fisheries data were also requested from the Melaka State Fisheries Department.

A questionnaire was also prepared for this purpose (**Appendix XIII**).

Table 6.40: Location of the Fish Landing Points within the Impact Zone

Fish Landing Point	Coordinate		Date
	Latitude	Longitude	
Sg. Duyong	02° 10.740’	102° 17.343’	270418
Alai (Pengkalan Punggur)	02° 10.272’	102° 18.432’	270418
Telok Mas	02° 09.582’	102° 19.006’	151118
Umbai	02° 09.419’	102° 20.210’	110119
Anjung Batu	02° 08.699’	102° 21.252’	110119
Pantai Siring	02° 08.355’	102° 21.749’	151118
Serkam	02° 08.108’	102° 22.982’	151118

Plate 6.7: Interview with Fishermen at the Study Area

b) Aquaculture

Discussion and interviews with aquaculture farmers particularly mussel farms operate off Telok Mas to Pantai Siring were undertaken. A questionnaire was also prepared for this purpose (**Appendix XIII**). In addition, aquaculture data was also obtained from the Melaka State Fisheries Department.

Plate 6.8: Interview with Mussel Operators at the Study Area

c) Recreational Fisheries

Discussion and interviews with boat and *kelong* operators operates within 5km radius of study area. A questionnaire was also prepared for this purpose (**Appendix XIII**).

6.10.3 Findings

6.10.3.1 Marine Ecology

a) Phytoplankton

Phytoplankton are the main primary producers in the majority of aquatic ecosystems, thus constituting the base of the food chain for zooplankton as well as in other linked communities, such as benthos and nekton. In addition, the productivity of any water body is determined by the amount of plankton it contains because they are the major primary as well as secondary producers. In view of this relationship, primary productivity also closely correlates with fish yields.

Phytoplankton also plays an important role as bioindicators for pollution, mainly because it affects their distribution, standing crop and chlorophyll concentrations. In addition, their distribution, abundance, species diversity and species compositions are used to assess the biological integrity of the water body (Townsend *et al*., 2000). Furthermore the concept of bioindicators can be extended beyond the presence/ absence by relating abundance, biomass or growths of algal species to environmental impacts in general or specific stress symptoms in particular.

The assessment of phytoplankton at the study area recorded three (3) different phyla i.e. Bacillariophyta, Dinoflagellata and Ocrophyta (**Table 6.41**). Bacillariophyta was the most abundant group in terms of species as well as densities at all sampling stations representing 98.2% of the total population of phytoplankton, while 1.34% was Dinoflagellata and 0.4% was Ocrophyta (**Chart 6.5**). The highest density of phytoplankton was recorded at S11 (within reclamation footprint) (180.58 cells/ml), followed by S10 (within reclamation footprint) (88.207 cells/ml) and S5 (foreshore area) (85.02 cells/ml), while the lowest was recorded at S2 (within reclamation footprint) (11.56 cells/ml) (**Chart 6.6**).

Bacillariophyta also known as diatoms are one of the most species-richest phytoplankton taxonomic groups. They have a worldwide distribution and can be found in both freshwater and marine environments (Quijano-Scheggia *et al.,* 2008). In marine environments, it is estimated that around 1,365 – 1,783 different planktonic diatoms species have been identified (Sournia *et al.,* 1991). Domination of Bacillariophyta (diatoms) generally indicates good marine water quality. Based on the study by Casea *et al.* (2008), diatoms normally form more than 80% of the total phytoplankton biomass in marine tropical waters. This is due to their critical role as primary producers as well as the key players in carbon and silicon cycles). The study by Mann (1999), estimated that, diatoms provided 20 – 25% of globally fixed carbon and atmospheric oxygen, thus influencing biogeochemical cycles worldwide.

Within the marine ecosystem, the Bacillariophyta is one of the most prolific group among other autotrophic eukaryotes population (Thompson, 1998). The bacillariophytes are responsible to sequester important biogeochemical cycles, where they contributed approximately 20% of the total primary production on Earth (Field *et al*., 1998).

Table 6.41: Phytoplankton Density (cells/ml) at Study Area

Taxa	Foreshore Area						Within Reclamation Footprint							Outside Reclamation Footprint					Off P. Besar & P. Burung	
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Phylum: Bacillariophyta																				
Amphora	-	0.25	-	-	-	0.25	-	-	-	-	-	0.25	-	-	-	-	-	0.25	-	-
Bacteriastrum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.75	-		-	-
Biddulphia	-	0.5	-	-	-	0.75	-	0.75	-	-	0.25	-	0.25	-	-	-	-	0.25	-	-
Cerataulina	-	0.25	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	1.51	-
Chaetoceros	-	-	-	-	-	2.26	-	-	-	-	-	1.51	-	-	-	-	-	-	-	3.52
Cocconeis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-
Coscinodiscus	2.51	-	6.79	-	0.75	-	1.51	0.50	0.50	-	3.77	0.25	0.50	0.50	0.25	1.00	0.25	-	-	-
Diploneis	-	-	-	0.25	-	0.25	-	-	-	-	0.25	-	-	-	0.50	-	0.5	-	-	0.50
Ditylum	-	0.50	-	-	-	-	0.25	-	1.51	-	1.00	-	-	0.50	-	0.25	-	-	1.00	-
Guinardia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-	0.75	1.00
Hemiaulus	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	0.50
Leptocylindrus	-	-	-	-	-	-	-	-	-	-	0.5	1.00	-	-	-	-	-	-	-	-
Navicula	-	0.25	-	0.25	-	1.00	-	-	-	0.75	-	0.50	-	-	-	-	-	-	0.25	-
Nitzschia	24.91	20.88	-	58.36	76.97	20.63	1.00	8.55	68.67	80.49	161.74	34.46	15.59	73.45	36.47	11.07	30.44	7.04	17.36	51.32
Pinnularia	-	-	-	-	-	-	-	-	-	-	-	0.25	0.25	-	-	0.25	0.25	0.50	-	-
Pleurosigma	1.76	0.75	0.75	-	-	-	0.50	1.25	2.26	1.76	-	2.01	0.25	0.25	2.52	0.75	1.00	0.50	0.75	-
Rhizosolenia	2.77	-	-	-	-	-	-	-	-	-	0.25	0.25	-	-	-	-	-	-	0.50	-
Skeletonema	-	1.51	-	-	-	4.02	-	-	-	-	-	-	1.51	-	4.78	2.01	4.28	1.51	-	7.29
Surirella	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.75	-	-	-	-
Thalassionema	0.50	-	2.01	1.51	1.26	5.28	4.53	5.28	-	-	8.30	3.02	0.50	0.50	0.50	3.27	-	-	2.52	3.52
Unidentified diatoms	3.52	-	4.78	3.77	5.79	3.52	3.52	1.51	2.51	4.02	3.77	2.01	5.28	3.02	3.02	2.52	3.02	3.27	-	9.05
Subtotal (cells/ml)	**35.97**	**24.64**	**14.33**	**64.14**	**84.77**	**37.71**	**11.31**	**17.84**	**75.45**	**88.02**	**179.83**	**45.26**	**24.13**	**78.22**	**48.04**	**22.62**	**39.99**	**13.07**	**24.89**	**76.70**

Taxa	Foreshore Area						Within Reclamation Footprint							Outside Reclamation Footprint					Off P. Besar & P. Burung	
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Phylum: Dinoflagellata																				
Ceratium	0.25	-	1.26	-	-	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-	
Peridinium	-	0.25	0.25	-	0.25	0.75	-	0.25	-	0.25	0.75	0.5.	-	-	-	1.00	-	0.25	1.00	3.02
Prorocentrum	0.75	0.25	0.50	0.25	-	-	0.25	-	-	-	-	-	-	0.25	-	-	-	-	0.50	0.75
Subtotal (cells/ml)	**1.00**	**0.50**	**2.01**	**0.25**	**0.25**	**0.75**	**0.25**	**0.50**	**0.00**	**0.25**	**0.75**	**0.50**	**0.00**	**0.25**	**0.00**	**1.00**	**0.00**	**0.25**	**1.50**	**3.77**
Phylum: Ocrophyta																				
Dictyocha	-	-	-	3.52		0.50	-	-	0.25	-	-	-	-	0.25	-	-	-	-	-	-
Subtotal (cells/ml)	**0.00**	**0.00**	**0.00**	**3.52**	**0.00**	**0.50**	**0.00**	**0.00**	**0.25**	**0.00**	**0.00**	**0.00**	**0.00**	**0.25**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Density (cells/ml)	**36.97**	**25.14**	**16.34**	**67.91**	**85.02**	**38.96**	**11.56**	**18.34**	**75.70**	**88.27**	**180.58**	**45.76**	**24.13**	**78.72**	**48.04**	**23.62**	**39.99**	**13.32**	**26.39**	**80.47**
Shannon Wiener Diversity Index (H')	**1.18**	**0.82**	**1.49**	**0.59**	**0.39**	**1.59**	**1.51**	**1.45**	**0.45**	**0.411**	**0.50**	**1.08**	**1.09**	**0.34**	**0.89**	**1.77**	**0.88**	**1.39**	**1.35**	**1.31**

Chart 6.5: <u>Phytoplankton Composition at the Study Area</u>

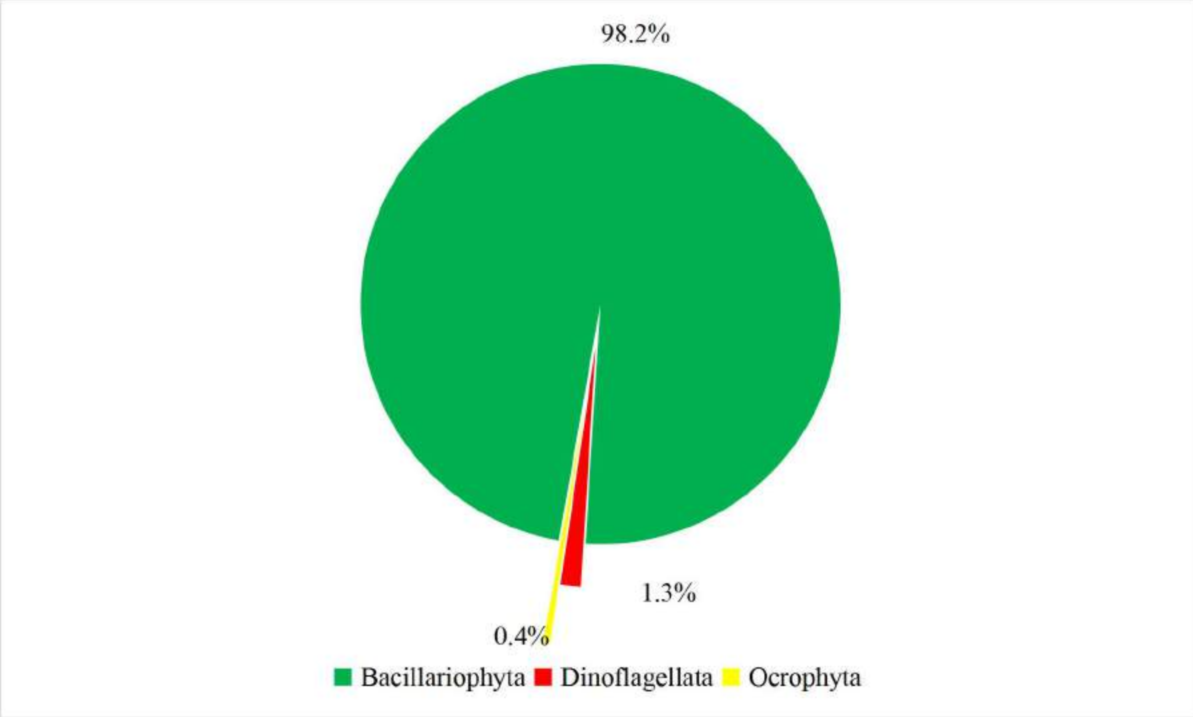
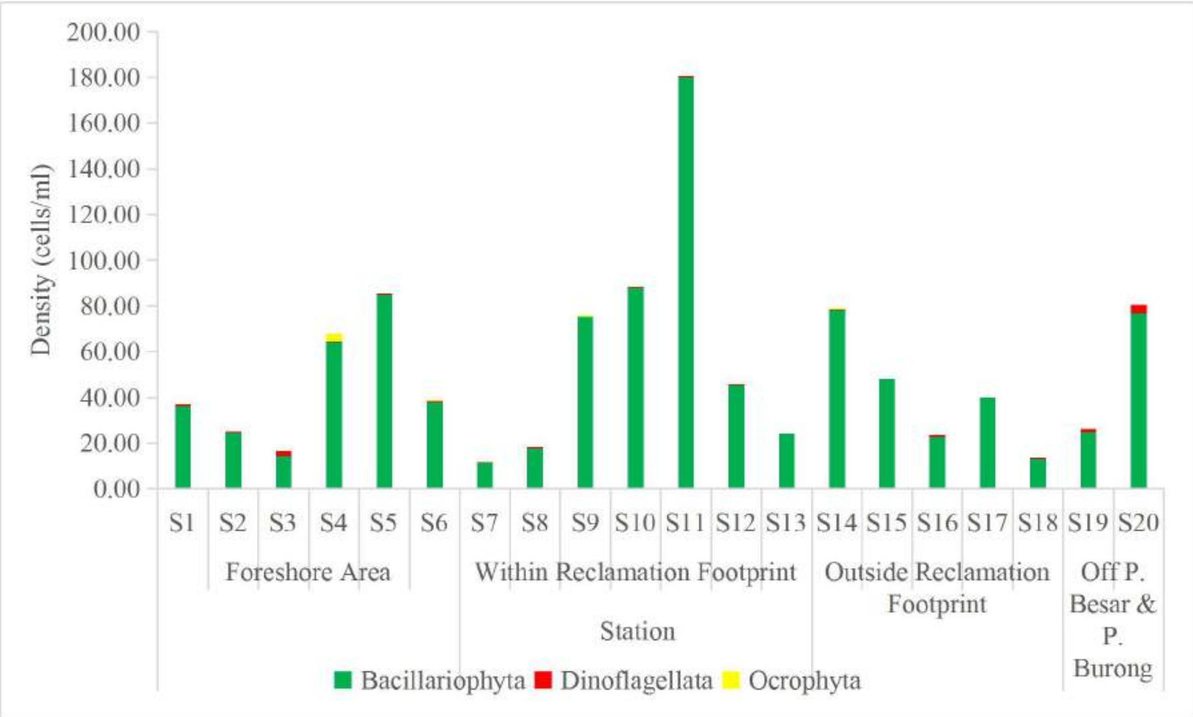


Chart 6.6: <u>Phytoplankton Density (cells/ml) at the Study Area</u>



A total of 21 taxa of Bacillariophyta were recorded at the study area, where 16 taxa recorded within 1km and 2km radius, while 14 taxa and 13 taxa within 4 km and 3km radius of proposed reclamation footprint respectively. The average density of bacillariophytes recorded at 50.35±39.87 cells/ml or ranged from 11.31 – 179.83 cells/ml. In terms of speciation, a significantly high abundance of *Nitzschia* was recorded at the study area, accounting for 79.4% of the total Bacillariophyta density. This taxa was found at all survey area, with the mean density recorded at 42.07±38.58 cells/ml or ranged from 1.00 - 161.74 cells/ml.

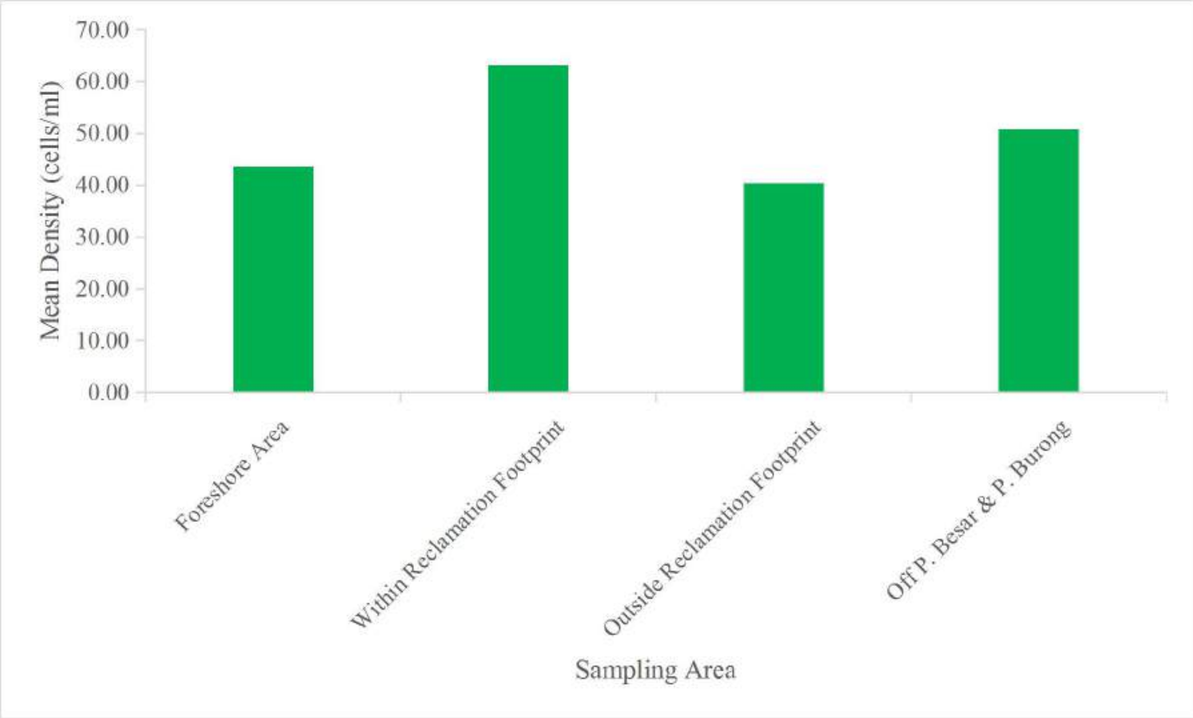
Previous studies reported that *Nitzschia* are commonly predominant in coastal waters off Malaysia and usually found in higher abundance than other taxa (Siti Zubaidah *et al.,* 2003; Matias *et al.*, 2001; Chua and Chong, 1975). Other taxa recorded mean density ranged from 0.05 – 1.35 cells/ml.

On the whole, the highest mean density of Bacillariophytes recorded within reclamation footprint (63.12±59.11 cells/ml and ranged from 11.31 – 179.83 cells/ml) and off Pulau Besar and Pulau Burong (50.80±36.64 cells/ml and ranged from 24.89 – 76.70 cells/ml). Mean density at foreshore stations and outside the reclamation footprint recorded at 43.59±26.17 (14.33 - 84.77) cells/ml and 40.39±25.26 (13.07 - 78.22) cells/ml respectively (**Chart 6.7**).

Dinoflagellata was represented by *Ceratium*, *Peridinium* and *Prorocentrum*, with mean density of 0.69±0.68 (0 - 3.77) cells/ml. The dominant taxon was *Peridinium*, accounting more than half (61.8%) of the total dinoflagellates density.

According to Ismael and Maria Del Socorro (2008), *Peridinium* was a large genus of small-to-medium-sized dinoflagellates in the marine ecosystem. Where HAB (Harmful Algal Blooms) concerned, study by Cembella (2003) reported that about 75 - 80% of toxic phytoplankton species are dinoflagellates. The toxic species can cause 'red tides' that will directly kill fish and shellfish due to toxin production, or indirectly kill because of effects caused by large numbers of cells that clog animal gills and deplete oxygen.

Chart 6.7: Mean Density (cells/ml) of Phylum Bacillariophyta at the Study Area



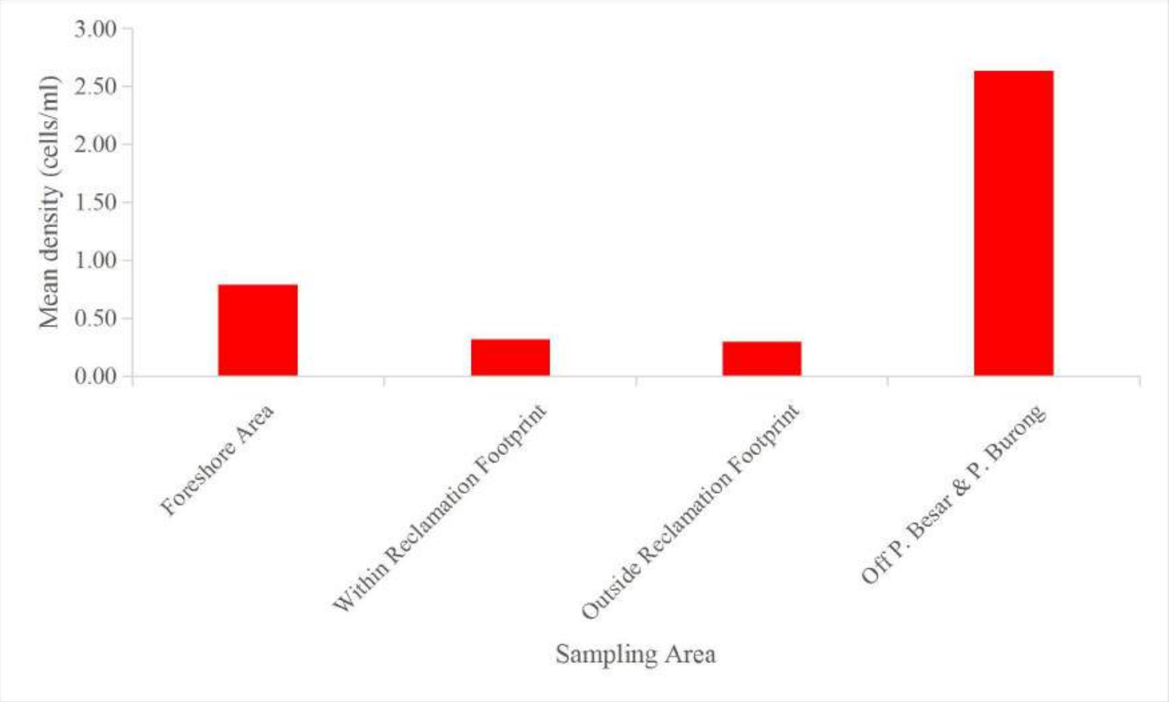
Note: Foreshore area (S1 - S6)
Within reclamation footprint (S7 – S13)
Outside reclamation footprint (S14 – S18)
Off P. Besar & P. Burong (S19 – S20)

For instance, blooms of *Peridinium quinquecorne* reported in lagoon of La Ensenada de La Paz, Gulf of California with an abundance ranged from 3,400 – 6,400 cells/ml (Ismael and Maria Del Socorro, 2008). However, this density is far higher than that recorded during the current study, indicating that the waters in the area do not support red tide blooms, at least at the time of sampling. However, the presence of HABs taxa during current study obviously of concern and need to be monitored.

On the whole, the highest mean density of dinoflagellate recorded at off Pulau Besar and Pulau Burong (2.64±1.60 cells/ml and ranged from 1.50 – 3.77 cells/ml). Tme mean density of dinoflagellata at other area was recorded less than 1.00 cells/ml (**Chart 6.8**).

As for Ocrophyta, it was represented by *Dictyocha*. The contribution of this taxa to the density of phytoplankton at study area seems to be small. It was only recorded at S4 (3.52 cells/ml), S6 (0.5 cells/ml), S9 (0.25 cells/ml) and S14 (0.25 cells/ml).

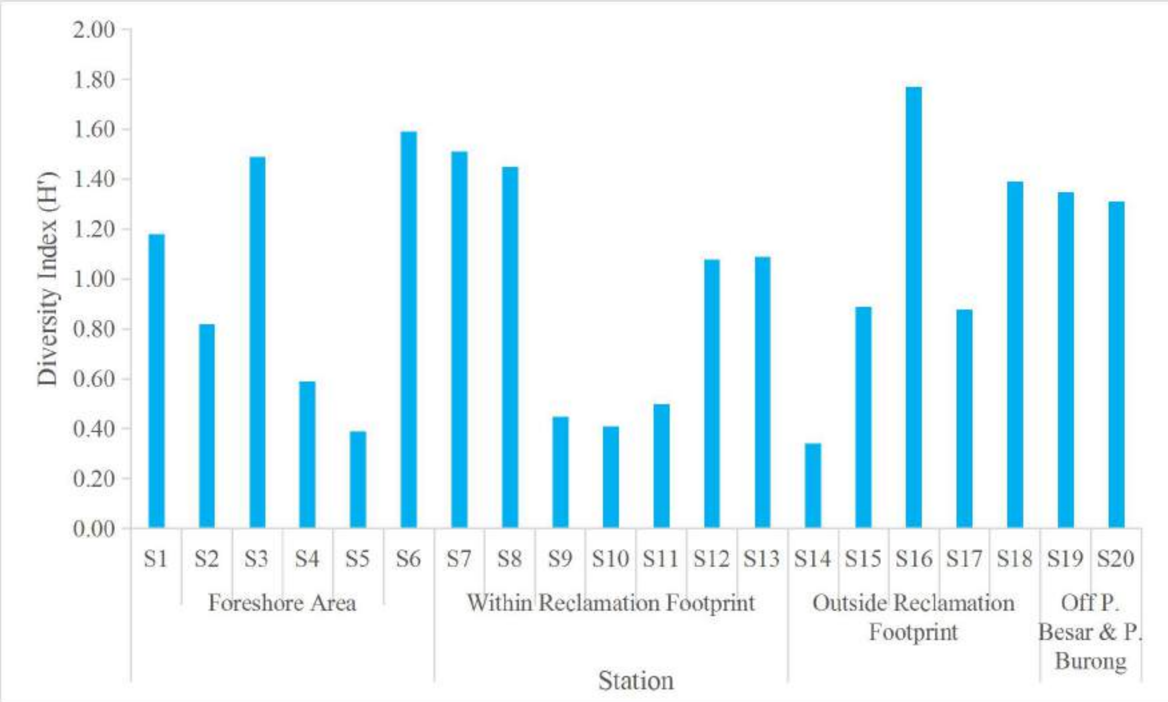
Chart 6.8: Mean Density (cells/ml) of Phylum Dinoflagellata at the Study Area



Note: Foreshore area (S1 - S6)
Within reclamation footprint (S7 – S13)
Outside reclamation footprint (S14 – S18)
Off P. Besar & P. Burong (S19 – S20)

Overall, the mean phytoplankton density at the study area was 51.26 cells/ml and ranged from 11.56 – 180.58 cells/ml. Most of taxa found during current study was a common species found in Malaysian waters. Species diversity is an important aspect of biological monitoring and a reliable parameter to determine how healthy an environment is. The mean Shannon Weiner Diversity Index (H') recorded at 1.02, where most of the stations found to be moderately diverse. The highest value recorded at S16 (1.77) and the lowest value at S14 (0.34), with both stations being located off reclamation footprint (**Chart 6.9**).

Chart 6.9: Phytoplankton Diversity Index (H') at the Study Area



b) Zooplankton

Zooplankton is an ecological community that serves as important trophic linkage between the primary producers (phytoplankton) and upper trophic level organisms in an aquatic food web. Zooplankton, like phytoplankton, are sound indicators of environmental conditions because they are sensitive to changes in water quality. Their distribution in the marine environment is governed by several abiotic and biotic factors such as salinity, temperature and food availability. Moreover, they also respond to a wide variety of disturbances including nutrient loading, acidification, contaminants, forage fish and sediment inputs.

The zooplankton distribution in the study area is shown in **Table 6.42**. There were a total of seven (7) phyla recorded i.e. Arthropoda (Crustacea), Ciliophora, Cnidaria, Chordata, Chaetognatha, Mollusca and Annelida. Arthropoda, which contributed 93.4% of the total zooplankton density, was the major group in this area, followed by Ciliophora with 4.8%. Other phyla contributed less than 1.0% (**Chart 6.10**). The highest zooplankton density was recorded at S17 (outside reclamation footprint) (201.50 ind./l), followed by S6 (foreshore area) (45.20 ind./l) and S3 (foreshore area) (44.16 ind./l), while lowest at S15 (2.54 ind./l) (outside reclamation footprint) (**Chart 6.11**).

Table 6.42: Zooplankton Density (ind./l) and Diversity (H') at the Study Area

Taxa	Foreshore Area						Within Reclamation Footprint							Off Reclamation Footprint					Off P. Besar & P. Burong	
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Phylum: Arthropoda																				
Class Malacostraca																				
Copepoda																				
Nauplii	7.50	0.54	8.16	8.30	4.40	17.20	3.84	6.00	4.00	2.60	1.20	1.44	1.84	2.48	0.18	2.40	134.50	0.40	0.35	2.20
Copepodids	0.50	0.60	5.16	2.30	3.20	4.40	5.16	3.90	1.90	1.80	2.56	2.16	0.72	1.20	0.14	0.50	9.50	0.40	0.25	1.00
Calanoids																				
Acartia	-	-	0.12	0.40	0.40	1.20	0.36	0.60	-	0.20	0.32	0.24	0.08	0.40	0.04	-	1.00	0.20		0.05
Bestiolina	-	-	0.48	1.40	-	-	1.68	2.10	0.70	0.70	2.16	0.64	0.56	2.16	-	-	-	-	-	-
Calanus	-	-	0.36	-	-	-	0.36	0.20	0.10	-	-	-	-	-	-	-	-	-	-	-
Eucalanus	19.00	1.96	24.84	16.20	14.00	12.00	14.88	14.40	9.90	6.10	8.16	4.56	2.00	5.52	1.22	2.54	37.00	2.60	0.85	2.20
Paracalanus	-	0.48	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.56	3.00	-	-	0.35
Labidocera	0.50	-	-	0.10	-	-	-	0.10	-	-	-	-	-	0.08	-	-	-	-	-	-
Cyclopoids																				
Oithona	2.00	1.56	1.32	2.70	3.60	4.00	1.68	1.60	6.40	3.90	5.04	3.76	2.24	-	0.52	1.82	4.00	2.80	2.00	2.15
Harpacticoid																				
Euterpina	1.00	0.22	1.44	1.20	2.40	0.80	1.56	2.10	1.90	1.80	2.08	1.68	1.36	0.96	0.08	1.24	0.50		0.15	0.15
Microsetella	-	-	-	-	-	-	-	0.10	-	-	0.16	-	-	-	-	-	0.50	0.20	0.10	-
Poecilostomatoid																				
Corycaeus	-	0.16	-	-	-	-	-	-	0.10	-	-	0.24	0.16		0.18	0.16		1.00	0.10	0.12
Oncaea	-		0.24	-	-	0.40	0.24	0.50	-	0.10	0.08	-	-	0.08	-	-	-	0.20	-	0.05
Decapoda																				
Unidentified decapod larvae	-	-	-	0.10	0.40	-	0.12	0.50	-	0.10	0.16	-	-	0.16	-	-	-	-	-	-
Subtotal (ind./l)	**30.50**	**5.52**	**42.12**	**32.70**	**28.40**	**40.00**	**29.88**	**32.10**	**25.00**	**17.30**	**21.92**	**14.72**	**8.96**	**13.04**	**2.38**	**9.22**	**190.0**	**7.80**	**3.80**	**8.27**

Taxa	Foreshore Area						Within Reclamation Footprint							Off Reclamation Footprint					Off P. Besar & P. Burong	
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Phylum: Ciliophora																				
Favella	2.00	-	0.36	0.50	-	1.20	0.12	0.10	0.10	-	-	-	-	-	-	-	11.00	-	-	-
Tintinopsis	2.00	0.14	0.72	0.30	2.00	3.60	0.24	0.10	0.20	0.60	0.08	0.64	0.64	0.40	0.08	0.26	0.50	0.60	-	0.25
Subtotal (ind./l)	**4.00**	**0.14**	**1.08**	**0.80**	**2.00**	**4.80**	**0.36**	**0.20**	**0.30**	**0.60**	**0.08**	**0.64**	**0.64**	**0.40**	**0.08**	**0.26**	**11.50**	**0.60**	**0.00**	**0.25**
Phylum: Cnidaria																				
Diphyes	-	-	-	-	-	-	-	-	-	-	-	-	0.08	-	-	-	-	0.40	-	-
Unidentified jelly fish	0.50	-	-	-	-	0.40	-	-	-	-	-	-	-	-	-	-	-	0.20	-	-
Subtotal (ind./l)	**0.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.40**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.08**	**0.00**	**0.00**	**0.00**	**0.00**	**0.60**	**0.00**	**0.00**
Phylum: Chordata																				
Oikopluera	-	-	0.36	-	-	-	0.24	0.30	0.10	-	-	-	-	-	0.02	0.02		0.20	0.05	-
Subtotal (ind./l)	**0.00**	**0.00**	**0.36**	**0.00**	**0.00**	**0.00**	**0.24**	**0.30**	**0.10**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.02**	**0.00**	**0.20**	**0.05**	**0.00**
Phylum: Chaetognatha																				
Sagitta	-	-	0.48	0.20	-	-	-	0.60	0.10	0.10	0.08	-	-	-	-	0.04	-	1.00	-	0.05
Subtotal (ind./l)	**0.00**	**0.00**	**0.48**	**0.20**	**0.00**	**0.00**	**0.00**	**0.60**	**0.10**	**0.10**	**0.08**	**0.00**	**0.00**	**0.00**	**0.00**	**0.04**	**0.00**	**1.00**	**0.00**	**0.05**
Phylum: Molluska																				
Unidentified bivalve larvae	2.50	0.04	-	0.40	0.40	-	-	0.30	0.20	0.30	0.24	-	-	-	0.02	-	-	-	-	0.10
Subtotal (ind./l)	**2.50**	**0.04**	**0.00**	**0.40**	**0.40**	**0.00**	**0.00**	**0.30**	**0.20**	**0.30**	**0.24**	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**	**0.00**	**0.00**	**0.00**	**0.10**
Phylum: Annelida																				
Unidentified polychaete larvae	-	0.04	0.12	0.10	-	-	-	0.10	0.10	-	0.16	-	0.08	-	0.04	-	-	-	-	0.05
Subtotal (ind./l)	**0.00**	**0.04**	**0.12**	**0.10**	**0.00**	**0.00**	**0.00**	**0.10**	**0.10**	**0.00**	**0.16**	**0.00**	**0.08**	**0.00**	**0.04**	**0.00**	**0.00**	**0.00**	**0.00**	**0.05**

Taxa	Foreshore Area						Within Reclamation Footprint							Off Reclamation Footprint					Off P. Besar & P. Burong	
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Total Density (ind./l)	37.50	5.74	44.16	34.20	30.80	45.20	30.48	33.60	25.80	18.30	22.48	15.36	9.76	13.44	2.54	9.54	201.5	10.20	3.85	8.72
Shannon Weiner Diversity Index (H')	1.59	1.77	1.45	1.62	1.67	1.71	1.65	1.88	1.69	1.87	1.83	1.84	1.97	1.70	1.68	1.80	1.10	2.09	1.44	1.82

Chart 6.10: <u>Composition of the Zooplankton at the Study Area</u>

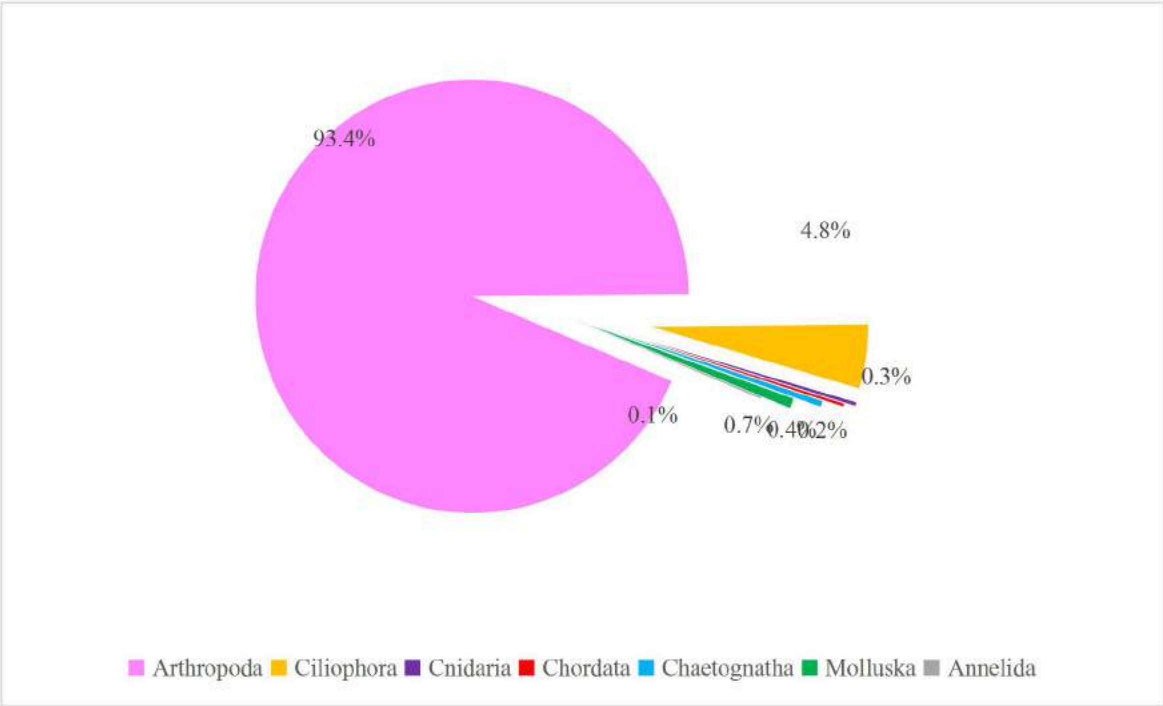
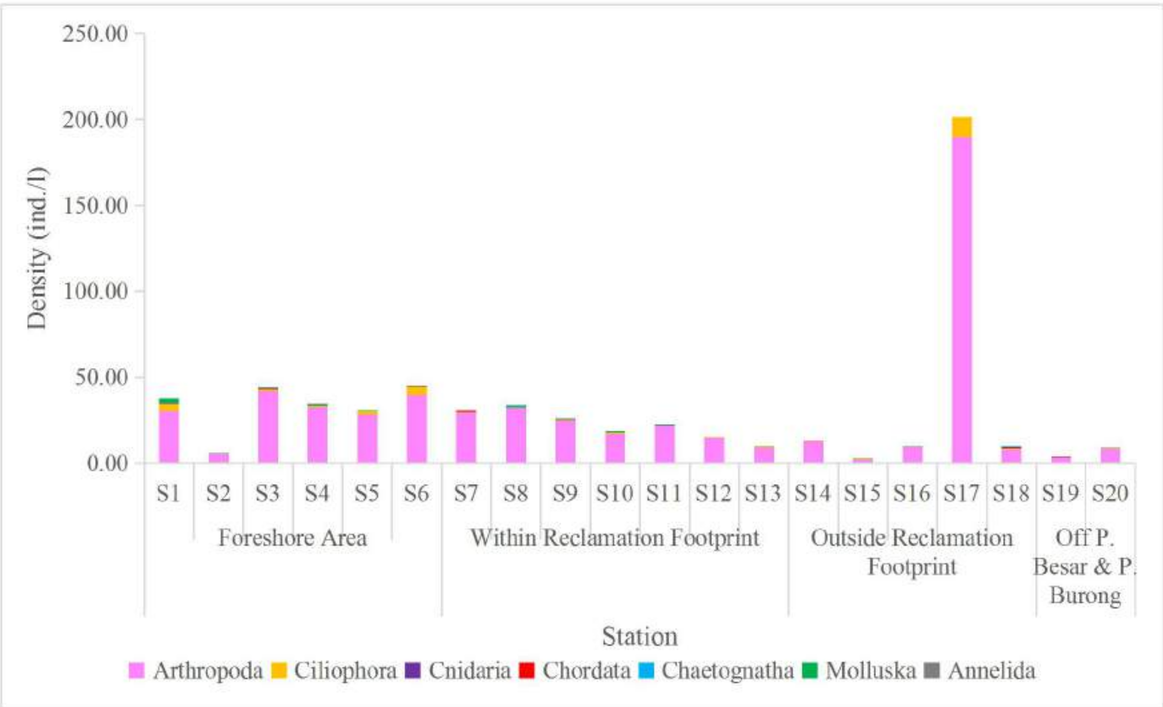


Chart 6.11: <u>Zooplankton Density (ind./l) at the Study Area</u>



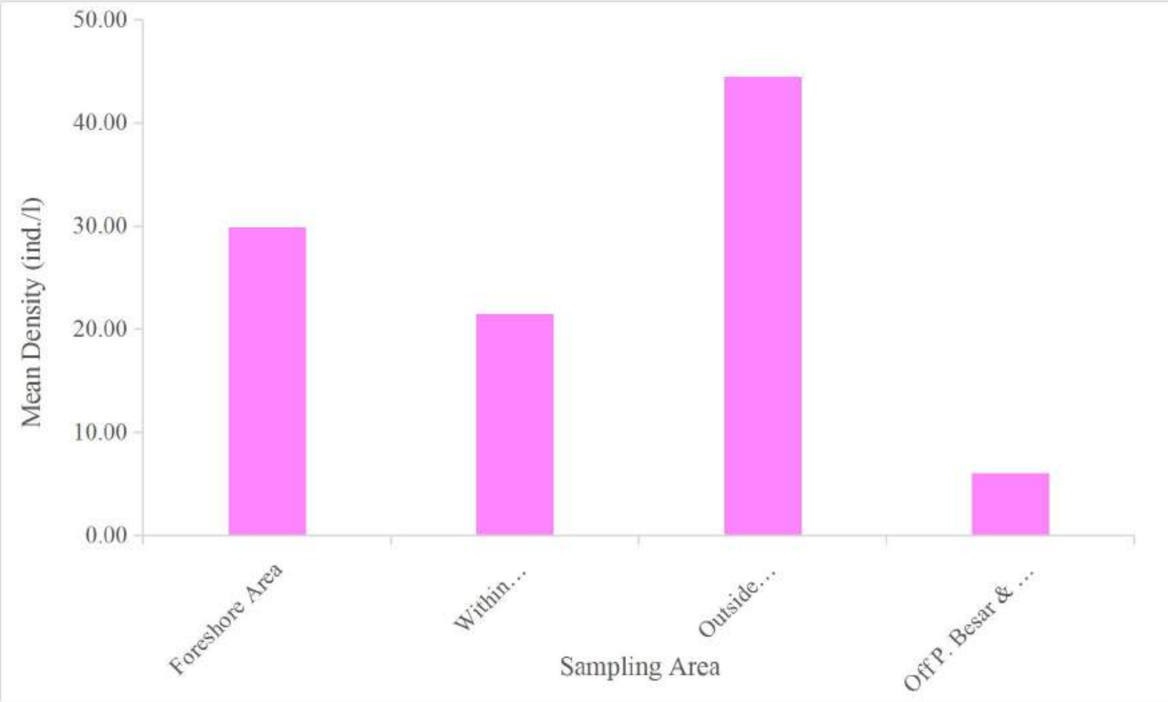
Zooplankton populations were dominated by Arthropoda (crustacean) with mean a density of 28.18 ind./l and ranged from 02.38 – 1.90 ind./l. The most dominant group was Copepoda, which constituted 99.7% of the total Arthropod density, while only 0.3% was contributed by Decapoda. Previous studies have showed that copepods to be distributed widely in seawater and account for 55 - 60% of the zooplankton populations in the Straits of Malacca (Rezai *et al.* 2011; Zannatul and Muktadir, 2009; Rezai 2002). According to Barnes *et al.* (1988), copepods dominate most aquatic ecosystems because of their resilience and adaptability to changing environmental conditions and ability to withstand varying environmental stresses. Copepods can hold up against harsh environmental conditions since they have the tough physical structures and versatile feeding habits (carnivorous and omnivorous) of all zooplankton (Ferdous and Muktadir, 2009).

A total of 14 taxa from Phylum Arthropoda were recorded at the study area. *Eucalanus* (Copepoda) was the most abundant taxa and constituted 35.5% of the total Arthropod density. The mean density of *Eucalanus* was recorded at 14.67 ind./l at foreshore area (S1 - S6), 8.57 ind./l within reclamation footprint (S7 - S13), 9.78 ind./l at area of outside the reclamation footprint (S14 - S18) and 1.53 ind./l area off P. Besar and P. Burong (S19 - S20). Studies showed that *Eucalanus* to be a common genus reported in Malaysian waters and usually found in high abundance (Johan *et al.*, 2013; Nakajima *et al.*, 2008).

On the whole, the highest mean density of arthropods were recorded in area outside the reclamation footprint (44.49 ind./l), followed by foreshore area (29.87 ind./l), within the reclamation footprint (21.41 ind./l) and area off P. Besar/P. Burong (6.04 ind./l) (**Chart 6.12**).

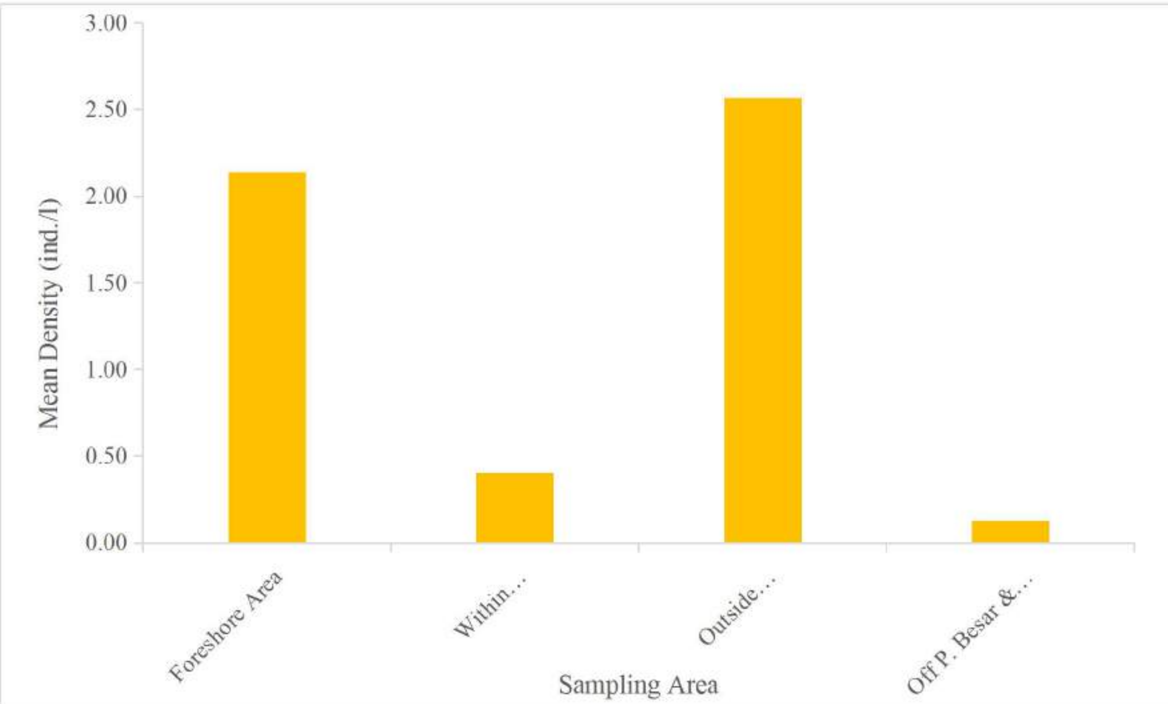
The second most abundant phylum was Ciliophora, which was represented by *Favella* and *Tintinopsis*. *Favella* and *Tintinopsis* are marine ciliates that consume about 60% of global marine primary production in the world's oceans. They are classified as neritic plankton and are be found only in nearshore and coastal waters (Dolan and Pierce, 2012). Their abundance is related to their complex behavior and their ability to capture prey efficiently and avoiding predators (Broglio *et al.*, 2001). Overall, the highest mean density of Ciliophora was recorded at area of outside the reclamation footprint (2.57 ind./l), followed by foreshore area (2.14 ind./l), within the reclamation footprint (0.40 ind./l) and area off P. Besar/P. Burong (0.13 ind./l) (**Chart 6.13**).

Chart 6.12: Mean Density (ind./l) of Phylum Arthropoda at the Study Area



Note: *Foreshore area (S1 - S6)*
Within reclamation footprint (S7 – S13)
Outside reclamation footprint (S14 – S18)
Off P. Besar & P. Burong (S19 – S20)

Chart 6.13: Mean Density (ind./l) of Phylum Ciliophora at the Study Area

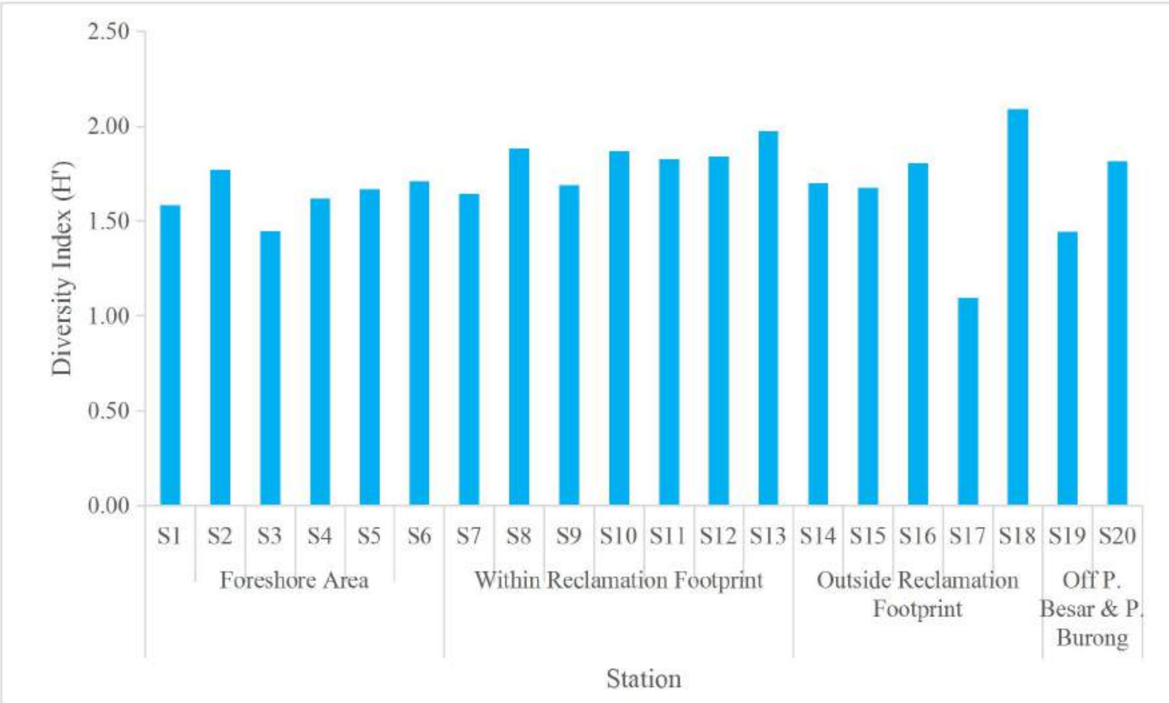


Note: *Foreshore area (S1 - S6)*
Within reclamation footprint (S7 – S13)
Outside reclamation footprint (S14 – S18)
Off P. Besar & P. Burong (S19 – S20)

Other phyla such as Mollusca, Chaegtognatha, Cnidaria, Chordata and Annelida were only present at low mean densities, ranging from 0.04 – 0.23 ind./l. Mollusca was represented by bivalve larvae, Chaegtognatha by *Sagitta*, Cnidaria by *Diphyes* and jelly fish, Chordata by *Oikopluera* and Annelida comprised of polychaete larvae.

Overall, the mean zooplankton density at the study area was 30.16 ind/l and ranged from 2.54 - 201.50 ind./l. The mean Shannon Weiner Diversity Index (H') recorded at 1.71, where most stations recorded moderate diversity pattern. The highest value was at S18 (2.09), while the lowest at S17 (1.10). Both stations located outside the reclamation footprint (**Chart 6.14**).

Chart 6.14: Zooplankton Diversity Index (H') at the Study Area



c) Macrobenthos

The benthic environment is important part of the marine ecosystem and is dominated by large numbers of marine invertebrates. Benthic communities, particularly macrobenthos, play a critical role in the diets of many shorebird and fish species, and can profoundly influence the abundance and species composition in the ecosystem. Apart from being a source of food for bottom feeding fish and crustaceans, macrobenthos also play an integral role in the recycling of nutrients, and conservation of water quality.

Most benthic organisms consume organic sediment as deposit feeders, and in the process, regenerate essential nutrients to the water column. The burrowing activities of the benthic organisms (bioturbation) also release nutrients into the water column. The macrobenthos also play an important ecological role in the mangrove ecosystem. The macrobenthos assist in the breakdown of particulate organic material by exposing them to microbes while their waste materials contain rich nutrients forming the food for other consumers (Thilagavathi *et al*., 2013). Their density and diversity would thus be a clear reflection of the primary and secondary productivity in the project site. Several factors are known to influence the distributions of macrobenthos of which include sediment types, temperature, productivity, salinity, oxygen and depth (Snelgrove, 2001).

A total of five (5) phyla of macrobenthos were recorded at the study area, namely Annelida, Arthropoda (Crustacea), Mollusca, Echinodermata and Chordata (**Table 6.43**). The most dominant phylum was the Annelida, accounted for 35% of the total density in the study area, followed closely by Arthropoda (Crustacea) (34.5%). Mollusca, Echinodermata and Chordata contributed 0.2 - 21.3% (**Chart 6.15**). In terms of station, the highest density of macrobenthos recorded at S15 (390 ind./m^2) and S4 (380 ind./m^2), which were located outside the reclamation footprint and foreshore area respectively. The lowest density recorded at S3 (100 ind./m^2) (**Chart 6.16**).

The most abundant phylum was Annelida, which was represented by 16 families and 33 species. The mean density recorded at 73 ind./m^2. The most dominant family was the Nephtyidae, which comprised about 17.8% of the total polychaete density, followed by and Spionidae (13.7%) and Capitellidae (9.6%), while the other comprised less than 8.5%.

Table 6.43: Macrobenthos Density (ind./m²) and Diversity (H') at the Study Area

Taxa	Foreshore Area						Within Reclamation Footprint							Outside Reclamation Footprint					Off P. Besar & P. Burong	
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Phylum: Annelida																				
Class Polychaeta																				
Family Amphinomidae																				
Chloeia flava	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
Family Capitellidae																				
Notomastus latericeus	-	10	-	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	-	-
Notomastus aberans	20	20	-	-	-	-	-	-	-	-	30	-	-	-	-	-	-	-	-	-
Heteromastus similis	10	-	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capitella capitata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-
Family Eunicidae																				
Eunice indica	-	-	-	-	10	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-
Marphysa sanguinea	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Family Glyceridae																				
Glycera alba	-	20	-	-	-	-	-	-	-	-	-	20	-	-	-	-	-	20	-	-
Family Lumbrineridae																				
Lumbrineris latrelli	-	-	-	30	-	-	20	-	20	-	-	-	-	-	-	-	-	-	-	-
Lumbrineris aberrans	-	-	-	-	-	10	-	-	10	-	-	-	-	-	-	-	-	-	10	-
Lumbrinereis mucronata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	-
Family Maldanidae																				
Axiothella sp.	-	-	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-	-	-	-
Euclymene lombricoides	-	-	-	-	-	-	-	-	-	-	30	-	30	-	-	-	-	-	-	-
Family Nephtyidae																				
Aglaophamus dicirroides	-	-	-	30	-	-	-	-	-	20	-	-	-	-	-	-	-	-	-	-
Aglaophamus dicirrus	20	-	-	-	-	-	-	-	-	10	30	20	20	-	30	-	-	-	-	10
Nephtys polybranchia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10

Taxa	**Foreshore Area**						**Within Reclamation Footprint**							**Outside Reclamation Footprint**					**Off P. Besar & P. Burong**	
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Nephtys cornuta	10	-	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	20	-
Family Nereididae																				
Nereis reducta	-	-	-	10	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-
Perinereis sp. A	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-
Perinereis sp. B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
Drilonereis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	20	-
Family Onuphidae																				
Onuphis eremita	10	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Family Orbiniidae																				
Scoloplos (Leodamas) gracilis	-	-	-	-	-	-	20	10	10	-	-	-	-	-	-	-	-	-	-	-
Scoloplos (*Leodamas*) *rubra*	10	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-
Family Paraonidae																				
Paradoneis lyra	-	-	-	40	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Family Phyllodocidae																				
Eulalia sp.	-	-	-	-	-	-	20	-	-	-	20	-	10	-	20	-	-	-	-	-
Eteone siphodonte	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Family Pilargidae																				
Ancistrosyllis albini	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Family Spionidae																				
Prionospiop malayensis	-	-	-	50	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-	-
Paraprionospio pinnata	-	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	-	-	-	10
Prionospio cornuta	20	-	-	-	-	-	-	-	-	-	-	10	20	-	20	-	-	-	-	-
Minuspio cirrifera	-	-	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Family Sternaspidae																				
Sternaspis scutata	-	-	-	-	-	20	-	30	-	-	20	30	-	-	30	-	-	-	-	-
Family Terebellidae																				

Taxa	**Foreshore Area**						**Within Reclamation Footprint**							**Outside Reclamation Footprint**					**Off P. Besar & P. Burong**	
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Loimia medusa	-	-	30	-	-	-	-	30	50	-	-	-	-	-	-	-	-	-	-	-
Thelepus setosus	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal (ind./m^2)	**100**	**60**	**40**	**160**	**30**	**100**	**120**	**80**	**150**	**30**	**160**	**80**	**90**	**0**	**110**	**10**	**0**	**30**	**80**	**30**
Phylum: Arthropoda (Crustacea)																				
Order Amphipoda																				
Suborder Gammaridea	-	60	20	120	90	-	-	30	-	50	-	-	-	-	80	20	-	70	60	50
Order Decapoda																				
Infraorder Brachyura																				
Family Portunidae	-	-	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Family Calappidae	-	-	-	-	-	20	10	20	-	-	-	10	-	-	-	-	-	10	-	-
Family Galatheidae	-	-	-	-	10	10	-	-	-	-	30	20	-	10	-	-	10	-	-	-
Infraorder Caridea	-	-	-	-	-	-	-	-	-	20	-	-	-	-	20	-	20	10	20	10
Order Cumacea	-	-	-	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Order Isopoda	-	20	-	30	-	-	-	10	-	-	-	-	-	-	30	-	10	20	20	0
Order Mysida	-	-	-	-	-	-	-	-	-	20	-	-	-	30	30	60	120	-	-	30
Order Tanaidacea	-	-	-	10	-	-	-	20	-	-	-	-	-	-	-	-	10	10	-	-
Subtotal (ind./m^2)	**0**	**80**	**30**	**190**	**110**	**30**	**10**	**80**	**0**	**90**	**30**	**30**	**0**	**40**	**160**	**80**	**170**	**120**	**100**	**90**
Phylum: Mollusca																				
Class Bivalvia																				
Solen sp.	-	-	-	-	-	-	-	-	20	-	-	-	-	10	-	-	-	10	10	20
Tegillarca granosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-
Tellinides sp.	-	-	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
unidentified bivalve spats	30	80	-	-	70	-	-	120	60	50	50	80	-	50	120	20	-	-	-	50
Subtotal (ind./m^2)	**30**	**80**	**30**	**0**	**70**	**0**	**0**	**120**	**80**	**50**	**50**	**80**	**0**	**60**	**120**	**20**	**10**	**10**	**10**	**70**

Taxa	Foreshore Area						Within Reclamation Footprint							Outside Reclamation Footprint					Off P. Besar & P. Burong	
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Phylum: Echinodermata																				
Class Ophiuroidea																				
Ophiactis sp.	-	-	-	30	-	-	20	10	-	-	-	-	20	-	-	-	-	-	-	-
Ophionereis sp.	-	-	-	-	30	-	-	-	-	-	30	30	50	-	-	-	20	-	-	-
Ophiothrix sp.	-	-	-	-	-	-	-	-	-	-	-	-	30	-	-	-	30	20	20	-
Class Echinoidea																				
Unidentifed Echinoids	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	20
Subtotal (ind./m^2)	**0**	**0**	**0**	**30**	**30**	**0**	**20**	**10**	**0**	**0**	**30**	**30**	**100**	**0**	**0**	**0**	**50**	**30**	**20**	**20**
Phylum: Chordata																				
Superclass Osteichthys																				
Fish larvae	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal (ind./m^2)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**10**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Density (ind./m^2)	**130**	**220**	**100**	**380**	**240**	**130**	**150**	**300**	**230**	**170**	**270**	**220**	**190**	**100**	**390**	**110**	**230**	**190**	**210**	**210**
Shannon Weiner Diversity Index (H')	**1.99**	**1.66**	**1.51**	**2.12**	**1.65**	**2.03**	**2.03**	**1.99**	**1.99**	**1.64**	**2.23**	**1.85**	**1.96**	**1.17**	**2.03**	**1.17**	**1.58**	**2.01**	**2.14**	**1.99**

Chart 6.15: Composition of the Macrobenthos at the Study Area

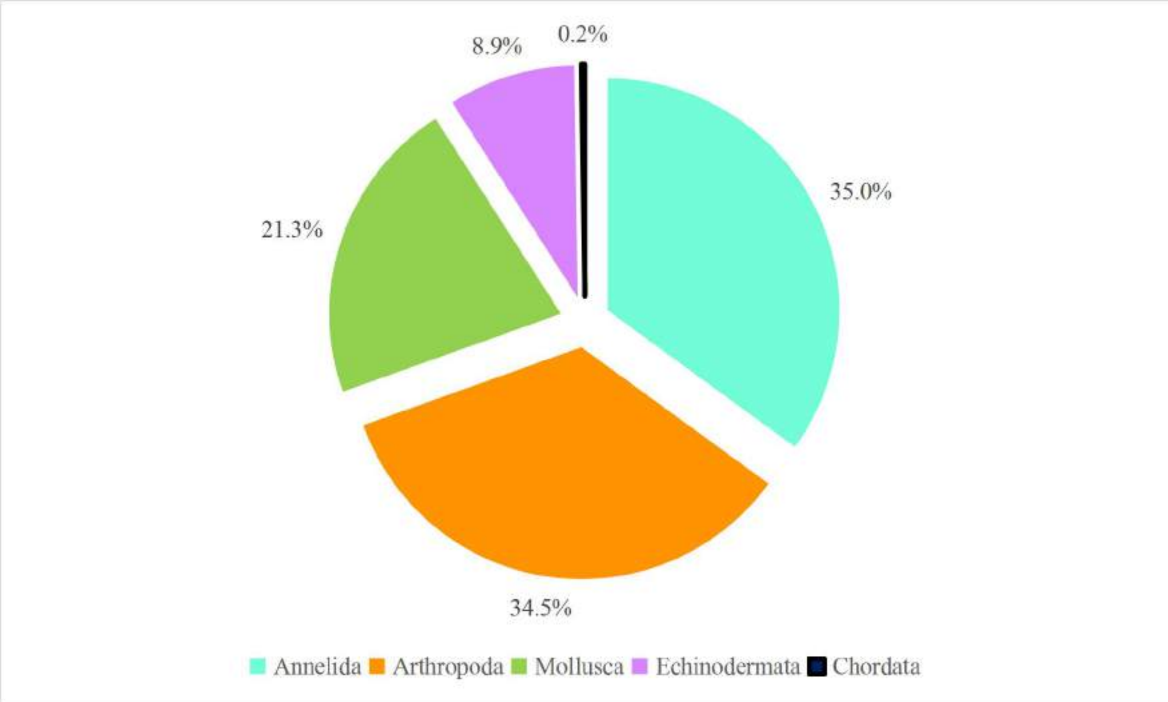
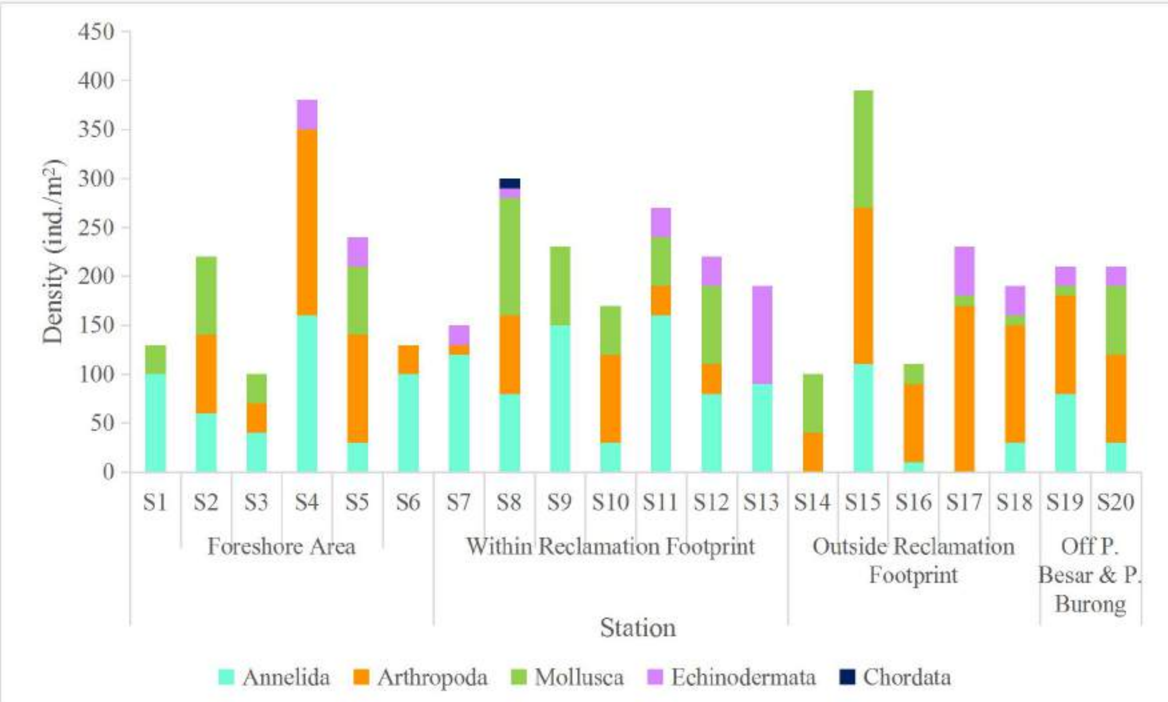


Chart 6.16: Macrobenthos Density (ind./m²) at the Study Area



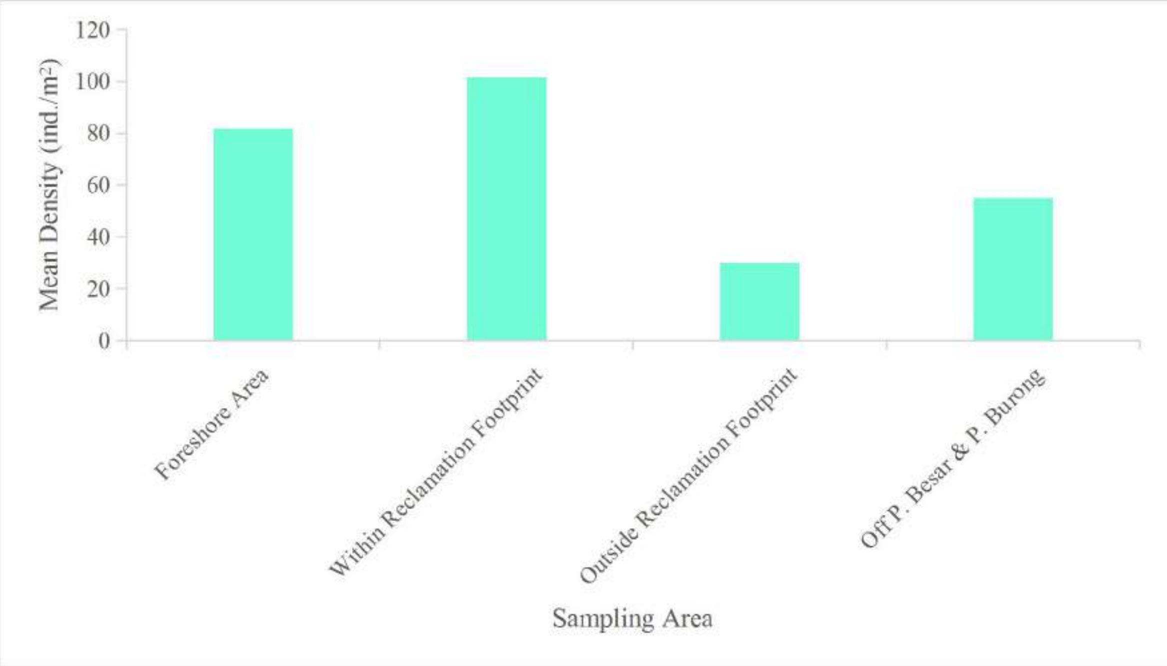
In term of species, *Aglaophamus dicittus, Sternaspis scutata* and *Loimia medusa* were found to be the most abundant species, constituting 9.6%, 8.9% and 7.5% of the total density of annelids respectively. The mean density was recorded at 6 - 7 ind./m^2. Other species recorded mean density of less than 4ind./m^2.

A predominance of polychaete worms is a normal phenomenon for coastal benthic organism in Malaysian waters. According to Day (1981), these annelids can be found at all depths of the marine ecosystem. In addition, they are known have high a tolerance to organic pollution and natural perturbation. Polychaete worms usually act as a representative group in the assessment of the health of aquatic ecosystem. Most polychaetes have short life cycle and high reproduction rates, which enable them to show quick response on any changes in the environment such as the input of pollutants or organic material. Polychaete larvae may be capable of long distance transport, while the adults are relatively inert (Dean, 2008).

On the whole, the highest mean density of annelids recorded within the reclamation footprint (101 ind./m^2), followed by foreshore area (82 ind./m^2), off P. Besar and P. Burong (55 ind./m^2) and area outside the reclamation footprint (30 ind./m^2) (**Chart 6.17**). Previous studies also reported high density and diversity of polychaetes at Malacca coastal water (Green Earth, 2016; O&L, 2011, 2009).

Phylum Arthropoda (Crustacea) was represented by Amphipoda, Portunidae, Calappidae, Galatheidae, Caridea, Cumacea, Isopoda, Mysida and Tanaidacea. The mean density was recorded at 72 ind./m^2 and ranged from 0 - 190 ind./m^2. The highest density was contributed by Amphipoda cover 45.1% of the total Arthropods count. The mean density of amphipods was 33 ind./m^2. Amphipods act as an important link between producers and higher consumers such as fish, invertebrates and birds in the food webs. Amphipods are also important indicators of water quality, particularly because of their sensitivity to contaminants, pesticides and pollution (Zaabar *et al*., 2015).

Chart 6.17: Mean Density (ind./m^2) of Phylum Annelida at the Study Area



Note: *Foreshore area (S1 - S6)*
Within reclamation footprint (S7 – S13)
Outside reclamation footprint (S14 – S18)
Off P. Besar & P. Burong (S19 – S20)

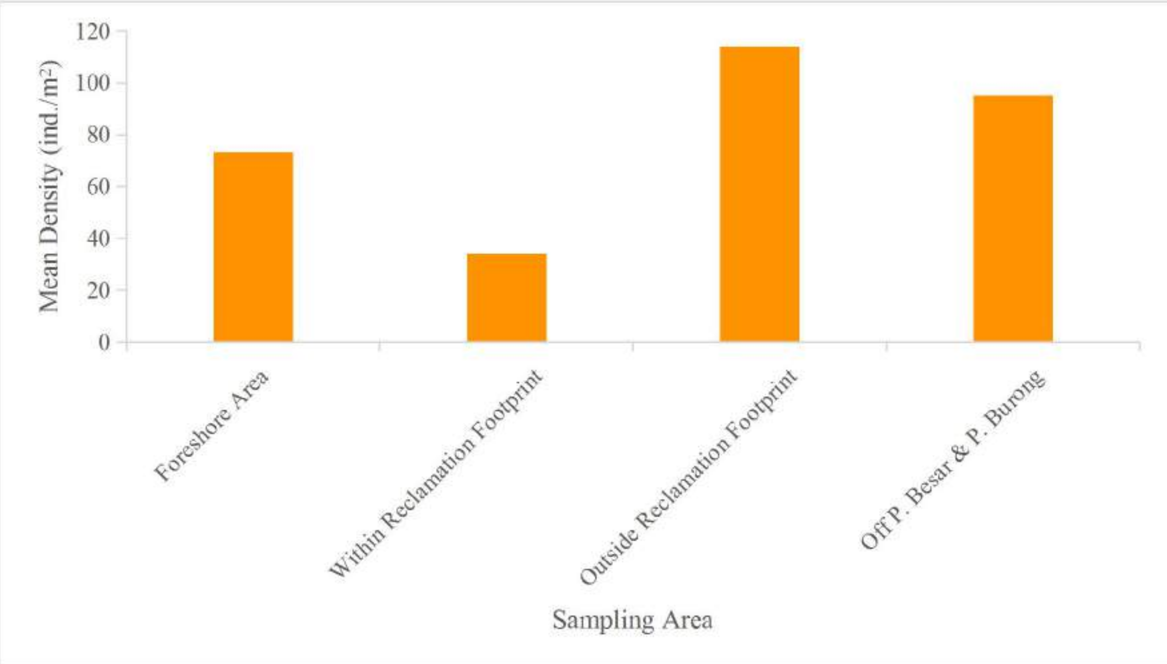
The density of Arthropods showed an opposite trend as compared to annelids, where highest density recorded at area of outside the reclamation footprint (114 ind./m^2), followed by off Pulau Besar and P. Burong (95 ind./m^2), foreshore area (73 ind./m^2) and lowest within reclamation footprint (34 ind./m^2) (**Chart 6.18**). The high density outside the reclamation food print and P. Besar/ P. Burong could be related to the lower pollution loads off the areas. Foreshore areas receive daily inputs from land based pollutant flows are probably the main reason for the low density of arthropods recorded during current study.

Phylum Mollusca was represented by *Solen* sp., *Tegillarca granosa, Tellinides* sp. and bivalve spats under Class Class Bivalvia. The mean density was recorded at 45 ind./m^2. The high density was mostly contributed by unidentified bivalve spats cover 87.6% of the total Mollusca count. The mean density of bivalve spats was 39 ind./m^2. Bivalve spat is the stage where they begin to lose the larval organs such as velum, foot or eyespot, and form the adult structures. A new shell is also laid down by the mantle during this time.

Phylum Echinodermata was represented by *Ophiactis* sp., *Ophionereis* sp., *Ophiothrix* sp. and Unidentified Echinoids. The mean density recorded at 19 ind./m^2. *Ophionereis* sp. found to be more dominant, covering 43.2% of the total density of Echinoderms. The least abundant phylum was Chordata, which represented by unidentified fish larvae and only fond in S8 (10 ind./m^2).

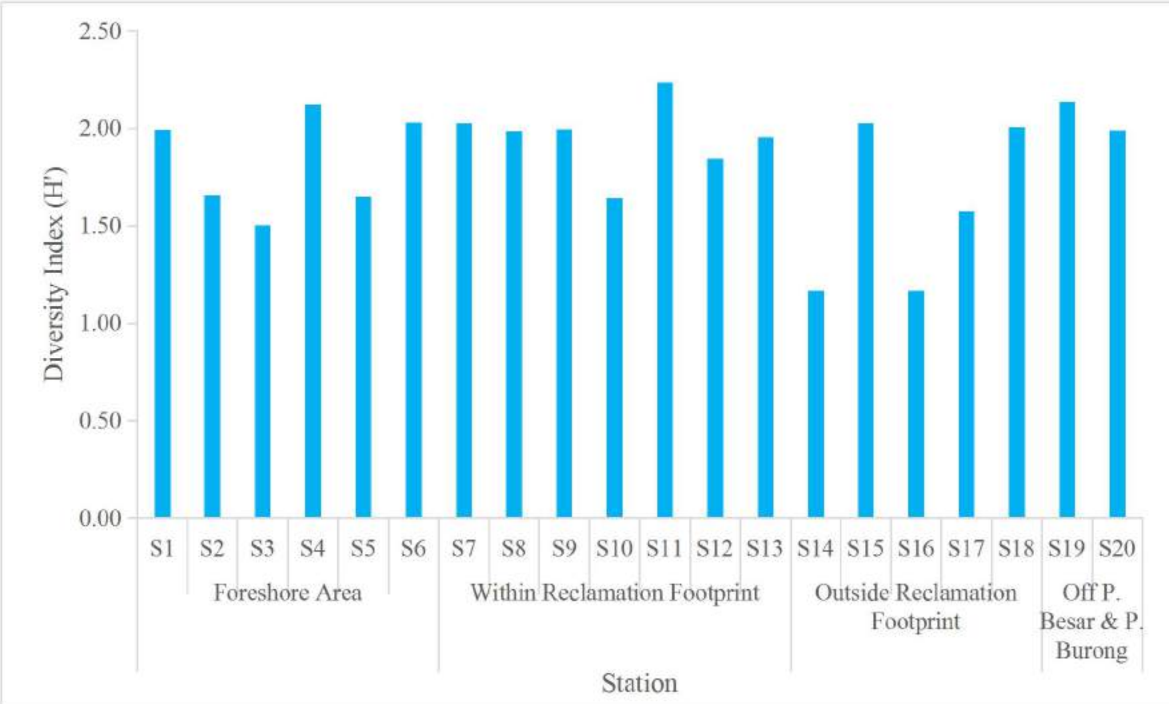
Overall, the mean macrobenthos density at the study area was 209 ind./m^2. The mean Shannon Weiner Diversity Index (H') recorded at 1.84, where most of the stations showed a moderate diversity pattern (**Chart 6.19**). The highest value recorded at S11 (within reclamation footprint) (2.23), followed by S19 (off Pulau Besar) (2.14) and S4 (foreshore area) (2.12).

Chart 6.18: Mean Density (ind./m^2) of Phylum Arthropoda at the Study Area



Note: Foreshore area (S1 - S6)
Within reclamation footprint (S7 – S13)
Outside reclamation footprint (S14 – S18)
Off P. Besar & P. Burong (S19 – S20)

Chart 6.19: Macrobenthos Diversity Index (H') at the Study Area



6.10.3.2 Fish Fauna

Fish is one of the major sources of high-quality protein, providing about 16% of animal protein for human consumption around the world (FAO, 1997). The fish is either caught in the wild or raised through fish farming or aquaculture. The distribution pattern of fish depends on behavioral response to refuge availability provided by structural complexity (Cocheret de la Morinière *et al*. 2004, Pittman *et al*. 2004), and available resources i.e. food (Laegdsgaard and Johnson 2001, Verweij *et al.* 2006), or they may be due to interactions of predation and competition (Laegdsgaard and Johnson 2001, Almany 2004).

A total of 142 individuals of fish and 11 individuals of crustaceans (crabs and horseshoe crabs) were caught at the study area. The fish caught belonged to 15 Families and comprised of 24 species, while crustaceans belonged to 3 families and 4 species (**Table 6.44**). Details of the fish caught are as in **Appendix XIII.**

Table 6.44: Summary of Fish Caught at the Study Area

Station	Family	Local Name	Scientific Name	No.	Length (cm)	Weight (g)	CPUE ($g/m^2/h$)
F1	Sciaenidae	Gelama	*Johnius balangerii*	11	12.8-15.0	26 - 57 (CW: 370)	0.649
	Sciaenidae	Gelama Batu	*Nibea soldado*	3	12.8- 13.2	29-31 (CW: 90)	0.158
	Pristigasteridae	Beliak Mata	*Ilisha kampeni*	6	14.6-19.4	21-53 (CW: 227)	0.398
	Pristigasteridae	Bersia	*Ilisha melastoma*	4	12.6-16.0	21-45 (CW: 142)	0.249
	Polynemidae	Senangin buis	*Polydactylus sextarius*	5	10.1-16.3	8-52 (CW: 188)	0.330
	Polynemidae	Senangin	*Eleutheronema tetradactylum*	1	25.8	152	0.267
	Haemulidae	Gerut-Gerut	*Pomadasys maculatus*	3	11.1-14.0	26-51 (CW:116)	0.204
	Haemulidae	Gerut-Gerut	*Pomadasys kaakan*	1	24.6	285	0.500
	Clupeidae	Selangat	*Anadontosoma chacunda*	3	13.5-14.5	34-39(CW:110)	0.193
	Leiognathidae	Kikek	*Secutor insidiator*	2	8.3-8.5	8-9 (CW:17)	0.030
	Engraulidae	Kasai Janggut	*Setipinna taty*	1	15.1	24	0.042
	Engraulidae	Kasai Minyak	*Thryssa hamiltonii*	1	16.6	36	0.063
	Ariidae	Duri	*Arius jella*	1	20.2	72	0.126
	Gerreidae	Kapas	*Gerres erythrourus*	1	9.6	17	0.030
	Portunidae	Ketam Mere	*Charybdis* sp.	1	7.5	83	0.146
	Limulidae	Belangkas	*Tachypleus gigas*	2	13.6-14.1	261-273 (CW: 534)	0.937
F2	Pristigasteridae	Beliak Mata	*Ilisha kampeni*	11	14.4-19.4	25-55 (CW: 462)	0.811
	Pristigasteridae	Bersia	*Ilisha melastoma*	3	15.2-15.5	37-44(CW:123)	0.216
	Sciaenidae	Gelama	*Johnius balangerii*	14	10.0-16.1	9-46 (CW: 485)	0.851
	Clupeidae	Selangat	*Anadontosoma chacunda*	7	11.0-15.4	18-37 (CW: 195)	0.342
	Clupeidae	Tamban	*Sardinella fimbriata*	1	14.4	28	0.049
	Limulidae	Belangkas	*Tachypleus gigas*	4	12.0 -17.4	117-482(CW: 1130)	1.982
F3	Clupeidae	Tamban	*Sardinella fimbriata*	21	13.8-15.1	26-39 (CW: 644)	1.130
	Mugilidae	Belanak	*Planiliza melinopterus*	3	15.7-18.1	41-68 (CW: 167)	0.293

Station	Family	Local Name	Scientific Name	No.	Length (cm)	Weight (g)	CPUE ($g/m^2/h$)
F3	Pristigasteridae	Bersia	*Ilisha melastoma*	3	13.1-15.0	25-42 (CW: 102)	0.179
	Pristigasteridae	Beliak Mata	*Ilisha kampeni*		18.7-18.8	37-45 (CW:82)	0.144
	Engraulidae	Kasai Minyak	*Thryssa hamiltonii*	2	16.1-16.4	32-33 (CW: 65)	0.114
	Clupeidae	Tamban	*Sardinella fimbriata*	2	14.4-14.6	28-31 (CW: 59)	0.104
	Dasyatidae	Ketuka	*Himantura walga*	1	18.9	232	0.407
	Chirocentridae	Parang	*Chirocentrus nudus*	1	40.6	255	0.447
	Scombridae	Tenggiri Batang	*Scomberomorus commerson*	1	28.6	133	0.233
	Portunidae	Ketam Renjong	*Portunus pelagicus*	1	14.7	260	0.456
	Limulidae	Belangkas	*Tachypleus gigas*	2	13.4-18.1	241-251	0.863
F4	Ariidae	Duri	*Arius jella*	5	18.9-26.5	73-245(CW:926)	1.625
	Ariidae	Duri Pulut	*Netuma thalassina*	2	22.2-24.3	141-195 (CW: 336)	0.589
	Ariidae	Duri	*Plicofollis platystomus*	1	29.4	320	0.561
	Ariidae	Duri	*Plicofollis dussumieri*	1	31.0	351	0.616
	Sciaenidae	Gelama Batu	*Nibea soldado*	6	11.6-15.2	23-47 (CW: 241)	0.423
	Sciaenidae	Gelama	*Johnius balangerii*	2	17.6-17.9	62-68 (CW:130)	0.228
	Clupeidae	Selangat	*Anadontosoma chacunda*	1	14.3	38	0.067
	Dasyatidae	Ketuka	*Himantura walga*	1	16.6	159	0.279
	Cynoglossidae	Lidah	*Cynoglossus bilineatus*	1	28.2	141	0.247
	Muraenesocidae	Malong	*Congresox talabon*	1	58.0	170	0.298
F5	Ariidae	Duri	*Arius jella*	2	25.7-28.8	216-291 (CW: 507)	0.889
	Cynoglossidae	Lidah	*Cynoglossus bilineatus*	2	29.2-31.1	143-189 (CW: 332)	0.582
	Polynemidae	Senangin	*Eleutheronema tetradactylum*	1	25.5	129	0.226
	Engraulidae	Kasai Janggut	*Setipinna taty*	1	14.6	23	0.040
	Xanthidae	Ketam Batu	*Menippe* sp.	1	5.4	40	0.070
Total				**153**	**-**	**11,220**	**19,684**

Note: 1. cw: Composite weight, 2: The nets were affixed for a standard time of 2 hours, 3. Mesh size net were 285 m^2 ((70 m x 1.5 m)+ (60 m x 3 m))

Plate 6.9: Fish Caught at the Study Area

Plate 6.10: Fish, Crabs and Horseshoe Crab Caught at the Study Area

The most dominant fish group caught was Family Sciaenidae, which was a demersal fish, with a total of 36 individuals. The number contributed approximately 25.4% of the total number. It was represented by Gelama (*Johnius belangerii*) (27 individuals) and Gelama Batu (*Nibea soldado*) (9 individuals). They were caught at F1, F2 and F4. The fish were caught having a total lengths of 10-17.9 cm and weighed at 9 - 68 g for *J. belangerii* and 12.8 -15.2 cm (23 - 47g) for *N. soldado*. Most of the fish caught were adults.

The Scianidae family is well distributed throughout Indo-West Pacific, west to the Persian Gulf, east to southern China and southeast Asia, where they inhabit the shallow coastal waters up to 40m (Monikh *et al.,* 2014). They are also a common fish caught in Malaysian waters (Bashir *et al.,* 2013). In addition, these species are often used as biological indicators for heavy metals and pollutant as these substances often found deposited within the fish's adipose tissue (Monikh *et al*., 2014).

The second most dominant fish group caught was Family Clupeidae with a total of 35 individuals, contributing 24.6% of the total number of fish caught. This family is a pelagic fish. The Clupeidae was represented by two species i.e Selangat (*Anadontosoma chacunda*) (11 individuals) and Tamban (*Sardinella fimbriata*) (24 individuals). Both of these species commonly form schools in coastal waters. They were caught at F1 - F4. The total length of fish caught ranged from 11.0 – 15.4 cm (18 - 39 g) for *A. chacunda* and 13.8 -15.1 cm (26 - 39g) for *S. fimbriata*. Most of *A. chacunda* caught were adults, while *S. fimbriata* were juveniles. The clupeoids include many of the most important food fishes in the world, and are also commonly caught for production of fish oil and fish meal.

The third most dominant fish group caught was Family Pristigasteridae with a total of 29 individuals. It was represented by Beliak Mata (*Ilisha kampeni*) and Bersia (*Ilisha melastoma*). They were caught at F1, F2 and F3. The fish caught having a total lengths of 14.4 – 19.4 cm and weighed at 21 - 55 g for *I. kampeni* and 12.6 -16.0 cm (21 – 45 g) for *I. melastoma*. Most of the fish caught were adults. These species are commonly found in coastal areas and are schooling fishes of tropical and subtropical seas.

The fish fauna assessment also recorded the presence of other fish species such as Duri (*Arius jella, Netuma thalassinus, Plicofolis platystomus, Plicofollis dussumieri*) from Family Ariidae, Senangin (*Eleutheronema tetradactylum, Polydactylus sextarius*) from Family Polynemidae, Kasai Janggut (*Setipinna taty*) and Kasai Minyak (*Thryssa hamiltonii*) from Family Engraulidae, Gerut-gerut (*Pomadasys maculatus, Pomadasys kaakan*) from Family Haemulidae, Lidah (*Cynoglussus bilineatus*) from Family Cynoglossidae, Pari (*Himantura walga*) from Family Dasyatidae, Parang (*Chirocentrus nudus*) from Family Chirocentridae, Kapas (*Gerres erythrourus*) from Family Gerreidae, Kikek (*Secutor insidiator*) from Family Leiognatidae, Belanak (*Planiliza melipterus*) from Family Mugillidae, Malong (*Congresox talabon*) from Family Muraenesocidae and Tenggiri Batang (*Scomberomorus commerson*) from Family Scombridae. Around 1-12 individuals were caught for each of the species. Most of fish caught were adults, except Senangin (*Eleutheronema tetradactylum*), Parang (*Chirocentrus nudus*), Tenggiri Batang

(*Scomberomorus commerson*) and Duri (*Arius jella, Netuma thalassinus, Plicofollis dussumieri*).

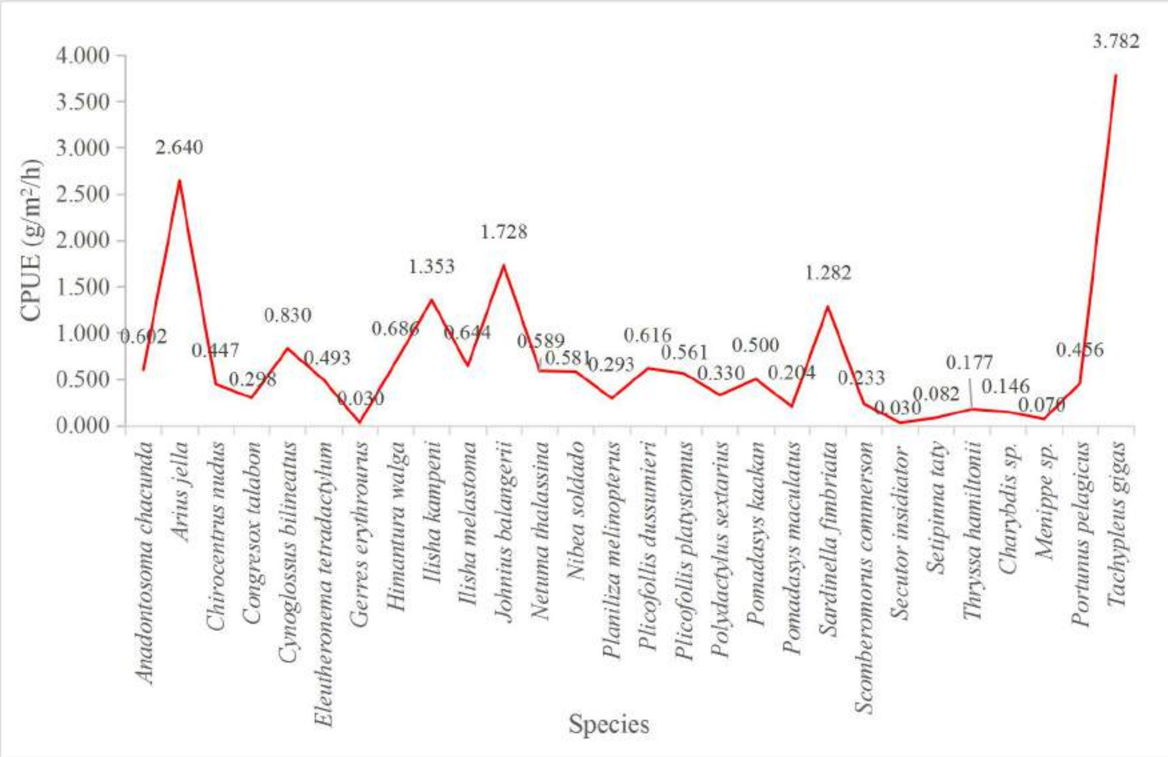
As for the crustacean group, the commercial species caught was Ketam Renjong (*Portunus pelagicus*) from Family Portunidae. Only one individual of adult *P. pelagicus* was caught i.e F3. The total carapace width was 14.7 cm, weighed at 260g. The mature size for *Portunus pelagicus* is around 8 cm (Sukumaran and Neelakantan, 1996). This species is generally known to inhabit the coastal areas similar to the study area. They are assumed as commercial fishing subjects in Malaysia among the fishermen and has a steady demand in market (Ikhwanuddin *et al.,* 2012). They are primarily carnivorous with distinct feeding preference for benthic animals. However, under certain circumstances, *P. pelagicus* can resort to marine plants and seagrass (Kunsook *et al*., 2014).

In addition, there was also other species of crab were caught i.e Ketam Mere (*Charybdis* sp.) from Family Portunidae and Ketam Batu (*Menippe* sp.) from Family Xanthidae. One individual each of *Charybdis* sp. and *Menippe* sp. was caught at F1 and F5 respectively. Both of these crabs were at juvenile stage. The carapace width and weight of *Charybdis* sp. recorded at 7.5 cm and 83 g respectively, while 5.4 cm and 40g for *Menippe* sp.. Crustaceans were further represented by horseshoe crabs i.e. Belangkas (*Tachypleus gigas*) and were caught at F1 (2 individuals), F2 (4 individuals) and F3 (2 individuals).

Overall, high number of catch was recorded at F1 (46 individuals), followed by F2 (40 individuals) and F3 (39 individuals), while the least number of catch was at F5 (7 individuals).

In term of biomass, there was no significant difference of CPUE value at F1- F4, with value ranging from 4.251 - 4.933 g/m^2/hour. As least number of fish caught at F5, low CPUE value was also recorded i.e 1.809 g/m^2/hour. However, in term of species, highest CPUE value was demonstrated by Belangkas (*Tachypleus gigas*) at 3.782 g/m^2/hour, followed by Duri (*Arius jella*) (2.640 g/m^2/hour), Gelama (*Johnius balangerii*) (1.728 g/m^2/hour), Beliak Mata (*Ilisha kampeni*) (1.353 g/m^2/hour) and Tamban (*Sardinella fimbriata*) (1.2823 g/m^2/hour). Other species showed low CPUE value of less than 1 g/m^2/hour (**Chart 6.20**).

Chart 6.20: Marine Fish Biomass (CPUE: g/m²/h)



6.10.3.3 Marine Habitat

a) Mangrove

Mangroves are woody plants that grow in tropical and subtropical regions along the coasts, bays, estuaries, lagoons and in the rivers, reaching upstream up to the point where the water still has saline intrusion. Mangroves are the dominant coastal vegetation in Malaysia. Malaysia has 577,558 ha of mangrove forests, with 59% in Sabah, 23% in Sarawak and the remaining 18% in Peninsular Malaysia. There are 436,714 ha (more than 75%) that has been gazetted as forest reserves, while remaining 130,142 ha is classified as state land that can be used for other purposes (Aldrie and Latiff, 2006).

In Melaka, the total mangrove area is 1,308.68 ha, which constitutes about 0.79% of the total land area in the state. However, only 92 ha (1.80%) mangrove forest has been gazetted under the Permanent Forest Reserve (PRF). Most mangroves were concentrated within estuaries as well as along the river banks. The largest area of mangrove in Melaka is situated in the district of Jasin (699.56 ha) near Kg. Bagan Upeh, Kg. Bulang, and Kg.

Pulai Barat, while the remaining mangroves were concentrated at Alor Gajah and Melaka Tengah district, covering an area of 555.01 ha and 54.11 ha mangrove areas, respectively (**Figure 6.30**).

Mangrove ecosystems provide protection and habitat (e.g. breeding and nursery ground) for a wide diversity of aquatic species of different taxonomic groups. Mangroves are also important, particularly for estuarine fish, because of the detritus and dissolved organic carbon contributed to estuarine food web (Kasawani *et al*., 2007). The presence of mangroves is potentially vital for the sustenance of the near shore fisheries of any region. Studies undertaken by Mohd. Zaki (1991) at the mangrove-adjacent fishing ground in East Johore reported the landings of 17 different species of shrimps from the coastal waters within 3 – 5 km from the shore. Eight (8) common genera comprised of *Penaeus*, *Metapenaeus*, *Parapenaeopsis*, *Metaparapenaeopsis*, *Trachypenaeus*, *Solanocera*, *Plesionika* and *Heterocarpus*. Mangroves also reduce coastal erosion and flooding, supply and regenerate nutrients, store water as well as trap sediments and carbon (Dinerstein *et al*., 1995; Sasekumar and Wilkinson, 1984). Additionally, mangroves provide timber for construction, firewood, charcoal and poles (Hamilton and Snedaker, 1984).

Mangrove abundance is usually affected by dryness, salinity, tide and wave energy. Mangroves are generally more extensive along coasts that have high rainfall (Golley *et al*., 1975). Salinity also affects mangrove distribution since mangroves do not develop in pure freshwater environments (Ball, 1988). Tidal influence plays important indirect roles to their distribution such as transporting sediments, nutrients and clean water into the mangrove environment (Mckee, 1996). According to Tomlinson (1986), mangroves can grow well in a depositional environment with low wave energy. High waves prevent propagule establishment, expose shallow root systems and prevent fine sediments from accumulating.

Despite these values, mangroves are subject to large clearing worldwide. In Malaysia, it has been estimated that 1% of its mangroves have been lost every year since 1990 (Gong and Ong, 1990). Major factors that have caused mangrove degradation are human development (e.g. construction of ports, industries, resorts and residential areas), conversion of mangrove lands to aquaculture activities (e.g. fish and prawn farming) and inefficient reforestation techniques.

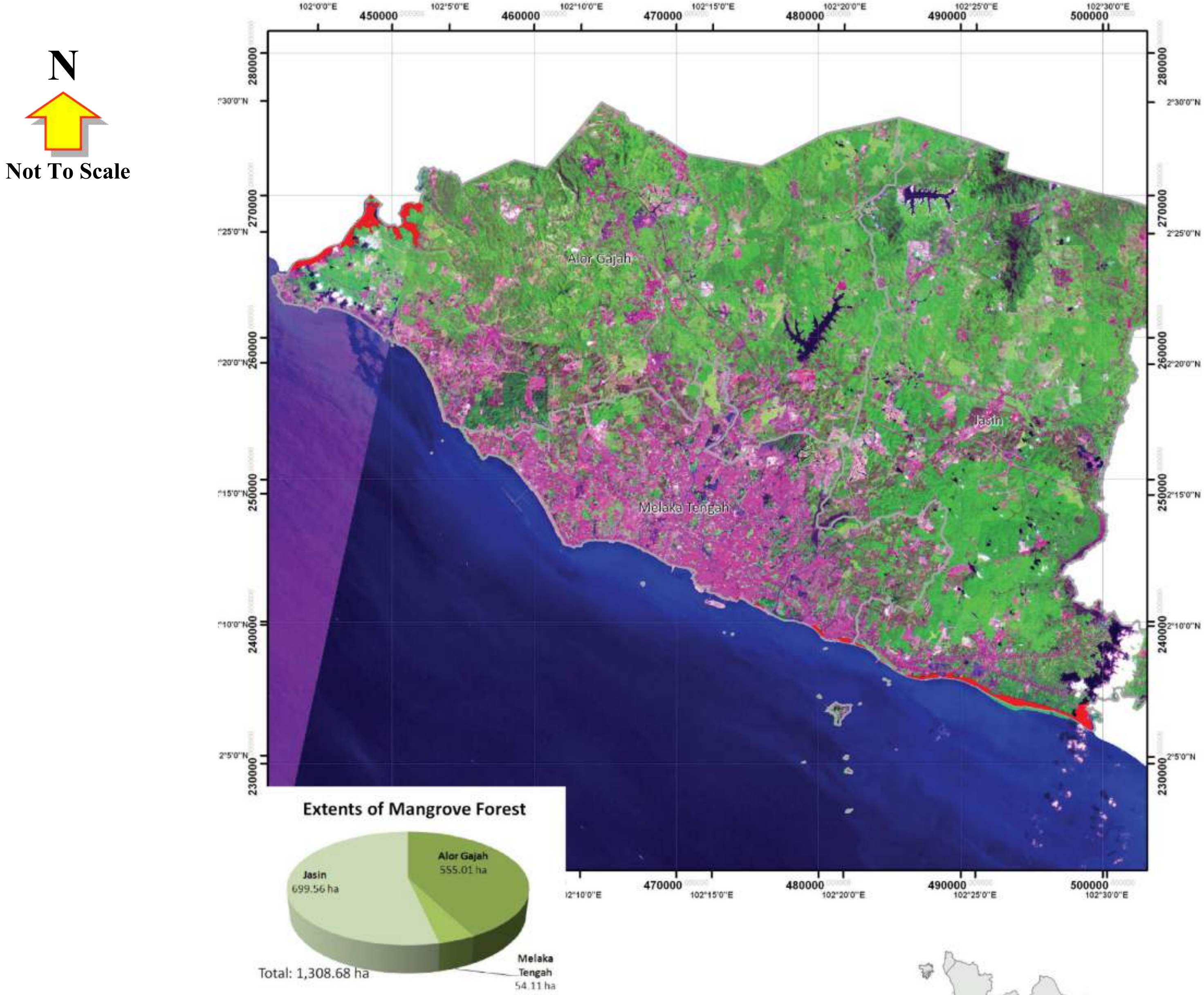


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Figure 6.30: Mangrove Forest in Melaka

In the current study, 23 transect lines for mangrove areas were surveyed, of which 18 transects were located along the coastline within 5km radius of the reclamation footprint, while another four (4) lines were surveyed at Pulau Besar. Refer to **Figure 6.31**. In addition, several mangrove areas were visually assessed i.e. at Pulau Burung Besar, Pulau Burung Kecil and Pulau Menatang. Details on the mangrove information for each transect are as **Appendix XIII**.

A total of 29 species of mangroves belonging to 17 families were recorded from the study area. Among the listed families, Rhizophoraceae was the most dominant family, which were represented by seven (7) species. This was followed by Avicenniaceae and Meliaceae, with three (3) species each, while Pteridaceae and Rubiaceae was represented by two (2) species respectively. Other families were represented by a single species (**Table 6.45**). Rhizophoraceae has widespread distribution worldwide since they could adapt to extreme mangrove environments. This is related to the ability of their propagules to survive prolonged submersion in seawater (Tomlinson, 1986).

In detail, a total of 1,401 mangrove trees, 782 mangrove saplings and 279 shrubs were recorded from the transect lines (T1 – T23), where most of the area were dominated by trees. According to Bosire *et al*. (2008) and Kasawani *et al*. (2007), the presence of saplings indicated natural regeneration occurring, which was important for the restocking of forest stands. The Diameter Breast Height (DBH) and heights of mangrove trees ranged from 2 – 120 cm and 4 – 15 m respectively. As for mangrove saplings, the DBH ranged from 1 – 30 cm with heights from 0.5 – 3.0 m.

The mangroves on the mainland were mostly dominated by the *Rhizophora*, particularly of the species *Rhizophora apiculata* and *Rhizophora mucronata*. *Rhizophora* was recorded at both landward and seaward zone. According to Duke (2006), *Rhizophora* were widely distributed since they have been known highly tolerant of salinity and soil conditions that assist in stabilizing soils with their network of sturdy overlapping prop roots. Moreover, they have stilt roots that trap silt particles, xeromorphic features to reduce rate of transpiration and viviparous germination.

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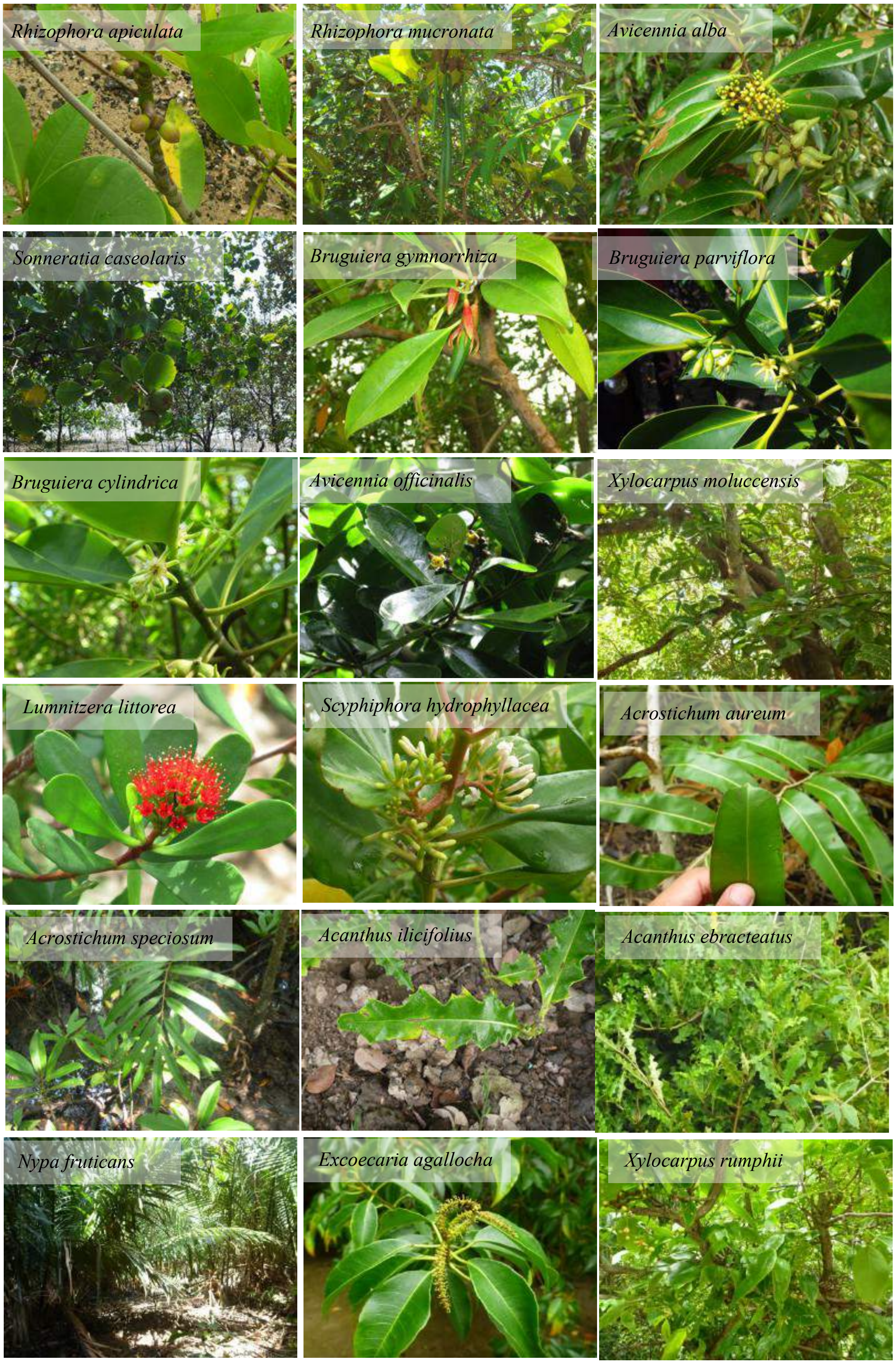
Figure 6.31: Location of the Mangroves Transect Lines at the Study Area

Table 6.45: List of Mangrove Species Found at the Study Area

Family	Scientific Name	Local Name	Life Form
True Mangrove			
Rhizophoraceae	*Ceriops decandra*	Tengar	Tree
	Rhizophora apiculata	Bakau Minyak	Tree
	Rhizophora mucronata	Bakau Kurap	Tree
	Rhizophora stylosa	Bakau Pasir	Tree
	Bruguiera cylindrica	Bakau Berus	Tree
	Bruguiera gymnorrhiza	Tumu Merah	Tree
	Bruguiera parviflora	Lenggadai	Tree
Avicenniaceae	*Avicennia alba*	Api- Api Putih	Tree
	Avicennia marina	Api- Api Jambu	Tree
	Avicennia officinalis	Api - Api Ludat	Tree
Meliaceae	*Xylocarpus granatum*	Nyireh Bunga	Tree
	Xylocarpus rumphii	Nyireh	Tree
	Xylocarpus moluccensis	Nyireh Batu	Tree
Pteridaceae	*Acrostichum aureum*	Piai Raya	Shrub
	Acrostichum speciosum	Piai Lasa	Shrub
Acanthaceae	*Acanthus ebracteatus*	Jeruju Putih	Shrub
Euphorbiaceae	*Excoecaria agallocha*	Buta-Buta	Tree
Sonneratiaceae	*Sonneratia alba*	Perepat	Tree
Arecaceae	*Nypa fruticans*	Nipah	Tree
Associated Mangrove			
Rubiaceae	*Morinda citrifolia*	Mengkudu	Tree
	Oxyceris longiflorus	Mentega Laut	Tree
Asteraceae	*Chromolaena odorata*	Kapal Terbang	Shrub
Asteraceae	*Pluchea indica*	Beluntas	Shrub
Bigoniaceae	*Dolichandrone spathacea*	Tuj	Tree
Combretaceae	*Terminalia catappa*	Ketapang	Tree
Guttiferae	*Calophyllum inophyllum*	Bintangor Laut	Tree
Malvaceae	*Talipariti tiliaceum*	Bebaru	Tree
Malvaceae	*Thespesia populnea*	Bebaru	Tree
Asclepiadaceae	*Sarcolobus globosus*	Peler kambing	Shrub

Plate 6.11: <u>True Mangroves Found at the Study Area</u>



Together with *Rhizophora*, other species that were also found dominating include *Sonneratia alba* and all species under genus *Avicennia*. *Avicennia* and *Sonneratia* were recorded, particularly towards the sea. A study undertaken by Macnae (1968) reported that the seaward fringe or low intertidal zone commonly inhabited by species of *Rhizophora, Avicennia* and *Sonneratia*. *Rhizophora* strands were easily distinguished from other mangrove trees by their distinctive stilt roots and bark patterns, while pencil-like pneumatophores and thick cone-shaped pneumatophores characterized *Avicennia* and *Sonneratia* respectively (Primavera *et al*., 2004).

Bruguiera sp. and *Ceriops decandara* mangroves were occasionally recorded towards the seaward zone. *Ceriops decandara* are more often grows within the tidal zone mixed with other Rhizophoraceae (Tomlinson, 1986). *Bruguiera* sp. was a type of facultative mangrove that showed no morphological structures to secrete salt, however, could adapt to salinity condition through physiological processes (Anukriti *et al*., 2009).

Many previous studies reported that species zonation patterns in mangroves were commonly due to the geomorphological processes, differential dispersal of propagules by tidal action, differential predation of propagules, physiological specialization and interspecific competition (Mckee, 1993; Smith, 1987; Ball, 1980). In that regard, there were no specific species zonation observed from the current study area, as most of the species were recorded interspersed along the transect line. However, it should be noted that the seaward zones were still dominated by the archetypal true mangrove species i.e. *Rhizophora*, *Avicennia* and *Sonneratia*.

On the other hand, on the island of Pulau Besar, the main mangrove species were *Rhizophora stylosa*, though there were also other species such as *Rhizophora apiculata*, *Sonneratia alba*, *Avicennia marina*, *Talipariti tiliaceum* and *Excoecaria agallocha*. This species of Rhizophora has been known to dominate in the area with hard sandy soil and even on rocky islands. A study by Mohd Nasir and Safiah Yusmah (2007) indicated that *Rhizophora stylosa* attributed about 95% of the total mangroves on Pulau Besar, which correlate with the dominance of this species in the current study. In addition, the *Rhizophora apiculata* was also another dominant species as they were also capable of growing in sandy soil and coral ramparts, although this species commonly preferred deep soft mud. Moreover, this species was easily propagated by propagules (Qifeng *et al*., 2009).

Aside from the transect lines, there were also mangroves that were observed present on the smaller islands within the impact zone i.e. Pulau Burung Besar, Pulau Burung Kecil and Pulau Menatang. Some of the species that were identified include *Sonneratia alba*, *Rhizophora stylosa*, *Avicennia marina* and *Xylocarpus granatum*. Most of the listed species were able to withstand elevated levels of salinity, thus underscoring their presence on these small island. On the other hand, mangroves was not observed at Pulau Serimbun, Pulau Lalang and Pulau Lalang, which is possibly due to the island having higher ground and sparse beach, which makes it harder for the mangroves to thrive at such environment.

Mangrove forest also comprised of mangrove associates species (or 'nonexclusive' species) that mainly distributed in a terrestrial or aquatic habitat, but also occur in the mangrove ecosystem (Liangmu *et al*., 2010). Previous studies have reported that mangrove associate behave differently from true mangroves. Moreover, they do not show higher salt tolerance and mostly grew best in freshwater environment (Youssef, 2007).

This study indicated that mangrove associates commonly were found at the middle part until the landward margin of mangrove forests. Among mangrove associates that occupied the forest floor were *Talipariti tiliaceum*, *Calophyllum inophyllum*, *Terminalia catappa*, *Dolichandrone spathacea*, *Chromolaena odorata*, *Oxyceris longiflorus, Morinda citrifolia, Pluchea indica, Thespesia populnea* and *Sarcolobus globosus.*

Plate 6.12: <u>Mangrove Associates Found at the Study Area</u>

b) Coral

Coral Speciation

Coral reefs are among the most diverse and valuable ecosystems on earth. They provide economic and environmental benefits worth about $375 billion each year to millions of people as shoreline protection, areas of natural beauty, recreation and tourism, sources of food and pharmaceuticals (Costanza *et al.,* 1997). In addition, they form nurseries and breeding grounds for an estimated 25% of all marine animals as well as home to one third fish species found worldwide (Reef Check Malaysia, 2008).

In Melaka, coral reefs have been recorded at Pulau Besar and other small islands in its surrounding i.e. Pulau Terendak, Pulau Lalang, Pulau Serimbun, Pulau Burung Besar and Pulau Burung Kecil, which is located off the Central Melaka district. Pulau Besar has been gazetted as Fisheries Prohibited Area under the Fisheries (Prohibited Area) Regulation (Amendment) 1988 (**Figure 6.32**). However, the coral reefs off the islands of Melaka have been poorly studied as compared to those within Marine Park, with very limited published studies.

Overall Description

A total of 26 species of hard corals belonging to 12 genera, six (6) species of soft corals and eight (8) species of gorgonians were recorded at the study area (**Table 6.46; Figure 6.33**). The highest number of hard coral species was contributed by family Faviidae with 8 species, followed by family Poritidae with 4 species. Other families i.e Agariciidae, Merulinidae, Euphyllidae, Fungiidae Acroporidae, Dendrophyllidae, Mussidae, Oculinidae, Siderastreidae and Pectiniidae were represented by 1- 2 species. Most common hard coral species were *Porites lobata*, *Platygyra pini*, *Favites complanata*, *Favia maxima* and *Goniopora lobata*.

Soft corals were represented by *Sinularia* sp., *Lobophytum* sp., *Sarcophyton* sp., *Rhodactis* sp., *Macrodactyla doorensis* and *Dendronephthya* sp., while the gorgonians were represented by *Juncella fragilis*, *Ctenocella pectinata*, *Dichotella gemmacea*, *Echinogorgia* sp., *Menella* sp., *Guaiagorgia* sp., *Melithaea* sp., and *Subergogia suberosa*.

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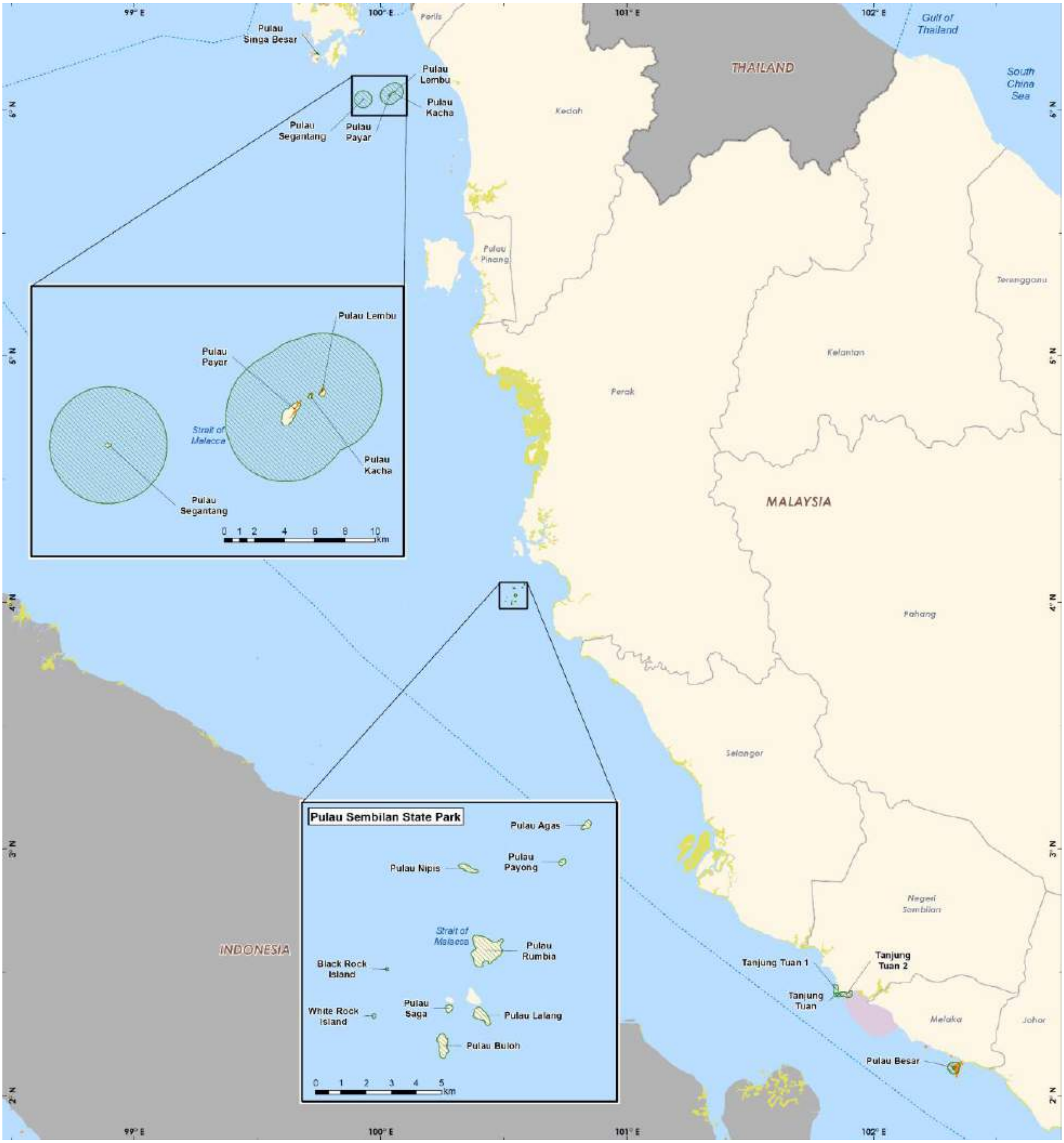
Not To Scale



Source: BOBLME, 2014

Figure 6.32: Location of Coral Reefs at Melaka

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Figure 6.33: Location of Coral Survey Transect Lines at the Study Area

Table 6.46: List of Coral Reefs Recorded at the Study Area

Family	Common Name	Scientific Name	Station							
			T1	T2	T3	T4	T5	T6	T7	T8
Hard Corals										
Faviidae	Lesser Star Coral	*Goniastrea edwardsi*	-	-	+	-	+	-	-	-
	Lesser Star Coral	*Goniastrea palauensis*	-	-	-	-	-	-	-	+
	Knob Coral	*Favia maxima*	+	+	+	-	+	+	+	-
	Knob Coral	*Favia maritima*	+	+	+	-	-	-	+	-
	Honeycomb Coral	*Favites complanata*	+	+	+	-	+	-	+	+
	Brain Coral	*Platygyra sinensis*	+	+	+	-	-	+	-	-
	Brain Coral	*Platygyra pini*	+	+	+	-	+	+	+	+
	Hedgehog Coral	*Echinopora gemmacea*	-	+	-	-	-	-	-	-
Poritidae	Boulder Coral	*Porites lobata*	+	+	+	+	+	+	+	+
	Branching Boulder Coral	*Porites cylindrica*	-	+	-	-	+	+	-	-
	Anemone Coral	*Goniopora minor*	+	-	+	-	-	-	-	-
	Anemone Coral	*Goniopora lobata*	+	+	-	-	+	+	+	+
Agariciidae	Lettuce Coral	*Pavona decussata*	+	+	-	-	+	-	-	-
	Elephant Skin Coral	*Pachyseris rugosa*	+	+	-	-	-	-	-	-
Merulinidae	Ruffled Coral	*Merulina ampliata*	+	+	-	-	-	+	-	+
	Brain Coral	*Cyphastrea serailia*	-	-	-	-	-	+	-	-
Euphyllidae	Pearl Bubble Coral	*Plerogyra sinuosa*	+	-	-	-	-	-	-	-
	Torch Coral	*Euphyllia glabrescens*	-	-	-	-	-	-	-	+
Fungiidae	Plate Coral	*Podabacia crustacea*	+	+	-	-	-	-	-	-
	Mushroom Coral	*Fungia fungites*	-	-	-	-	-	+	-	-
Acroporidae	Porous Star Coral	*Astreopora myriophthalma*	+	-	-	-	-	-	-	-
Dendrophyllidae	Disc Coral	*Turbinaria frondes*	+	+	-	-	+	-	-	+
Mussidae	Sinuous Cup Coral	*Symphyllia agaricia*	+	-	-	-	-	-	-	-
Oculinidae	Galaxy Coral	*Galaxea fascicularis*	+	+	-	-	-	+	+	-
Siderastreidae	Cat's Paw Coral	*Psammocora digitata*	-	-	-	-	-	-	-	+

Family	**Common Name**	**Scientific Name**	**Station**							
			T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**
Pectiniidae	Lettuce Coral	*Pectinia paeonia*	+	+	-	-	-	+	-	-
Soft Corals and Anemones										
Alcyoniidae	Smooth Leather Coral	*Sinularia* sp.	-	-	-	-	-	+	-	-
	Pimply Leather Coral	*Lobophytum* sp.	-	-	+	-	+	+	-	-
	Toadstool Leather Coral	*Sarcophyton* sp.	-	-	-	-	+	+	-	-
Actiniidae	Long Tentacle Anemone	*Macrodactyla doreensis*	-	+	-	-	-	-	-	-
Discosomatidae	Hairy Mushroom Anemone	*Rhodactis* sp.	-	-	-	-	-	+	+	-
Nephtheidae	Carnation Tree Coral	*Dendronephthya* sp.	-	-	-	-	-	-	-	+
Zoanthidae	Zoanthids	*Zoanthus* sp.	-	-	+	-	-	+	+	-
Gorgonians										
Ellisellidae	Sea Whip	*Juncella fragilis*	+	-	-	-	+	+	-	+
	Lyre Sea Fan	*Ctenocella pectinata*	+	-	-	-	-	+	-	-
	Asparagus Sea Fan	*Dichotella gemmacea*	+	-	-	-	+	+	-	-
Plexauridae	Maze Sea Fan	*Echinogorgia* sp.	+	-	-	-	-	+	-	-
	Maze Sea Fan	*Menella* sp.	+	-	-	-	-	-	-	-
Gorgoniidae	Blueberry Gorgonian	*Guaiagorgia* sp.	+	-	-	-	-	+	-	+
Subergorgiidae	Sea Fan	*Subergorgia suberosa*	-	-	-	-	+	+	-	+
Melithaeidae	Sea Fan	*Melithaea* sp.	-	-	-	-	-	-	-	+
Total No. of Species			**24**	**17**	**9**	**1**	**14**	**21**	**8**	**14**

Note: T1-T4: Pulau Besar, T5: Pulau Lalang, T6: Pulau Serimbun, T7, Pulau Burong Kecil, T8: Pulau Burong Besar

'=': Present, '-': Absent

Family Faviidae is one of the most diverse in terms of genera (Veron, 2009). It is also one of the most successful groups in terms of geographic distribution and overall abundance (Veron, 1986), and are commonly known as Brain Coral due to their distinct shape. Among the most prominent genera of this family include *Favia* and *Favites*, which rival the genera *Porites* from family Poritidae in terms of reef-building and massive structures (Veron, 2008). Most of the faviids recorded at the study area had a sub-massive or massive structure. This family is also the most commonly found within Malacca Straits, according to a study by Safuan *et al*. (2018).

The second most abundant family was Poritidae. It is among the fastest growing corals on reefs and an excellent reef-builders, due to their preference to grow into massive form. In addition, massive growth forms are usually favored in an environmentally stressful habitat. However, the poritid corals have wide range of morphologies that range from massive to branching to laminar and ramose. The genus *Porites* spp. have among the smallest polyps, while some species from *Goniopora* spp. have polyps that are large and long and always misidentified as sea anemones (Veron, 2000). In comparison with family Faviidae, this family has been known the dominate the reefs where they were recorded, particularly within Malacca Straits (Wikou and Woesik, 2006; Toda *et al.*, 2007; Safuan *et al*., 2016).

Details description of coral reef status for each transect lines are as follow.

Description based on Transect Line

i. Pulau Besar (T1 – T4)

Pulau Besar is the largest island in the state located approximately about 13km from the Malacca shore. Coral reefs are present surrounding the island, though much of it have been degraded and subjected to sedimentation and turbidity.

A total of four (4) transects were laid to assess the coral reefs at this island (**Figure 6.33**). The most productive area was T1 with live coral percentage of about 60% of

the 100m^2 quadrate, followed by T2 (20% coral cover) and T3 (10% coral cover). The least productive area was T4, with only 2% of the live coral cover.
According to Chou *et al*. (1994), the health status of coral reef can be described as 'Excellent' when live coral percentage cover is more than 75%, 'Good' 50 – 75%, 'Fair' 25 – 50 % and 'Poor' <25%. With respect to study area, only T2 could be described as 'Good', while T2 – T4 were categorized as 'Poor'.

In term of diversity, highest number of species were also recorded at T1 with 24 species, followed by T2 (17 species) and T3 (9 species), while lowest at T4 (1 species). T1 was mostly protected from the wave action of the Malacca Straits, and therefore clarifying the reasons for its diversity and density as compared to other transects. Wave action has been known to influence the reef community structure by affecting not only species composition, but also the morphology of sessile organisms (Cheroske *et al.,* 2000).

At T1, the water depth of the transect line varied from 1.0 – 10.0 m. The sediment types were generally fine sand and silt. Out of 24 species recorded, 18 species were hard corals and six (6) species were gorgonians (sea whips). The hard corals dominated the nearshore area, while the gorgonians were only recorded at the deeper part, approximately about 70 m from the shoreline.

The most dominant hard corals species found were Boulder Coral (*Porites lobata*), Brain Coral (*Platygyra sinensis*, *Platygyra pini*) and Disc Coral (*Turbinaria frondens*). These species have been known to be hardy species, due to their resilience to disturbance and competition (Zhao *et al*., 2016; Darling *et al.*, 2012; Anthony, 2006). In addition, three (3) species were exclusively recorded in T1 i.e. Pearl Buble Coral (*Plerogyra sinuosa*), Porous Star Coral (*Astreopora myriophthalma*) and Sinuous Cup Coral (*Symphyllia agaricia*). The corals were found covering the whole transect line, albeit under silt sediment conditions.

As for gorgonians, it was sparsely populated and was dominated by Sea Whips (*Juncella fragilis*) and Asparagus Sea Fan (*Dichotella gemmacea*).

T2 was directly affected by the wave action from the Malacca Straits, as a consequence of which the coral reefs were only found about 80 m from the shoreline. After the coral reef area (100 m onwards), the seabed dropped-off. The live coral percentage was only 20%, earlier sections of the transect made up mostly of silty sand and coral rubble.

Most of the hard corals were in massive and sub-massive form, which is the default form for the dominant species found i.e. Boulder Coral (*Porites lobata*) and Brain Coral (*Platygyra pini*). The massive form has been known to be resilient towards wave induced structural damage as compared to other coral formations (Baldock *et al.*, 2014).

As for soft coral, only one species was recorded i.e. Long Tentacle Anemone (*Macrodactyla doreensis*).

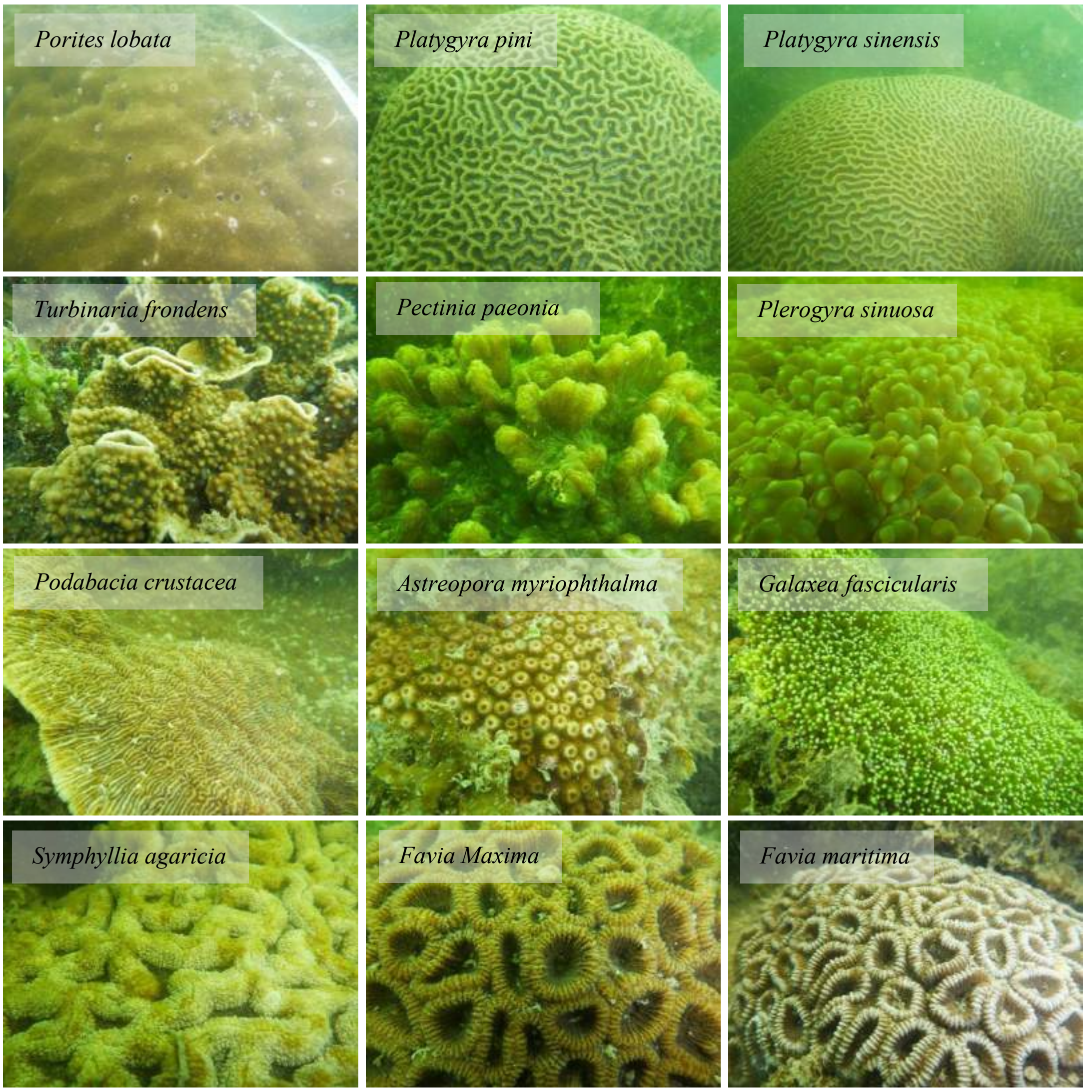
T3 water depth that ranged from 1.0 – 3.0 m, with silt dominating most of the seabed. The live coral percentage was only 10%, and categorized as 'poor'. This area was represented by eight (8) species of hard corals and one (1) species of soft corals. The hard corals species found include Lesser Star Coral (*Goniastrea edwardsi*), Knob Coral (*Favia maxima*, *F. maritima*), Honeycomb Coral (*Favites complanate*), Brain Coral (*Platygyra sinensis*, *P. pini*), Boulder Coral (*Porites lobata*) Anemone Coral (*Goniopora minor*). The most common species observed were *Porites lobata* and *Platygyra sinensis*. However, most of the hard corals were found to be of small sizes (between 0.3 - 1.0 m in diameter and less than 1.0m in height). As for soft coral, only one species was recorded i.e. Pimply Leather Coral (*Lobophytum* sp.).

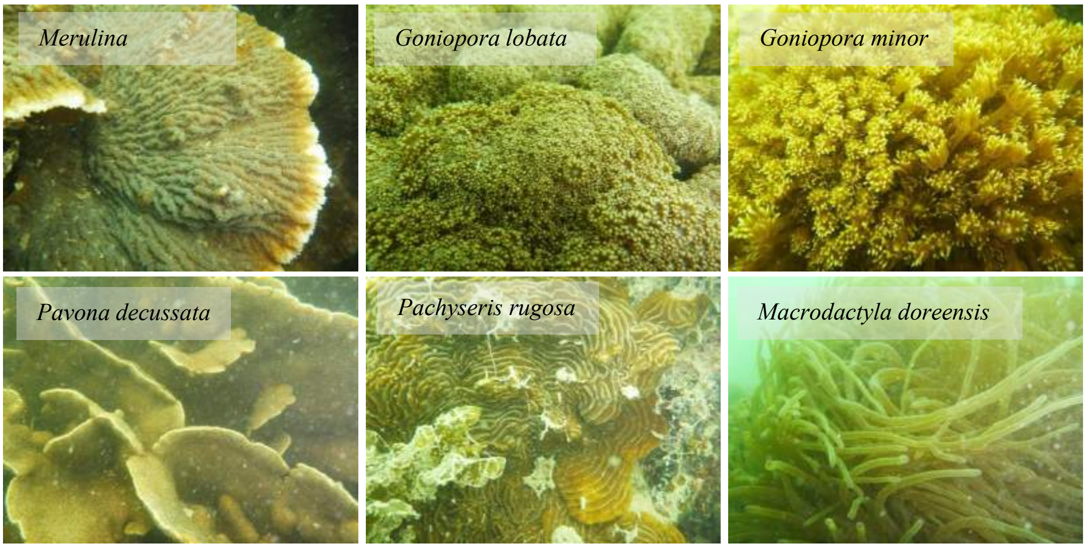
T4 was the least productive area with live coral cover of 2%. Only one (1) species was recorded i.e. *Porites lobata*. The distribution of the *P. lobata* observed were in patches and scattered. The distances between each coral patches were about 5 - 10 m. Most of live coral found to be less than 0.5 m in diameter. Dead coral observed throughout the area.

This area is faces the mainland of Peninsular Malaysia, and therefore was subjected to significant levels of sedimentation and turbidity, as indicated by the mud on the seabed. Therefore, the area was less diverse and had less coral cover as compared to other areas of study.

Sedimentation and turbidity has been known to affect the coral diversity by lowering new coral recruitment due to the lack of stable substrate for coral post-settlement. In addition, turbidity also disrupts photosynthesis by the corals, and causes a reduction in coral growth and survival (Fabricius, 2005).

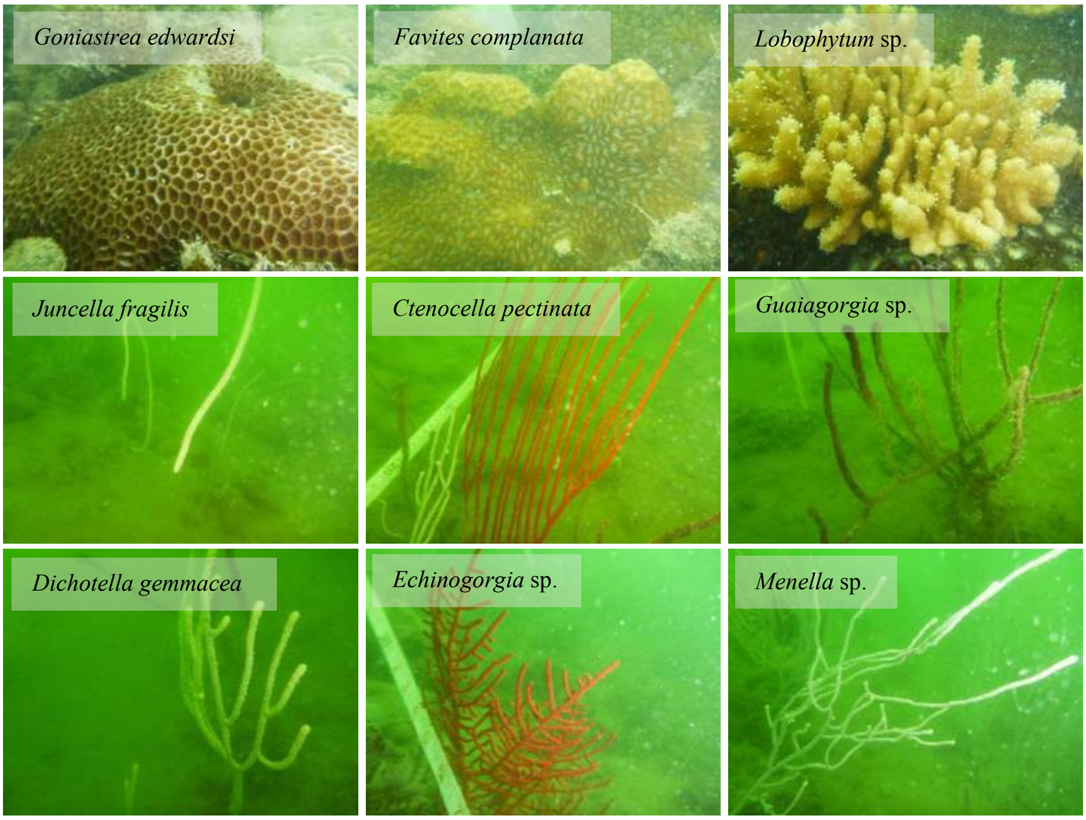
Plate 6.13: <u>Hard Corals Found at Pulau Besar</u>





Note: The pictures were taken from an average focus distance of 10 cm

Plate 6.14: Hard Coral, Soft Corals and Gorgonians Found at Pulau Besar



Note: The pictures were taken from an average focus distance of 10 cm

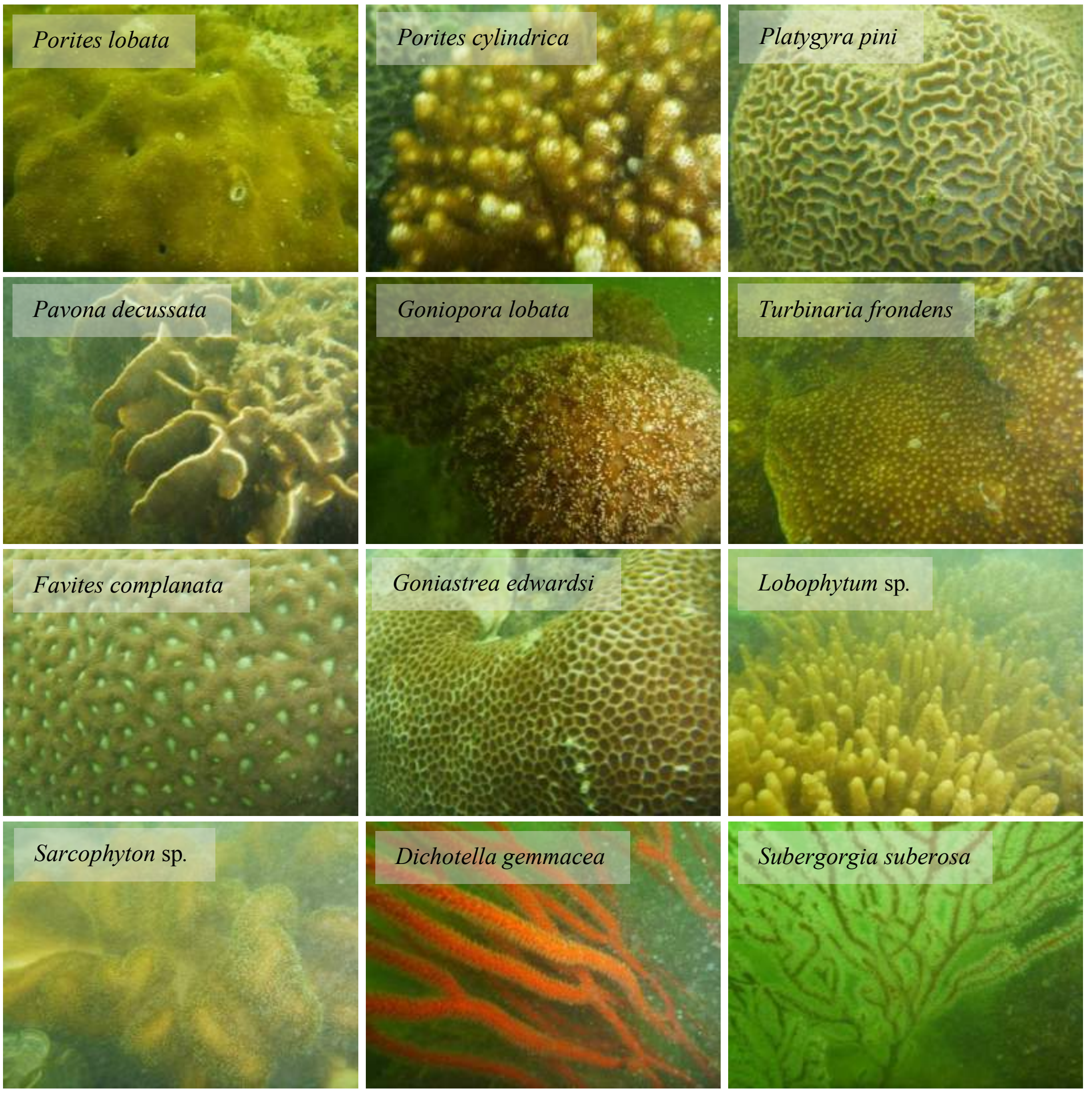
ii. Pulau Lalang (T5)

Pulau Lalang is small joined island with Pulau Terendak, located northeast of Pulau Besar. The islands are generally undeveloped and was overgrown with trees and shrubs. Both of the islands were surrounded by rocky slopes. There were only two sandy beaches at Pulau Lalang. The transect was laid in front of the beach of Pulau Lalang.

The live coral percentage was only 20% and categorized as 'poor'. The type of sediment was sandy mud and coral rubbles. The water depth was around 2 – 6 m. 14 species were identified, dominated by *Porites lobata* and *Pavona decussata*. Both species form massive formations, though *P. decussata* may also form upright plates. The corals sizes were slighter bigger as compared to those at T2 -T4 (Pulau Besar), ranging from 0.3 – 1.5 m in diameter and less than 1.0 m in height.

In addition, there were also soft corals (*Lobophytum* sp. and *Sarcophyton* sp.) as well as gorgonians (*Juncella fragilis, Dichotella gemmacea and Subergorgia suberosa*) recorded at this transect. The corals were observed up to 90 m of the transect line, where afterwards it became a drop-off.

Plate 6.15: <u>Hard Corals, Soft Coral and Gorgonians Found at Pulau Lalang</u>



Note: The pictures were taken from an average focus distance of 10 cm

iii. Pulau Serimbun (T6)

Pulau Serimbun is located northwest of Pulau Besar. Much like Pulau Lalang, the island was undeveloped and was also overgrown with trees and shrubs. The transect line were also laid in front of the only beach at the island.

Pulau Serimbun had 40% live coral cover. Most of corals were recorded at depth ranging from 1.0 – 3.0 m. The corals were observed along the transect line up until the 90 m mark, where afterwards the seabed dropped-off. A total of 11 hard corals, four (4) species of soft corals and six (6) species of gorgonians were recorded.

This area was mostly dominated by *Porites lobata* as well as soft corals (*Sinularia* sp., *Lobophytum* sp., *Sarchophyton* sp. and *Rhodactis* sp.).

An intense competition for space between the hard and the soft corals could be observed in this transect line. Soft corals have been known as the more effective competitors for space on hard substrates due toxic substance that they produce which could cause mortality on the hard corals even without contact (Sammarco *et al.*, 1983). However, the susceptibility of the hard corals vary between species, and also depend on other factors such as current speed, wave action and water quality.

It should be noted that this area was subject to sedimentation as compared to other areas. As observed, about 50% of the corals reefs were smothered by sediment. It is also possible that due to the sedimentation and turbidity that soft corals and gorgonians could thrive here as compared to the hard corals. This was because soft corals and gorgonians has been known to be very tolerant towards high turbidity (Erftemeijer *et al.*, 2012).

Plate 6.16: Hard Corals, Soft Corals and Gorgonians Found at Pulau Serimbun

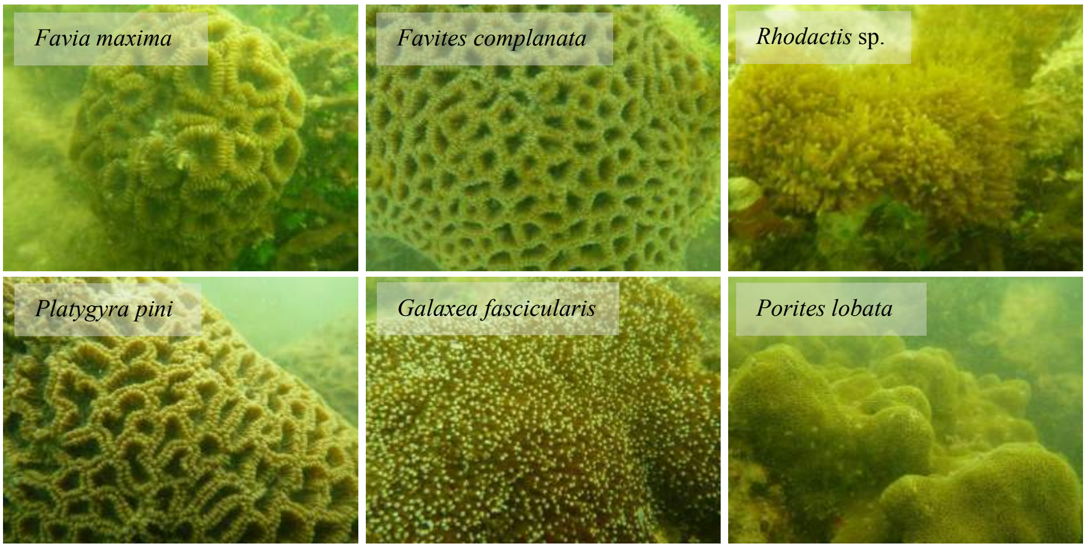
Note: The pictures were taken from an average focus distance of 10 cm

iv. Pulau Burong Kecil (T7)

Pulau Burong Kecil and Pulau Burong Besar form a group of islands located adjacent to the shoreline of Melaka. Both islands were located about 1 km away. The sediment type around the island is generally sandy, with water depths ranging from 1.0 – 3.0 m. The live coral percentage was only 20%, indicating its health status area as 'poor'. Seven (7) species of hard corals and two (2) soft coral species were recorded off the island. The most common species found were *Porites lobata* and *Platygyra pini.*

Most of the *Porites lobata* and *Platygyra pini* found were recorded ranging in less than 1.0 m in diameter and less than 0.5 m in height. No gorgonians were recorded in this area though the condition is suitable for the sea whips/ sea fan to thrive.

Plate 6.17: <u>Hard Corals and Soft Corals Found at Pulau Burong Kecil</u>



Note: The pictures were taken from an average focus distance of 10 cm

v. Pulau Burong Besar (T8)

Pulau Burong Besar was located to the south of Pulau Burong Kecil. The waters along the transect line had depths ranging from 2.0 – 5.0 m, with sediment consisting mainly of sandy silt. The live coral percentage was similar with Pulau Burong Kecil i.e. 20%, which indicates its health status as 'poor'.

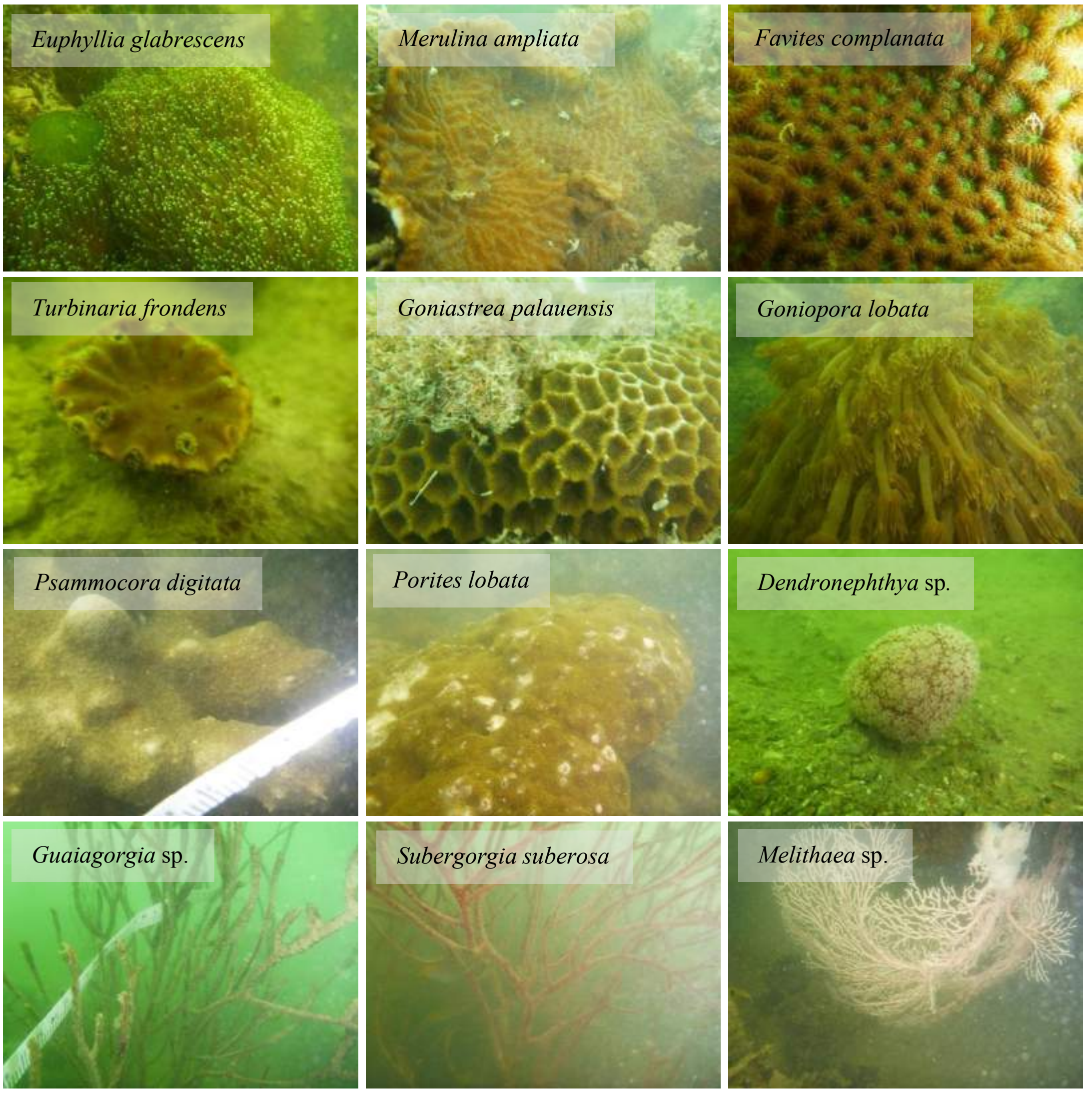
However, the total number of species was higher as compared to P. Burong Kecil i.e 14 species (9 species of hard coral, 1 species of soft coral and four species of gorgonians). As for hard coral, most dominant species was also *Porites lobata.* However, the area recorded larger size i.e within 1.5 – 2.0 m in diameter and more than 1.0 m in height.

As for soft coral, only one species was observed i.e *Dendronephthya* sp., while gorgonians represented by *Juncella fragilis, Guaiagorgia* sp., *Subergorgia suberosa* and *Melithaea* sp.

Overall, most of data from the transect lines indicated extensive degradation of coral reefs by sedimentation and were covered with silt and sand (**Plate 6.19**). Even though corals can grow in turbid waters, excessive sedimentation can damage and destroy coral reefs due to suspended sediment, thus blocking the light from reaching the corals. In addition, high sedimentation inhibits the settlement of coral larvae, thus preventing the recolonization (Masalu, 2000).

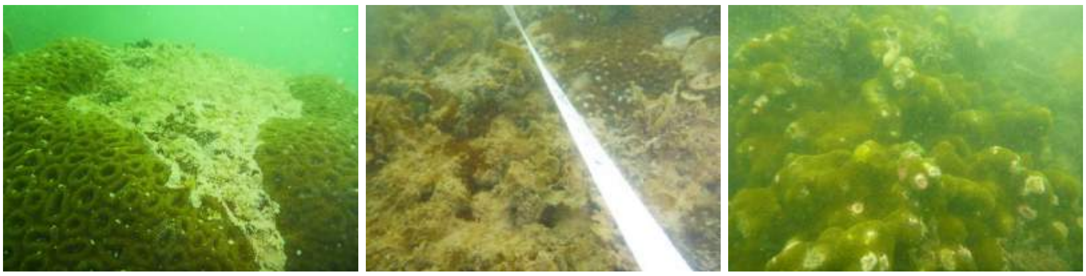
The scattered nature of reefs and their irregular shapes strongly point a situation where, historically, the reefs were much more extensive and far healthier than they are now. It is very probable that the pollution from the mainland as well as unrestricted tourism activity on the island has affected the corals into their current state. Given the fact that the existing reef is still considered rich and diverse, every effort should be made to ensure that the proposed reclamation project does not exacerbate current levels of degradation.

Plate 6.18: <u>Hard Corals, Soft Coral and Gorgonians Found at Pulau Burong Besar</u>



Note: The pictures were taken from an average focus distance of 10 cm

Plate 6.19: <u>Silt and Sand Covering the Corals</u>



Note: The pictures were taken from an average focus distance of 10 cm

vi. Pulau Menatang

Pulau Menatang is located about 500 m from the main shoreline. The waters around the island had depths <0.5 m, with high sediment consisting mainly of sandy silt and rock.

The island is generally rocky with sparse mangrove vegetation. Observation on the island does not indicate strong presence of corals due to the type of rock formation, as well as the unfavourable condition for corals to inhabit the area i.e. strong current and waves, as well as turbid waters.

Plate 6.20: View of Pulau Menatang

Associated Marine Fauna

Coral reefs support a diverse range of fauna, both vertebrate as well as invertebrate. This is because apart from playing a major role in protecting shorelines from storms and waves, they also act as refuges, feeding and nursery grounds for the fish fauna. The diversity of marine life is directly proportional to the complexity of the coral ecosystem i.e. the more complex and diverse the reefs, the more number of species the ecosystem supports (Luckhurst and Luckhurst, 1978). In addition, Bell *et al.* (1985) reported a positive correlation between coral cover and coral fish diversity in some fish communities.

Reef Fish

A total of 21 species of fish from 13 families were identified from the study area (**Table 6.47**). The highest number of species recorded at T1 with 21 species, followed by T8 (14 species) and T2 (11 species). The most abundant species were from Pomacentridae with five species, followed by Labridae (3 species), Nemipterida (2 species) and Serranidae (2 species). Generally, these families are the most common inhabitants of the coral reefs, mostly due to the protection and food availability.

One of the main indicator of fish groups for coral health were the Chaetodontidae (Butterflyfish). Generally, most of the butterfly fish are corallivores i.e. feed on the live tissue of living coral for their diet. Their presence, especially obligate corallivores, could indicate healthy condition of a reef. However, during the survey, only one (1) species of butterflyfish were recorded i.e. *Chelmon rostratus*, which were recorded in T1, T3 and T8. *Chelmon rostratus* is known as facultative corallivores, where they feed on live coral as well as on sponges, algae and mollusk. The presence of only one (1) species of Butterflyfish could not be used to determine the health of the coral reefs in this study due to the limited visibility.

Other than reef fishes, commercial fish species such as groupers (*Epinephelus* spp., *Cephalopholis* spp.), snapper (*Lutjanus* spp.) and threadfin (*Polynemus* spp.) were also observed at the study area. Reef areas provide food and shelter as well as nursery grounds for these fishes.

Visual surveys are usually biased and low visibility in turbid waters may lead to reduced observations. In addition, visual surveys can underestimate the abundance of the most common species, and species behavior may affect the results as some species are attracted to, while others may swim away from the diver (Dickens *et al.*, 2011). Therefore, the number of fish species observed in this study is only best estimation of the species present there.

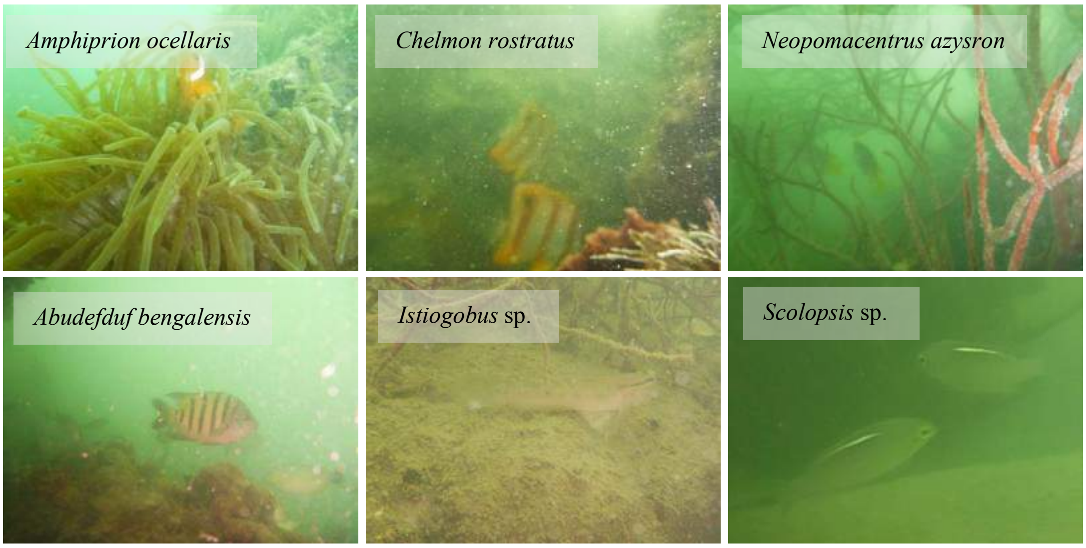
Table 6.47: List of Fish Recorded at the Study Area

Family	Local Name	Scientific Name	Station							
			T1	T2	T3	T4	T5	T6	T7	T8
Ambassidae	Glassfish	*Ambassis* sp.	+	-	+	-	-	-	-	-
Caesionidae	Fusilier	*Caesio cuning*	+	-	-	+	-	+	-	-
Chaetodontidae	Copperband Butterflyfish	*Chelmon rostratus*	+	-	+	-	-	-	-	+
Gobiidae	Goby	*Istigobius* spp.	+	-	-	+	-	+	-	+
Labridae	Pastel-Green Wrasse	*Halichoeres* spp.	+	+	-	-	-	+	+	+
Labridae	Bluntheaded Wrasse	*Thalassoma* spp.	+	+	-	-	-	+	+	+
Labridae	Wrasse	*Pomacentrus* sp.	+	+	+	-	+	+	+	+
Lutjanidae	Indian Snapper	*Lutjanus* spp.	+	+	-	-	+	-	-	+
Monacanthidae	Fringed Filefish	*Monacanthus ciliatus*	+	-	-	-	+	+	-	+
Nemipteridae	Whiptailfish	*Pentapodus* sp.	+	-	-	-	-	-	-	-
Nemipteridae	Bream	*Scolopsis* sp.	+	-	-	-	-	-	+	-
Polynemidae	Threadfin	*Polynemus sp.*	+	-	-	-	-	-	-	-
Pomacentridae	Black Damselfish	*Neoglyphidodon melas*	+	-	-	-	+	+	-	+
Pomacentridae	Yellowtail Demoiselle	*Neopomacentrus azysron*	+	+	+	-	-	+	+	+
Pomacentridae	Green Damsel	*Chromis* spp.	+	+	+	-	+	+	+	+
Pomacentridae	Sergeantfish	*Abudefduf bengalensis*	+	+	+	-	+	-	-	+
Pomacentridae	False Clownfish	*Amphiprion ocellaris*	-	+	-	-	-	-	-	-
Serranidae	Grouper	*Cephalopholis* spp.	+	+	-	-	-	-	+	+
Serranidae	Grouper	*Epinephelus* spp.	+	+	-	-	-	-	+	+
Siganidae	Rabbitfish	*Siganus* spp.	+	+	-	-	-	-	+	+
Synodontidae	Lizardfish	*Synodus* spp.	+	-	-	-	+	+	-	-
Total Number of Species			**20**	**11**	**6**	**2**	**7**	**10**	**9**	**14**

Note: T1-T4: Pulau Besar, T5: Pulau Lalang, T6: Pulau Serimbun, T7, Pulau Burong Kecil, T8: Pulau Burong Besar

'=': Present, '-': Absent

Plate 6.20: Fish Observed at the Coral Reef Areas



Invertebrates

Invertebrates account for the vast majority of fauna in reef ecosystems. Many of these invertebrates rely on corals for food, habitat or settlement cues. In turn, many corals are also reliant on the services of particular invertebrates, leading to strong correlation between abundance of corals and associated invertebrates. The loss of coral taxa can lead to decline in invertebrate biodiversity and will, in turn, affect coral reef ecosystem function (Stella *et al.*, 2011).

With respect to the study area, a total of seven (7) groups of associated marine invertebrates were recorded i.e. Porifera, Mollusca, Echinodemata, Annelida, Cnidaria, Crustacea and Bryozoans. These groups were represented by more than 24 species (**Table 6.48**). Highest number of species were recorded at T1 (21 species), followed by T5 (18 species) and T2 (16 species).

Porifera (sponges) were the most commonly observed invertebrates, and it was found at most of the transect line. Several species listed include *Xestospongia testudinaria*, *Dendrilla* sp., *Haliclona cymaeformis* and *Gelliodes fibulata*. The sponges, particularly *Xestospongia testudinaria* was commonly covered with *Polydorella* sp. (spionid worms). Aside from the corals, sponges could also function as a habitat for to other marine organisms due to their structural strength.

On the other hand, sponges also play an important role in the nutrient cycling, thus making them an integral part of the ecosystem. The effect of turbid water on the sponges has not been fully documented, as different species of sponges has different mechanisms to adapt to the turbidity. However, it should be noted that the sponges in the current study were mostly smaller as compared to sponges in other locations. For reference, barrel sponges at Labuan has been recorded with size of more than 1.0 m in height (Envsolve, 2018), but at the study area, most of it was recorded below 0.5 m in height.

Pedum spondyloideum was usually observed embedded in massive coral colonies of the *Porites* species. Close relationship between *Pedum* and host corals showed that the corals provide support and protection to the *Pedum*, and the *Pedum* help in enhancing water circulation for coral feeding (Scaps and Denis, 2007).
DeVantier and Endean (1988) showed that *Pedum* can reduce the effects of heavy levels of predation by the starfish *Acanthaster planci* on their hosts on the Great Barrier Reef by repelling foraging starfish on contact by repeated expulsions of jets of water. However, *Pedum* may cause structural weakness to the host, since their presence, both alive and dead, results in a cavity inside the coral skeleton (Scaps, 2011).

Zoanthids (*Zoanthus* sp.) also dominated at several areas such as T3 (Pulau Besar), T6 (Pulau Serimbun) and T7 (Pulau Burong Kecil). The *Zoanthus* sp. form a dense carpet covering the area around the hard corals structure. The domination of *Zoanthus* sp. at these areas was possibly due to its aggressive behavior (Sebens, 1982), especially in a favorable environmental conditions i.e. shallow water and high turbidity.

Feather duster worms (*Sabellastarte* sp.) were also commonly found at the study area. It had various colours and commonly found embedded on *Porites* species. Feather star (*Oligometra* sp., *Himerometra robustipinna, Himerometra* sp. and *Stephanometra* sp.) was also commonly observed at most of transect lines.

Table 6.48: List of Invertebrates Recorded at the Study Area

Family	Common Name	Species	Station							
			T1	T2	T3	T4	T5	T6	T7	T8
Porifera										
Chalinidae	Sponge	*Haliclona cymaeformis*	+	+	-	-	+	+	+	-
Darwinellidae	Spiky Sponge	*Dendrilla* sp.	+	-	-	-	+	-	-	+
Niphatidae	Grey Encrusting Sponge	*Gelliodes fibulata*	+	+	-	-	+	-	-	+
Petrosiidae	Giant Barrel Sponge	*Xestospongia testudinaria*	+	+	+	-	-	+	-	+
-	Sponges	Unidentified sponges	+	+	+	-	+	+	+	+
Mollusca										
Cypraeidae	Cowries	*Cypraea* spp.	+	-	-	-	-	-	+	+
Muricidae	Sea Snails	*Drupa* sp.	+	+	+	-	-	-	+	+
Nassariidae	Mud Snails	*Nassarius* spp.	+	+	+	-	+	+	-	-
Ostreidae	Oyster	*Ostrea* sp.	-	-	-	-	+	-	-	-
Pectinidae	Coral Clam	*Pedum spondyloideum*	+	+	-	-	+	-	-	-
Potamidae	Sea snails	*Cerithidea* sp.	+	+	-	+	+	+	+	+
Echinodermata										
Colobometridae	Feather Star	*Oligometra* sp.	+	-	-	-	+	+	+	+
Himerometridae	Red Feather star	*Himerometra robustipinna*	+	+	+	-	-	+	+	+
Himerometridae	Feather Star	*Himerometra* sp.	+	+	+	-	+	+	+	+
Mariametridae	Feather Star	*Stephanometra* sp.	+	-	-	-	+	+	+	+
Annelida										
Sabellidae	Feather Duster Worm	*Sabellastarte* sp.	+	+	+	-	+	+	+	+
Serpulidae	Christmas Tree	*Spirobranchus* spp.	+	-	-	-	+	-	-	-
Spionidae	Spionid worm	*Polydorella* sp.	-	-	+	-	-	+	-	-

Family	Common Name	Species	Station							
			T1	T2	T3	T4	T5	T6	T7	T8
Cnidaria										
Aglaopheniidae	Stinging Hydroids	*Macrorhynchia* sp.	+	+	-	-	+	-	+	-
Aglaopheniidae	Ostrich Plume Hydroid	*Aglaophenia* sp.	+	+	-	-	+	-	+	-
Zoanthidae	Zoanthids	*Zoanthus* sp.	-	-	+	-	-	+	+	-
Crustacea										
Diogenidae	Hermit Crab	*Clibanarius* sp.	+	+	-	-	+	+	+	+
Portunidae	Swimming Crab	*Charybdis* sp.	+	+	+	-	+	+	+	+
Bryozoan										
Phidoloporidae	Lace coral	*Triphyllozoon sp.*	+	+	-	-	-	-	+	+
Total Number of Species			**21**	**16**	**10**	**1**	**18**	**15**	**15**	**15**

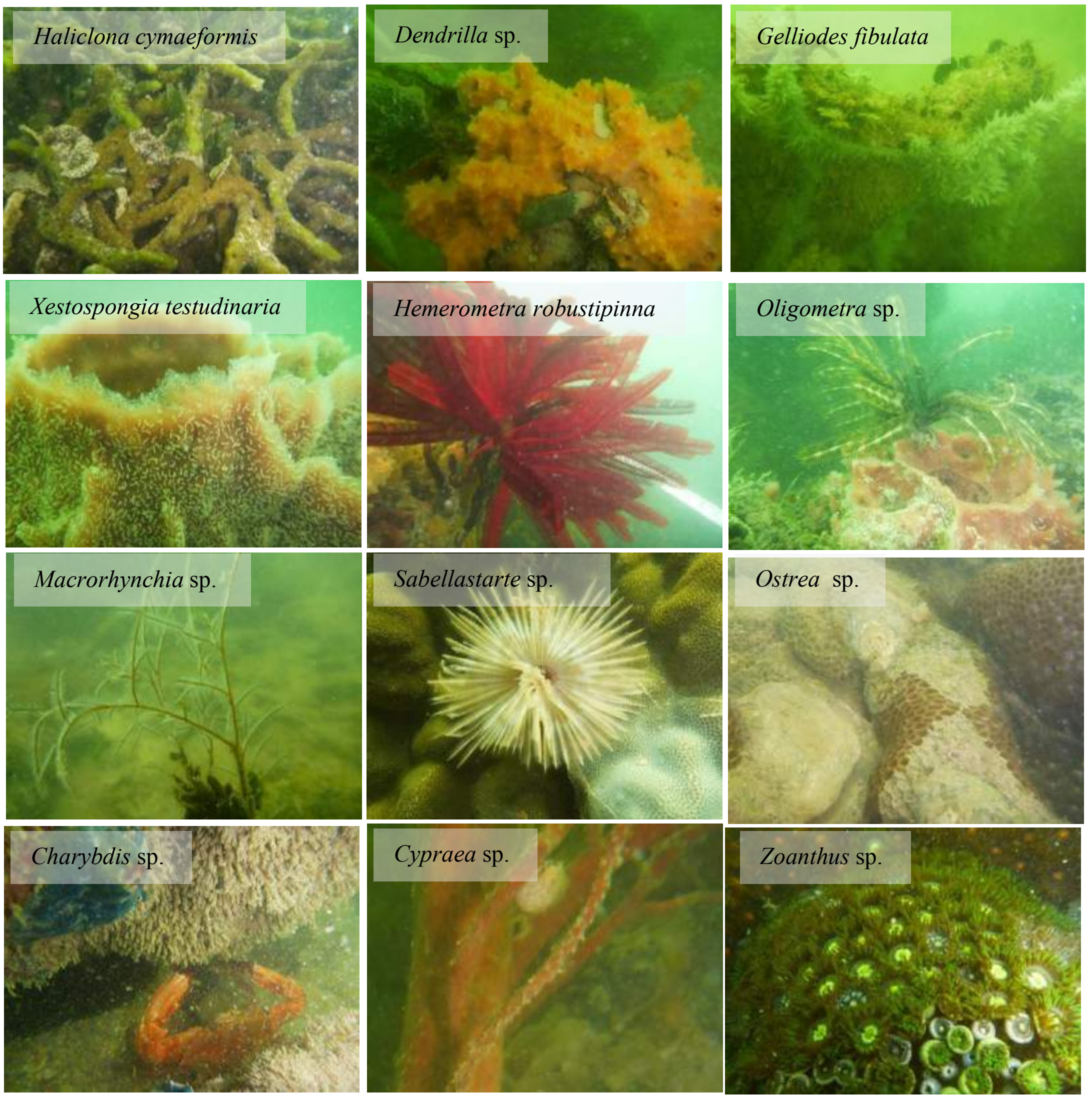
Note: T1-T4: Pulau Besar, T5: Pulau Lalang, T6: Pulau Serimbun, T7, Pulau Burong Kecil, T8: Pulau Burong Besar

'=': Present, '-': Absent

Cowries (*Cypraea* spp.) was commonly attached at gorgornians. Other species were limited such as Oyster (*Ostrea* sp.) only observed at T5, Christmas tree (*Spirobranchus* spp.) at T1 and T5 and Spionid worm (*Polydorella* sp.) at T3 and T6.

Some marine invertebrates such as the Crown-of-Thorns (*Acanthaster planci*) and Horn Drupe (*Drupella* sp.) known as predators of living corals and their abundance can cause significant damage to the reefs. However, during the current study, they were not observed at all transect lines.

Plate 6.21: <u>Invertebrates Found at the Coral Reef Areas</u>



Note: The pictures were taken from an average focus distance of 10 cm

Seaweed

Malaysian waters are rich with a wide variety of macroscopic algae or seaweeds. Seaweeds are photosynthetic organisms possessing chlorophyll and simple reproductive structures, but lacking true root, stems and leaves. Seaweeds act as a role in the complex web of life as the main primary producers in aquatic environments. They are the foundation of food chain in aquatic ecosystems. Seaweed beds also provide shelter, breeding and nursery grounds for a variety of organisms such as crustaceans, fish, squid, cuttlefish, gastropods and others (Lim *et al.*, 2001).

The distribution and composition of seaweeds change with time and place due to factors such as light, temperature, nutrients as well as grazing by molluscs. In addition, human activities that contribute excess sediments and suspended solids also can cause changes to their distribution (Diez *et al*., 2003).

Seaweeds are generally found associated with corals, driftwood, epiphytes, mudflats, mangroves, water column, rock substratum and stones, sand substratum, wooden structures, fish cages and fish nets. The tally of the Malaysian marine algae currently stands at 386 specific and intraspecific taxa (17 taxa of Cyanophyta, 102 Cholophyta, 182 Rhodophyta and 85 Phaeophyta) (Phang *et al.,* 2007).

With respect to the study area, seaweeds were comprised of two (2) main divisions namely Chlorophyta (green algae) and Phaeophyta (brown algae). Chlorophyta were represented by 11 species, while the Phaeophyta were represented by three (3) species (**Table 6.49**).

Under division Chlorophyta, the highest number of species was recorded under family Caulerpaceae, which were represented by *Caulerpa racemosa*, *Caulerpa lentillifera*, *Caulerpa sertularioides* and *Caulerpa peltata*. In terms of station, *C. racemosa* was the most widespread, being recorded at most of the transect lines.

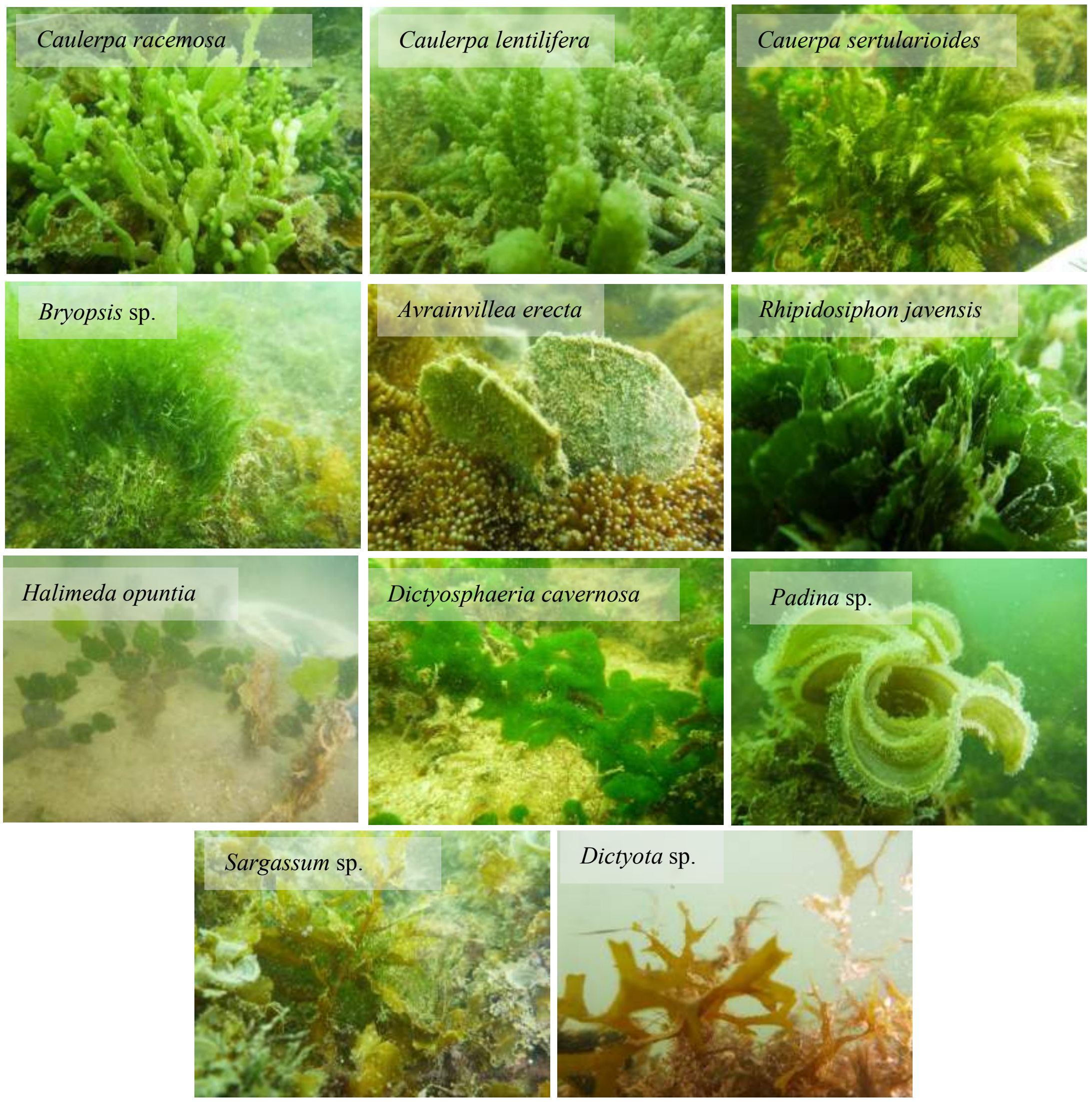
Table 6.49: List of Seaweeds Recorded at the Study Area

Family	Common Name	Species	Station							
			T1	T2	T3	T4	T5	T6	T7	T8
Chlorophyta (Green Algae)										
Caulerpaceae	Oval Sea Grapes	*Caulerpa racemosa*	+	+	+	-	+	-	+	+
	Round Sea Grapes	*Caulerpa lentillifera*	-	-	-	-	+	+	-	-
	Delicate Green Seaweed	*Caulerpa sertularioides*	-	-	-	-	-	-	+	+
	Flattop Sea Grapes	*Caulerpa peltata*	+	-	-	-	-	-	-	+
Dichotomosiphonaceae	Sea Fan Seaweed	*Avrainvillea erecta*	+	+	+	-	+	+	+	+
	Cluster Sea Fan Seaweed	*Avrainvillea lacerata*	-	-	-	-	-	-	+	+
Udoteaceae	Pleated Fan Seaweed	*Rhipidosiphon javensis*	-	-	-	-	-	+	-	-
Siphonocladaceae	Green Bubble Seaweed	*Dictyosphaeria cavernosa*	-	-	-	-	-	+	+	+
Bryopsidaceae	Hairy Green Seaweed	*Bryopsis* sp.	-	-	+	-	-	-	-	-
Halimedaceae	Calcareous Green Algae	*Halimeda opuntia*	+	+	+	+	+	+	-	-
Ulvaceae	Sea Lettuce	*Ulva* sp.	+	+	+	-	-	-	+	-
Phaeophyta (Brown Algae)										
Dictyotaceae	Branching Brown Seaweed	*Dictyota* sp.	-	-	-	+	+	+	+	-
	Peacock's Tail	*Padina* sp.	+	-	+	+	+	+	+	+
Sargassaceae	Brown Algae	*Sargassum* sp.	+	+	+	-	+	+	+	+
Total No. of Species			**7**	**5**	**7**	**3**	**7**	**8**	**9**	**8**

Note: T1-T4: Pulau Besar, T5: Pulau Lalang, T6: Pulau Serimbun, T7, Pulau Burong Kecil, T8: Pulau Burong Besar

'=': Present, '-': Absent

Plate 6.22: Seaweeds Found at the Coral Reef Areas



Note: The pictures were taken from an average focus distance of 10 cm

Caulerpa have a chemical defense which prevents predators and grazers such as sea urchins and fish from feeding on them. According to Amade and Leme (1998), a toxin produced by *Caulerpa* i.e. caulerpenyne, is a major secondary metabolite. This defensive mechanism has allowed them to successfully colonize many habitats and substrates. In addition, they able to withstand severe nutrient limitations, which probably partly explains its growth ability (Delgado *et al.*, 1996).

Family Dichotomosiphonacea was represented by two (2) species i.e. *Avrainvillea erecta* and *Avrainvillea lacerata*. The difference between these two species is that *A. erecta* usually form solitary paddle-shaped blades, while *A. lacerata* usually form clusters of leaves. Both of these species are usually associated with other species of seaweed and seagrass.

Other families were each represented by single species i.e *Rhipidosiphon javensis* from family Udoteaceae, *Dictyosphaeria cavernosa* from family Siphonocladaceae, *Bryopsis* sp. from family Bryopsidaceae, *Halimeda opuntia* from family Halimedaceae and *Ulva* sp. from family Ulvaceae. The most common species recorded was *Halimeda opuntia*. *H. opuntia* is a unique form of calcareous algae that features tight, segmented discs and commonly found attached to rocks, sandy bottom and other algae. The presence of hard calcium carbonate within the tissues make the plant inedible to most herbivores. This species does not possess a rhizome as other species of *Halimeda*, but is an encrusting variety that spreads both laterally and horizontally (Pereira, 2015).

Phaeophyta was represented by *Sargassum* sp., *Padina* sp. and *Dictyota* sp., where *Sargassum* sp. and *Padina* sp. were found at most of the transect lines. *Sargassum* are a robust macroalgae with strong stipes and holdfast. These distinctive characteristics make it possible for *Sargassum* to withstand strong wave action and predators contributing to the survival of the taxa (Asmida *et al*., 2017). *Sargassum* can be found abundantly in Malaysian coastal waters. *Sargassum* are often preferentially consumed by herbivorous fish and echinoids because it has relatively low level of phenolics and tannins (Steinberg, 1986).

Padina sp. was also found to be dominant at the study area, where they are easily identified due to their fronds. *Padina* is one of the only two genera under Phaeophyta that is calcified (Huisman, 2000, Kraft *et al.*, 2004), with the other one was *Newhousia* which were only recorded in Hawaii. *Padina* features a single holdfast that could securely anchors the algae to rocks, shells and coral fragments.

Corals and algae have been known to compete for space and is also prevalent in the current study. Widespread replacement of coral by algae may indicate coral mortality, though it is more due to external factors i.e. pollution and turbidity, instead of competitive overgrowth. However, this factor could still affect coral recruitment, which in turn would change the overall ecosystem (McCook *et al.*, 2001). Therefore, there is still potential for coral recovery in this area, and action must be followed through by all of the stakeholders.

Seagrass

During the survey, only one species of seagrass was recorded i.e. *Thalassia hemprichii*, which was recorded in T1, T3, T6 and T7. They usually form small patches on the sediment, which are usually covered with silt. Algae usually grow on this seagrass, which can smother them. This type of seagrass is usually eaten by both turtles and dugong, and therefore could be foraging grounds for the turtles which nests in Melaka.

Plate 6.23: Seagrass (*Thalassia hemprichii*) Found at the Coral Reef Areas

Note: The pictures were taken from an average focus distance of 10 cm

c) Marine Turtle

The coastline of Melaka has great conservation value in terms of its importance as nesting sites for marine and estuarine turtles. Of the four (4) species of marine turtles found in Malaysian waters, the Hawksbill Turtle (Eretmochelys imbricata) or locally known as 'Penyu Karah or Penyu Sisek' are known to nest along the sandy beaches on the Melaka coastline. These species are listed in the IUCN (International Union for the Conservation of Nature) Red Data Book as Critically Endangered (Mortimer and Donnelly, 2008).

There are a total of 19 nesting sites located along Melaka coastline (**Chart 6.21**). Nesting occurs throughout the year although the main nesting season is between April – October and the peak season is during June - August. In 2017, out of 19 landing sites, only 13 landing sites have been recorded landed by turtles i.e Pulau Upeh, Kem Terendak, Balik Batu, Pasir Gembur, Padang Kemunting, Teluk Belanga, Kg. Teluk, Kuala Linggi, Meriam Patah, Tg. Serai, Sg. Kertah/ Sg. Tuang, Tg. Dahan and Pengkalan Balak. A total of 573 turtle landings were recorded in 2017, which increased from 574 landings in 2016. In addition, data from the Melaka State Fisheries Department indicated no turtle landings were recorded in Tg. Kling, Tg. Bidara, Sg. Udang, Teluk Gong, Kampung Tengah and Pulau Burong/ Pulau Lalang in 2017 (**Table 6.50**).

Where study area is concerned, only 7 landings of the Hawksbill Turtle (*E. imbricata*) was recorded in 2011 specifically at Pulau Burong/ Pulau Lalang. No landings were recorded in 2017 (Department of Fisheries, Melaka 2018- unpublished).

Data from the Melaka State Fisheries Department reported that, highest concentration of hawksbill turtles in Melaka from 2007 to 2017 to be in Padang Kemunting, Pulau Upeh and Kem Terendak. Turtle landing in Padang Kemunting showed increasing pattern from 66 landings in 2009 to 174 landing in 2017. However, turtle landings in Pulau Upeh and Kem Terendak showed a significantly decline throughout the period (**Chart 6.21**). The development pressure and extensive reclamation activities along the coastline have inevitably affect the turtle ladings in Melaka.

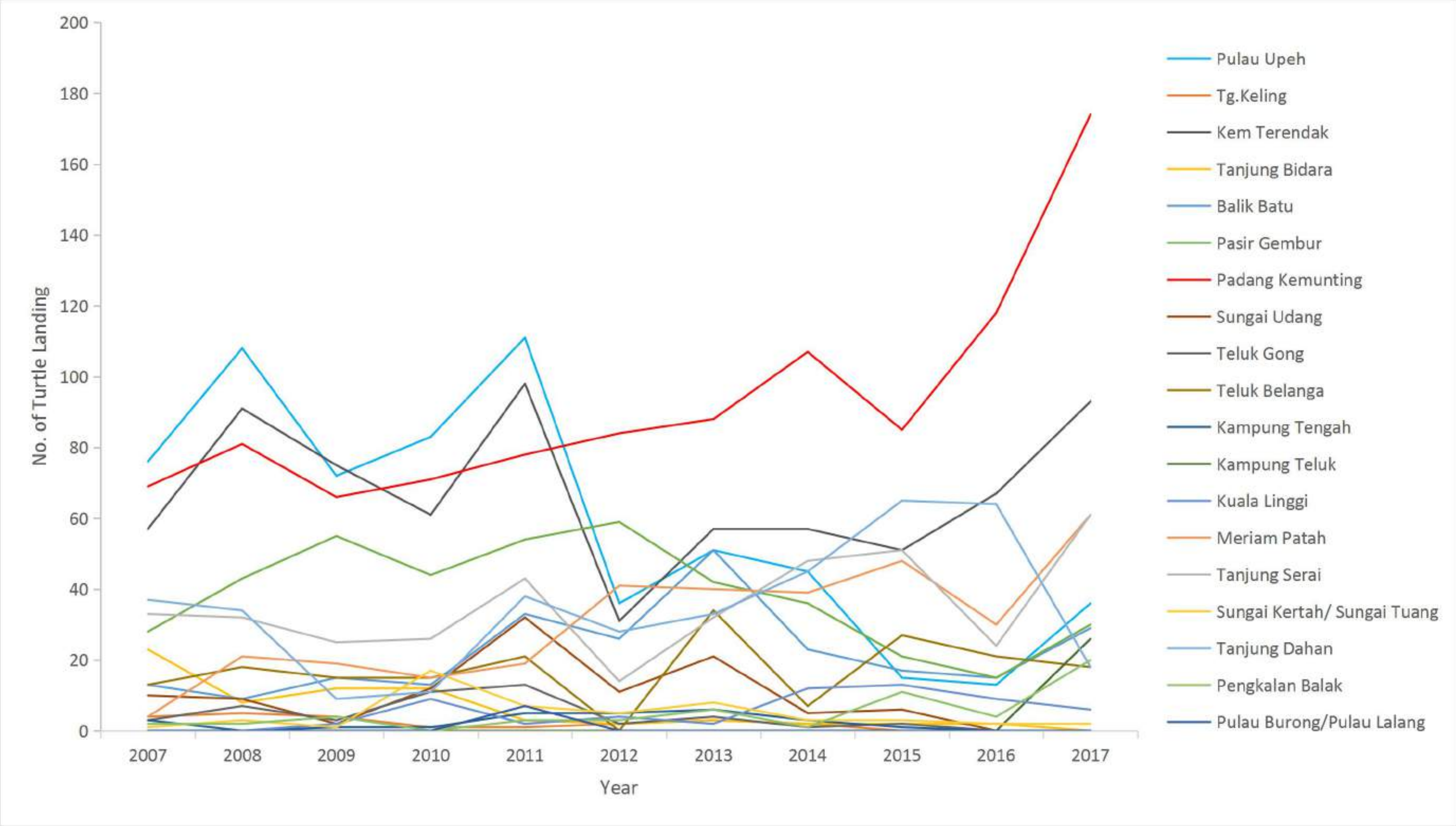
Table 6.50: Hawksbill Turtle Landings along the Melaka Coastline in 2017

Turtle Landing Site	Month												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Pulau Upeh	-	-	-	4	5	6	9	7	5	-	-	-	**36**
Tanjung Keling	-	-	-	-	-	-	-	-	-	-	-	-	**0**
Kem Terendak	-	-	-	5	8	20	28	13	1	5	10	3	**93**
Tanjung Bidara	-	-	-	-	-	-	-	-	-	-	-	-	**0**
Balik Batu	-	-	-	1	6	6	6	3	3	2	1	-	**28**
Pasir Gembur	-	-	1	1	2	1	14	7	-	-	1	1	**28**
Padang Kemunting	2	1	2	14	23	37	50	27	20	7	2	3	**188**
Sungai Udang	-	-	-	-	-	-	-	-	-	-	-	-	**0**
Teluk Gong	-	-	-	-	-	-	-	-	-	-	-	-	**0**
Teluk Belanga	-	-	-	-	1	3	3	2	5	5	-	-	**19**
Kampung Tengah	-	-	-	-	-	-	-	-	-	-	-	-	**0**
Kampung Teluk	-	-	-	-	-	6	6	10	4	-	-	-	**26**
Kuala Linggi	-	-	2	1	1	-	-	-	-	-	-	-	**4**
Meriam Patah	-	-	2	6	10	13	16	13	2	-	-	-	**62**
Tanjung Serai	-	-	-	3	6	16	14	17	6	-	-	-	**62**
Sungai Kertah/ Sungai Tuang	-	-	-	-	-	-	-	-	-	1	-	-	**1**
Tanjung Dahan	-	-	1	4	2	8	2	2	-	-	-	-	**19**
Pengkalan Balak	-	-	-	-	2	1	2	2	-	-	-	-	**7**
Pulau Burong/ Pulau Lalang	-	-	-	-	-	-	-	-	-	-	-	-	**0**
Total	**2**	**1**	**8**	**39**	**66**	**117**	**150**	**103**	**46**	**20**	**14**	**7**	**573**

Note: Yellow column- Turtle landing site within 5 km radius of project site

Source: Department of Fisheries, Melaka, 2018-unpublished

Chart 6.21: Hawksbill Turtle Landings in Melaka from 2007- 2017



Source: Department of Fisheries, Melaka, 2018-unpublished

6.10.3.4 Fisheries and Aquaculture

a) Marine Capture Fisheries

Capture fisheries is locally important in and adjacent to the project area. Details of capture fisheries activity in the State as well in the vicinity of the site is discussed separately below.

Overview of Marine Capture Fisheries at Melaka State

The marine fishery in Melaka is very small compared to other production such as agriculture, animal husbandry, manufacturing and services industries. The coastal waters of Melaka support only artisanal fisheries owing to its rather limited area and low exploitable fisheries resources, compared to other areas of Peninsular Malaysia. In 2017, there were 1,074 fishermen operating 83 inboards and 756 outboard powered boat along the coastal waters of Melaka. Only traditional gears, particularly drift nets, were employed. There were no commercial gears, such as trawls and purse seines, operating in these waters.

In 2017, estimated fish landings from coastal waters of Melaka amounted to 1,769 tonnes, valued at RM 31.53 million (Department of Fisheries, 2018). In the same year, fish landings in Peninsular Malaysia totalled 1,125,449 tonnes, valued at RM 8,803.25 million. Melaka's fish landings formed only 0.2% of the total catch for Peninsular Malaysia.

Reviews of the catch data over 10 years from 2008 to 2017, it indicated that there were no major differences in landings between the years, ranging from 1,666 – 2,019 tonnes. However, the wholesale values showed increasing pattern from RM18.10 million in 2009 to RM31.53 million in 2017 (**Chart 6.22**).

Chart 6.22: Trend of Fish Landings and Wholesale Value in Melaka from 2008 - 2017

Source: Department of Fisheries, 2009-2018

A listing of major species found in Melaka waters is provided in **Table 6.51**. Of the finfish, major species caught were pelagic species such as Parang (*Chirocentrus dorab*) and Tenggiri (*Scomberomorus* spp.). Demersal fishes include Duri (*Arius* spp.), Gelama (*Johnius* spp.), Pari (*Himantura* spp./ *Gymnura* spp./ *Myliobatis* spp./ *Dasyatis* spp.) and Malong (*Muraenesox* spp.), while the main shrimp catch was the Udang Putih (*Penaeus merguiensis*) and Udang Baring (*Acetes* spp.). The major species recorded in catches are Duri (14.5%), Gelama (11.5 %) and Pari (10.6%).

Table 6.51: List of Fish Landed in Melaka, 2017

Malay Name	Common Name	Scientific Name	Landings (Tonnes)
Daun baharu	Spotted batfish	*Drepane punctata*	23
Duri	Marine catfish	*Arius* spp.	257
Gelama	Croaker	*Johnius* spp.	204
Gerut-gerut	Grunter	*Pomadasys* spp.	43
Jenahak	John's snapper	*Lutjanus johni*	40
Kerapu	Grouper	*Epinephelus* spp.	27
Malong	Pike Congerl	*Muraenesox* spp.	58
Alu-alu	Barracuda	*Sphyraena* spp.	31
Bawal putih	Silver pomfret	*Pampus argentius*	17
Bawal tambak	Black pomfret	*Pampus chinensis*	17
Belanak/Kedera	Mullets	*Liza* spp.	38
Kurau	Threadfin	*Eleutheronema* spp.	18

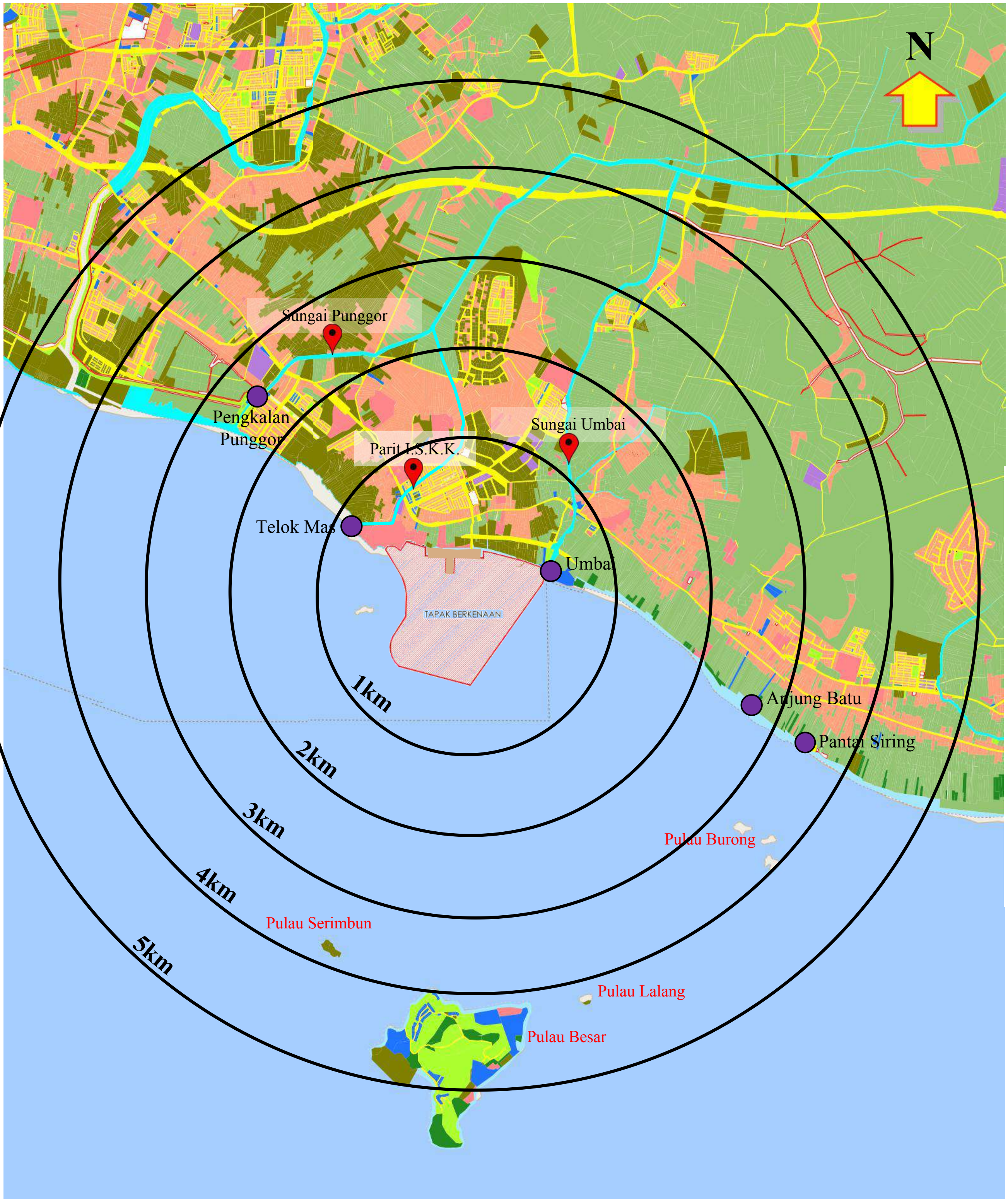
Malay Name	Common Name	Scientific Name	Landings (Tonnes)
Senangin	Threadfin	*Polynemus* spp.	17
Talang	Queenfish	*Scomberoides* spp.	4
Parang	Wolf herring	*Chirocentrus dorab*	136
Tenggiri	Spanish mackerel	*Scomberomorus* spp.	123
Timah	Ribbon fish	*Lepturacanthus* spp.	67
Yu	Sharks	*Carcharhinus* spp.	24
Pari	Rays	*Himantura* spp./ *Gymnura* spp./ *Myliobatis* spp./ *Dasyatis* spp.	188
Ikan campur	Mixed fishes	-	209
Udang putih besar	Banana prawn	*Penaeus merguiensis*	81
Udang putih sedang	Banana prawn	*Penaeus merguiensis*	82
Udang putih kecil	Banana prawn	*Penaeus merguiensis*	63
Udang putih baring	Acetes shrimp	*Acetes* spp.	2
Total			**1,769**

Source: Department of Fisheries, 2018

<u>Overview of Marine Capture Fisheries at the Study Area</u>

There were five fishing bases within 5km radius of the proposed reclamation area i.e Sg. Duyong, Alai (Pengkalan Punggor), Telok Mas, Umbai and Pantai Siring (include Anjung Batu) (**Figure 6.34**). All these fishing bases were within Melaka Tengah Fisheries district.

Plate 6.24: <u>Fish Landing Points Within 5km Radius of the Proposed Reclamation Site</u>



Legend

● Fishing Landing Points

Figure 6.34: Fish Landing Points Within 5km Radius of the Proposed Reclamation Site

Fishing Population

In 2017, a total of 348 licensed fishermen operated in study area (**Table 6.52**). Most of the fishermen were based at Sungai Duyong (138 fishermen), followed by Pantai Siring (74 fishermen) and Umbai (66 fishermen). In term of ethnicity, most of fishermen were Malays (288 fishermen). Chinese and Indians were only registered from Sg. Duyong (46 Chinese, 1 Indian) and Alai (2 Chinese, 1 Indian) (Department of Fisheries, Melaka, 2018-unpublished).

Table 6.52: No. of Fishermen According to Ethnicity at the Study Area, 2017

Fishing Base	No. of Fishermen				
	Malay	Chinese	Indian	Other	Total
Sg. Duyong	81	46	1	10	**138**
Alai	52	2	1	-	**55**
Telok Mas	15	-	-	-	**15**
Umbai	66	-	-	-	**66**
Pantai Siring	74	-	-	-	**74**
Total	**288**	**48**	**2**	**10**	**348**

Note: Data for Sg. Duyong included fishermen from Padang Temu, Pengkalan Punggur included in Alai & Anjung Batu included in Pantai Siring

Source: Department of Fisheries, Melaka, 2018-unpublished

Fishing Vessel

Both inboard and outboards operate in study area. Generally, outboard powered boats were dominant and only small numbers of inboard powered vessels were used. In 2017, a total of 246 (89.1%) outboard and 30 (10.9%) inboard powered boats were licensed in the study area (**Table 6.53**). The highest number of outboard vessels were recorded at Sg. Duyong (70 boats or 28.5%), while the lowest number were at Telok Mas, with only 15 boats (6.1%). Inboard vessels (30 boats) were only employed at Sg. Duyong, while none were recorded at the other fishing bases (Department of Fisheries, Melaka, 2018-unpublished).

Table 6.53: No. of Fishing Vessel Recorded at the Study Area, 2017

Fishing Base	No. of Fishing Boat		
	Outboard Powered Boat	Inboard Powered Boat	Total
Sg. Duyong	70	30	**100**
Alai	51	-	**51**
Telok Mas	15	-	**15**
Umbai	54	-	**54**
Pantai Siring	56	-	**56**
Total	**246**	**30**	**276**

Note: Data for Sg. Duyong included boats from Padang Temu, Pengkalan Punggur included in Alai & Anjung Batu included in Pantai Siring

Source: Department of Fisheries, Melaka, 2018-unpublished

Fishing Gear

There were three (3) types of fishing gears used in both outboard and inboard vessels i.e. drift nets, long lines and portable traps (**Plate 6.25**). In 2017, there were a total of 393 licensed fishing gear in study area. The highest number of fishing gear employed were drift net (276 units), followed by long lines (96 units) and portable traps (21 units). In the 1980s, the reclamation area was a major *Acetes* shrimp fishing grounds, which was harvested using push nets (*langgai*). However, due to the heavily disturbed seabed along the shoreline caused mainly by reclamation, this activity has since ceased. Currently, push nets were only employed to collect live shrimps as fishing baits for recreational fishing (**Plate 6.26**).

Plate 6.25: Fishing Gears Used by Fishermen at the Study Area

Plate 6.26: Push Net (*Langgai*) Operated by Fishermen at Umbai

Fishing Operations

The proposed reclamation area is a major fishing grounds for those using outboard powered boat. Fishing activity were undertaken within 20-25 days/month. For inboard powered boats from Sg. Duyong, most of them go beyond 3km from shoreline to undertake fishing activities.

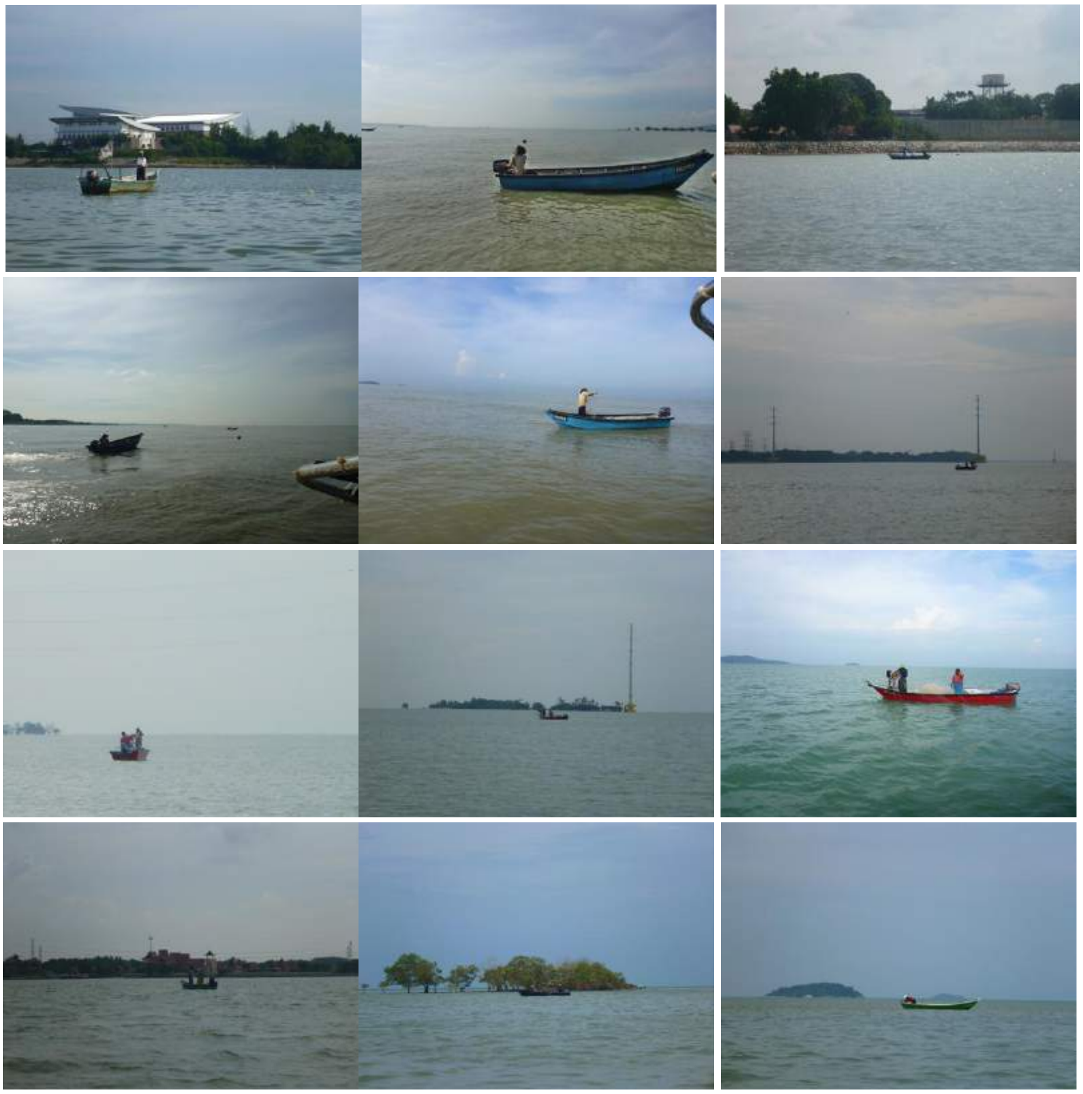
Landings

Volume

In 2017, a total of 529.16 tonnes of fish were landed from study area. In the same year, fish landings in study area contributed 64.3% and 29.9% of the total catch for district (823.65 tonnes) and State (1,769 tonnes) respectively. Overall, fish landings at Melaka District showed increasing pattern from 881.09 tonnes in 2012 to 939.89 tonnes in 2015, before slightly decreased to 823.65 tonnes in 2017 (**Chart 6.23**).

From the survey, volume of fish landed per day was around 5-10 kg/boat of fish is landed using drift net and portable traps, while for long line, landings ranged from 10-13 kg/boat.

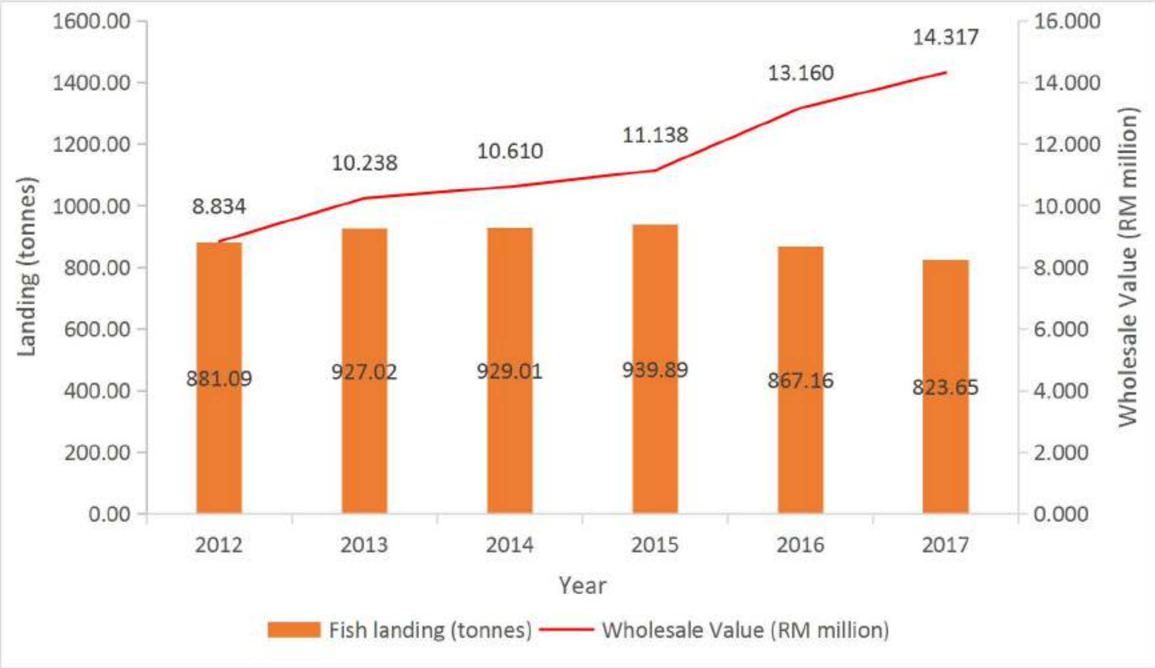
Plate 6.27: <u>Fishing Activities Carried out Along the Coastal Area</u>



<u>Value</u>

From the value standpoint, in 2017, the wholesale value of fish landed from Melaka Tengah amounted to RM14.317 million. In the same year, the wholesale value of fish landings in Melaka amounted to RM31.53 million, i.e. the district contributed 45.1% of the total value for Melaka State. Overall, the wholesale value showed increasing pattern from RM8.834 million in 2012 to RM14.317 million in 2017 (**Chart 6.23**).

Chart 6.23: Trend of Fish Landings and Value in Melaka Tengah from 2012 – 2017



Source: Department of Fisheries, Melaka, 2018-unpublished

Catch Profile

In 2017, major fish species caught by fishermen at the study area were Duri (*Arius* spp.), Gelama (*Johnius* spp.), Pari (*Himantura* spp./ *Gymnura* spp./ *Myliobatis* spp./ *Dasyatis* spp.), Parang (*Chirocentrus dorab*) and Tenggiri (*Scomberomorus* spp.) (Department of Fisheries, Melaka, 2018-unpublished).

In addition, the study area is also important for horseshoe crab, (Belangkas; *Tachypleus gigas*) landing. Based on interviews with fishermen from Sg. Duyung, Alai, Telok Mas, Umbai, Anjung Batu and Tg. Siring, there were approximately 45 fishermen involved in harvesting of horseshoe crab. Only female horseshoe crabs were caught using drift nets employed along the intertidal zone, especially at the mudflats fronting the mangrove areas. Fishermen deploy the nets twice a month during new and full moon. This corresponds to the spawning of horseshoe crab, whereby spring tide lead to higher water level, thus create suitable condition for spawning (Zaleha *et al.,* 2012). According to Chatterji and Abbidi (1993), horseshoe crabs prefer spawning during full moon as compared to new moon, since presence of moonlight will help them to migrate.

Most of the horseshoe crabs were sold to the middleman. The price ranged between RM7-10/individual, depending on the quality of the crab. In a month, approximately 2,030 – 3,330 ind. (1,030 – 1,665kg) of horseshoe crabs were harvested, with the wholesale value ranging from RM20,225 –33,175. A study by Razali *et al.* (2017) reported that the netting method employed by the local fishermen for harvesting of horseshoe crab in Melaka returned higher harvest quantity, i.e. approximately 16,860 ind./month were recorded in 2017. However, the landing has declined due to overharvesting and anthropogenic factors. The decline has also contributed to surge in market value and overexploitation of horseshoe crabs.

Plate 6.28: Horseshoe Crab Caught at the Study Area

b) Aquaculture

In addition to commercial fishing, aquaculture was also undertaken in the state. The aquaculture systems practiced include brackishwater pond culture, mussel farming, freshwater pond culture, freshwater cage culture and freshwater cement tank culture.

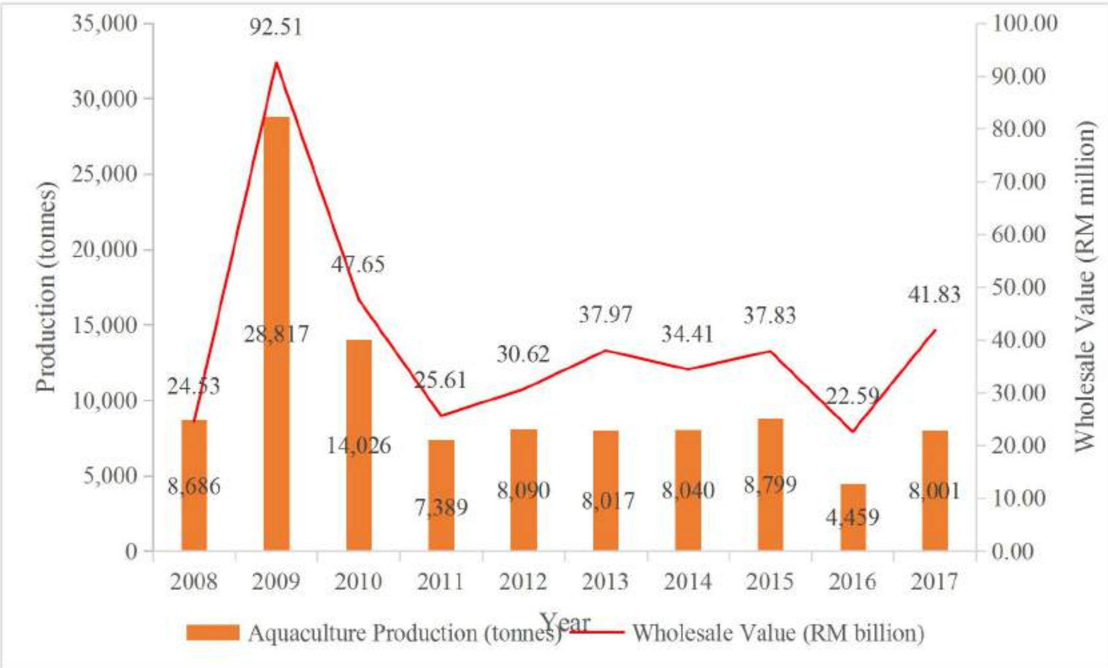
Overview of Aquaculture in Melaka

In 2017, there were a total of 187 culturists in the state, with an estimated of 8,000.71 tonnes, valued at RM41.83 million. Most of aquaculture production was contributed by freshwater pond culture (93.5% of the total state production), while other culture system contributed 2.9% - 3.6% (Department of Fisheries, 2018).

In the same year, aquaculture production in Peninsular Malaysia amounted to 207,229.06 tonnes, valued at RM2.672 billion i.e. Melaka's aquaculture production formed only 3.9% of the total production for Peninsular Malaysia.

Reviews of the aquaculture production data over 10 years from 2008 to 2017 indicate that the highest production was recorded in 2009 with 28,817 tonnes and valued at RM92.51 billion. However, production dropped to 7,389 tonnes in 2009. Between 2012 and 2015, the aquaculture production was quite stable within 8,017 – 8,799 tonnes, before decreased to only 4,459.11 tonnes in 2016. In 2017, the production increased back to 8,001 tonnes (**Chart 6.24**).

Chart 6.24: Trend of Aquaculture Production and Wholesale Value in Melaka from 2008 – 2017



Source: Department of Fisheries, 2009-2018

Overview of Aquaculture in Study Area

The main aquaculture activity undertaken at study area was mussel farming, which was undertaken along the coastal area off Telok Mas to Pantai Siring (**Figure 6.35)**. In 2017, a total of 10 culturists operated 10 farms (*panggar*), covering area of approximately 5 acres. Each *panggar* contained at least 200 stakes. The major species reared was Asian Green Mussel (*Perna viridis*). The production from January 2017 to April 2018 was estimated at 9.6 tonnes, valued at RM57,600 (Department of fisheries, Melaka, 2018-unpublished).

Plate 6.28: Mussel Farming Operated off Telok Mas to Anjung Batu

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Figure 6.35: Location of Mussel Farming Areas at the Study Area

c) Recreational Fisheries

Recreational fishing (or sports fishing) is the sport of catching fish. Also known as angling, it includes the catching of freshwater and saltwater fish, typically with rod, line, and hook. Recreational fishing, often called sport fishing to distinguish it from commercial fishing, is a popular participant sport. There is little data on angling in Malaysia.

Though the study area was not commercially popular as recreational fisheries hotspot, but it still supports a level of recreational fisheries activities. There were two (2) type of angling activities were undertaken in this area namely shore-based angling, boat-based angling and *kelong* based angling. Commonly, shore and *kelong*-based angling uses line casting, while boat-based anglers use trolling and line casting.

Fishing Effort and Catch Type

Fishing effort was estimated using a model developed by Gopinath *et al.* (2013). The model is not commodity-based, but takes time input into account, and is more reminiscent of contingent valuation models used in nature-based tourism (Hakim, 2011) rather than traditional fish stock models.

The modeling indicated that total fishing effort amounted to 10,091 person-days per year, where 42.9% was shore-based angling, while remaining 28.5% each from boat-based and *kelong*-based angling. From the investigation, the total economic value for recreational fisheries at study area amounted to RM1.153 million.

The detailed elaboration on each angling location according to their type of angling activities was discussed below.

Shore-based angling

Shore based angling was undertaken at Pantai Siring, Anjung Batu and Umbai. The investigation estimated fishing effort of shore-based angling at 4,331 person-days per year. The detailed information for each site was as follows.

Pantai Siring

There were about 4 - 6 anglers angling at breakwater area and rock revetment on a daily basis and the number increased to more than 10 - 12 anglers on weekends and public holidays. Commonly anglers spent their time around 4 - 6 hours. Most of the anglers were local people. The common baits used were *pumpum* (Polychaeta worms) and shrimp and targeted sea bass (*Lates calcarifer*), catfish eel (*Plotosus* spp.) and snapper (*Lutjanus* spp.) as their main catches. Other common fishes caught included croaker (*Johnius* sp.), mullet (*Liza* sp.) and marine catfish (*Arius* sp.). The investigation indicated that the total fishing effort amounted to 1,531 person-days a year (**Table 6.54**).

Anjung Batu

Angling activity was also observed at Anjung Batu. During weekdays, number of angler ranged from 2 - 4 anglers, while during weekends, number of anglers were found to have increased, ranging from 5 - 7 anglers. Most angling activity undertaken during high tide. The types of bait used were *Pumpun* (polychaete worms), live prawn, squid and Kembong (*Rastrelliger* spp.). The common species of fish caught were Pari (*Himantura* spp., *Gymnura* spp.), Tanda (*Lutjanus russelli*), Senangin (*Polynemus* spp., *Eleutheronema* spp.), Gelama (*Pennahia* spp., *Johnius* spp.) and Semilang (*Plotosus* spp.). On the whole, the study estimated fishing effort for shore-based angling at Anjungt Batu at 879 person-days per year (**Table 6.54**).

Umbai

Angling activity was also observed at Umbai, where around 4 - 6 anglers were recorded during weekdays. During weekend, number of anglers involved ranged from 15 – 20 anglers. Each angler used around 1 – 2 units of rod-and-line. *Pumpun* (polychaete worms), live prawn and Kembong (*Rastrelliger* spp.) commonly used as bait. Major species caught including Siakap (*Lates calcarifer*), Senangin (*Polynemus* spp., *Eleutheronema* spp.), Gelama (*Pennahia* spp., *Johnius* spp.) and Semilang (*Plotosus* spp.). Overall, the study estimated fishing effort for shore-based angling at Pantai Acheh was 1,921 person-days per year (**Table 6.54**).

Table 6.54: Shore-based Angling Effort at the Study Area

Location	Weekdays	Person hours/ yr.	Weekends	Person hours/ yr.	Total Person Hours	Total Person Days
Pantai Siring (high tide: 5 hours)	5 anglers	6,525	11 anglers	5,720	12,245	1,531
Anjung Batu (high tide: 5 hours)	3 anglers	3,915	6 anglers	3,120	7,035	879
Umbai (high tide: 5 hours)	5 anglers	6,525	17 anglers	8,840	15,365	1,921
Total						**4,331**

Note: Example calculation person hours/yr. for Pantai Siring

- *Weekdays: 5 anglers x 5 hours x 261 days/year = 6,525*
- *Weekends: 11 anglers x 5 hours x 104 days/year = 5,720*
- *Total Person Days (total person hours/year /8 hours)*
- *(6,525 + 5,720)/8 = 1,531 person-day*

Boat-based angling

Boat based angling was undertaken using fishing boats since anglers rented these boats as there are no specific boat operators in this area. The staging point for the activity was at Pantai Siring, Umbai and Pengkalan Punggur. There were four (4) boats available for rental at each point. The rental rate from Pantai Siring and Umbai for angling in the coastal waters was around RM380/trip and RM600/trip (12 hours) for Pulau Undan and Pulau Besar, while for Pengkalan Punggur, the rate was RM700/trip (8 hours) for Pulau Besar and RM1,000/trip (12 hours) for offshore area. Each boat could accommodate around 4-5 anglers/boat. At Pantai Siring and Umbai, an average of 2 trips/month/boat was undertaken, while at Pengkalan Punggur was around 5-6 trips/month/boat. The activity was concentrated during weekends and public holidays.

According to boat operators, more than 80% of anglers were from Melaka itself, while others from Kuala Lumpur, Singapore, Perak and Selangor. Majority of the anglers were about 25 - 35 years old. Most of anglers were Malays, who contributed more than 50% of the total anglers, followed by Chinese (<40%), Indians (>10%) and foreigners (1%).

The main fishing gear was rod-and-line with 2 to 4 rods per person. Anglers commonly used live shrimp, juvenile Belanak (*Mugil* spp.) and small size octopus as baits. Live shrimp cost about RM1/individual, juvenile Belanak (*Mugil* spp.), RM0.60-0.80/individual and small octopus, RM1.50/individual.

Commonly, the fish caught included Jenahak (*Lutjanus johnii*), Tanda (*Lutjanus russelli*) Kerapu (*Epinephelus* spp.), Merah (*L. malabaricus*), Senangin (*Polynemus* spp.), Tenggiri (*Scomberomorus* sp), Alu-alu (*Sphyraena* spp.), Golden Trevally (*Charanx ignobilis*), Talang (*Scomberoides* spp.), Bawal (*Pampus* spp.), Kerisi (*Nemipterus* spp.) and Mengkerong (*Saurida* spp.).

The study indicated that the fishing effort for boat-based angling amounted to 2,880 person-days a year, 50% contributed by Pengkalan Punggur (1,440 person-days a year), while remaining 25% each by Pantai Siring and Umbai (720 person-days a year) (**Table 6.55**).

Table 6.55: Boat-based Angling Effort at the Study Area

Location	Weekdays	Person hours/yr.	Weekends	Person hours/yr.	Total Person Hours	Total Person Days
Pantai Siring (12 hours)	-	-	10 anglers	5,760	5,760	720
Umbai (12 hours)	-	-	10 anglers	5,760	5,760	720
Pengkalan Punggur (8 hours)	-	-	30 anglers	11,520	11,520	1,440
Total						**2,880**

Note: Example calculation person hours/yr. for Pantai Siring

- *Person hours/yr.*
- *Weekdays: not undertaken*
- *Weekends: 2 trips/month x 4 boats x 5 anglers x 12 hours x 12 months = 5,760 person hours/yr.*
- *Total Person Days (total person hours/year/8 hours)*
- *5,760/8 = 720 person-day*

Kelong-based angling

Angling was also undertaken at from fishing platforms (or *Kelong*), located off Pantai Siring. A total of four (4) units of *Kelong* were available for angling activity. The fees were RM40/angler for a 24-hour duration. Angling was undertaken both during weekdays and weekends, normally around 7am – 7pm.

During weekdays, the number of anglers were around 5 anglers/week, while increased to 15 angler/week during weekends. The common baits used were *pumpun* (polychaete worms) and live prawn. Normally, each angler used 2 – 3 units of rod-and-line.

The main catch was Pari (*Himantura* spp., *Gymnura* spp.), Senangin (*Polynemus* spp., *Eleutheronema* spp.), Siakap (*Lates calcarifer*), Duri (*Arius* spp.) and Gelama (*Pennahia* spp., *Johnius* spp.), with weight of fish ranging from 1 – 3 kg/individual. On the whole, the study estimated fishing effort for floating raft-based angling at Sg. Kembong at 2,880 person-days per year (**Table 6.56**).

Table 6.56: *Kelong*-based Angling Effort at the Study Area

Location	Weekdays	Person hours/ yr.	Weekends	Person hours/ yr.	Total Person Hours	Total Person Days
Pantai Siring (24 hours)	5 anglers	5,760	15 anglers	17,280	23,040	2,880
Total						**2,880**

Note: Example calculation person hours/yr. for Pantai Siring

- *Person hours/yr.*
- *Weekdays: 5 anglers/week x 4 weeks/month x 12 months x 24 hours = 5,760 person hours/yr.*
- *Weekends: 15 anglers/week x 4 weeks/month x 12 months x 24 hours = 17,280 person hours/yr.*
- *Total Person Days (total person hours/year/8 hours)*
- *(5,760 + 17,280)/8 = 2,880 person-day*

Plate 6.29: *Kelong* Operated off Anjung Batu

Output Values and Socio-Economics

The data from the all locations involving recreational fisheries activity along the study area indicated that the total fishing effort amounted to 10,091 person-days per year. The economic value of recreational fisheries is difficult to estimate. Some of the anglers were from outside the state while others are local residents.

MIER (2000) adopted a value of RM50 per person-day. This figure is clearly outdated. For instance, the boats at Pantai Siring and Umbai rent out RM600 for five (5) anglers, which averages out at RM120/angler, while RM700 – RM1,000 for five (5) anglers at Pengkalan Punggur, which averages out at RM140 – 200/angler. The cost of shore and *Kelong*-based fishing is not as high, but RM50 would probably be insufficient to cover cost of bait, food and other relevant expenses. Assuming:

a) An average payout of RM150/person-day for boat-based anglers.
b) An average payout of RM100/person-day for shore and *Kelong*-based anglers.

It is estimated the direct economic value from the recreational fisheries amounts to RM 1.153 million per year.

Table 6.57: Estimation of the Total Economic Value at the Study Area

Fishing Type	Total Person Days	Unit Economic Value	Total Economic Value
Shore-based angling	4,331	RM 100	433,100
Boat-based angling	2,880	RM 150	432,000
Kelong-based angling	2,880	RM 100	288,000
Total	**27,690**	-	**1,153,100**

6.11 Road Network and Traffic Volume

The site is accessible via the old Federal Road Route 5 which connects Melaka City Centre and Muar (Jalan Melaka – Muar). The existing land traffic mostly comes from the residents staying nearby the project area. The location of the Project site and its surrounding road network in the State is given in **Figure 5.1.**

6.11.1 Traffic Volume

The existing traffic volume for the road network of the project site is sourced from the Road Traffic Volume Malaysia (RTVM) 2015, acquired from Kementerian Kerja Raya Malaysia. The RTVM 2015 is prepared by Unit Perancang Lebuh Raya, Kementerian Kerja Raya Malaysia and it comprises the data of traffic volume and traffic growth for Malaysia. The data of traffic volume is obtained through traffic census which is carried out at the designated traffic census stations at each state of Malaysia.

The nearest census station is selected to reflect the existing traffic volume for the road network of the project site. The selected traffic census station is MR 108 (Jalan Melaka-Muar). **Figure 6.36** shows the location of the traffic census.

The average traffic volume and vehicles recorded for year 2015 and the annual traffic growth rate are detailed in **Table 6.58.**

Table 6.58: Traffic Volume and Annual Trafffic Growth Rate for Year 2015

Traffic Census Station	Peak Hour	Peak Hour Traffic (vehicles/hr)	16 hr. Traffic (vehicles /hr)	Level of Service (LOS)		Annual Traffic Growth Rate
				LOS at Traffic Census	Arahan Teknik (Jalan) 13/87	
MR 108 (Jalan Melaka-Muar)	1700-1800	2,523	22,430	**F**	D	-0.8 %

Source: Road Traffic Volume Malaysia 2015, JKR Malaysia

Based on **Table 6.58,** it can be concluded that the LOS has exceeded the acceptable limit. The annual traffic growth rate is decreasing.

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Source: Kementerian Kerja Raya Malaysia

Figure 6.36: Traffic Census Station