Photo 6.3 Soakaway No. 3 located approximately 650 m from Soakaway No. 1.

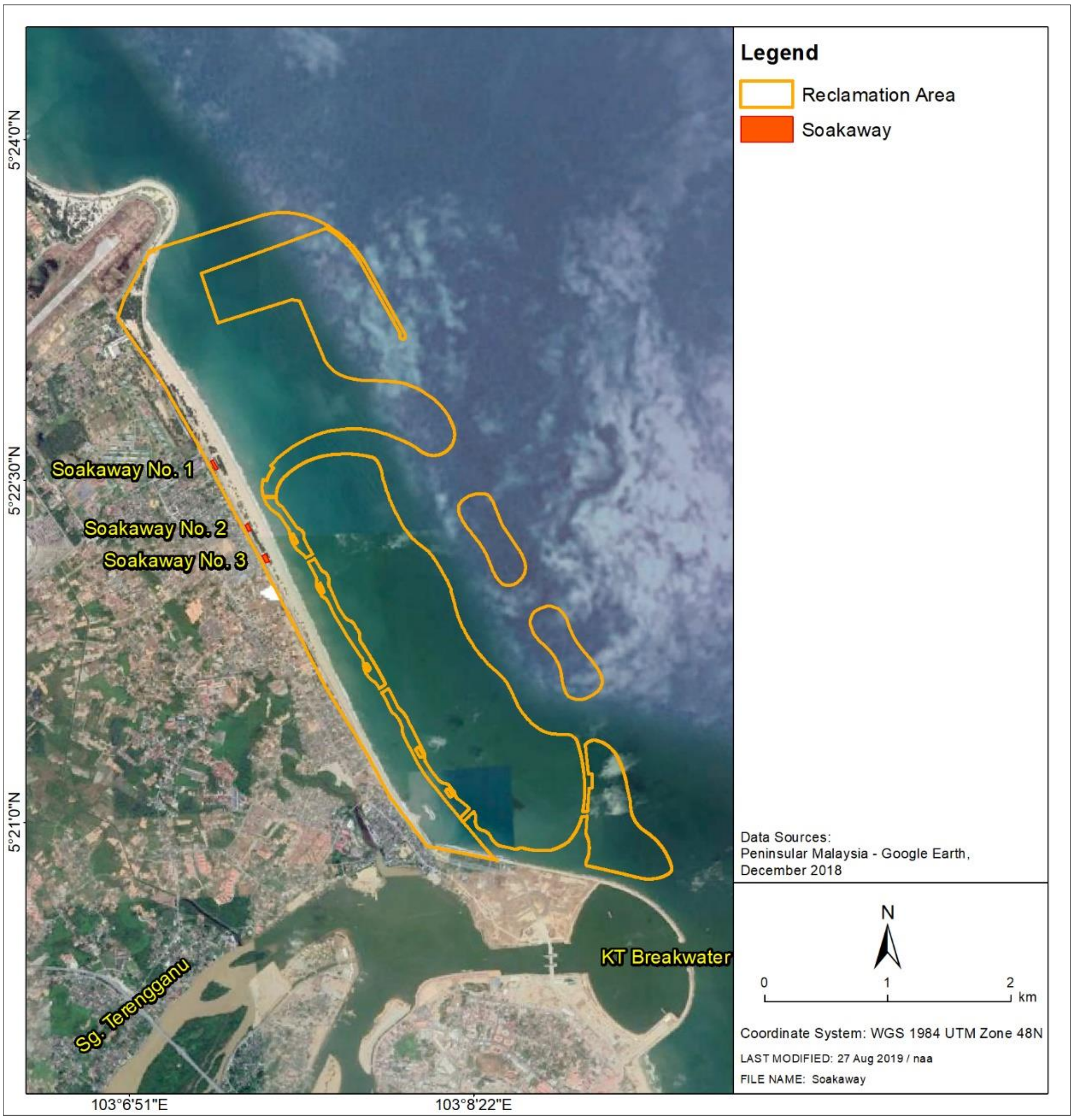


Figure 6.21 Location of soakaways.

6.2.4 Marine Sediments

6.2.4.1 Physical Characteristics

In a dynamic marine environment such as the Project area, understanding the physical and chemical properties of the surface sediment in the area becomes important. This is to establish a baseline and to also be able to quantitatively assess impacts using numerical models. Samples were taken along three transects along the site from the shore to depths of approximately 4 m, and for the proposed navigation channel, out to a depth of around 11 m.

Findings indicate that the Project area is predominantly sand (>90 % sand at most stations) as shown in Figure 6.22. Higher amounts of silt (26-27 %) were found in the southern part of the Project area, closer to Kuala Terengganu, in water depths of 7.3 m. A sample in the dredging area S4b at a depth of approximately 11 m was also higher in fines, with 27 % silt and 7 % clay.

Examples of sediment collected from the stations are shown in Photo 6.4.

Photo 6.4 Examples of sediment physical attributes.

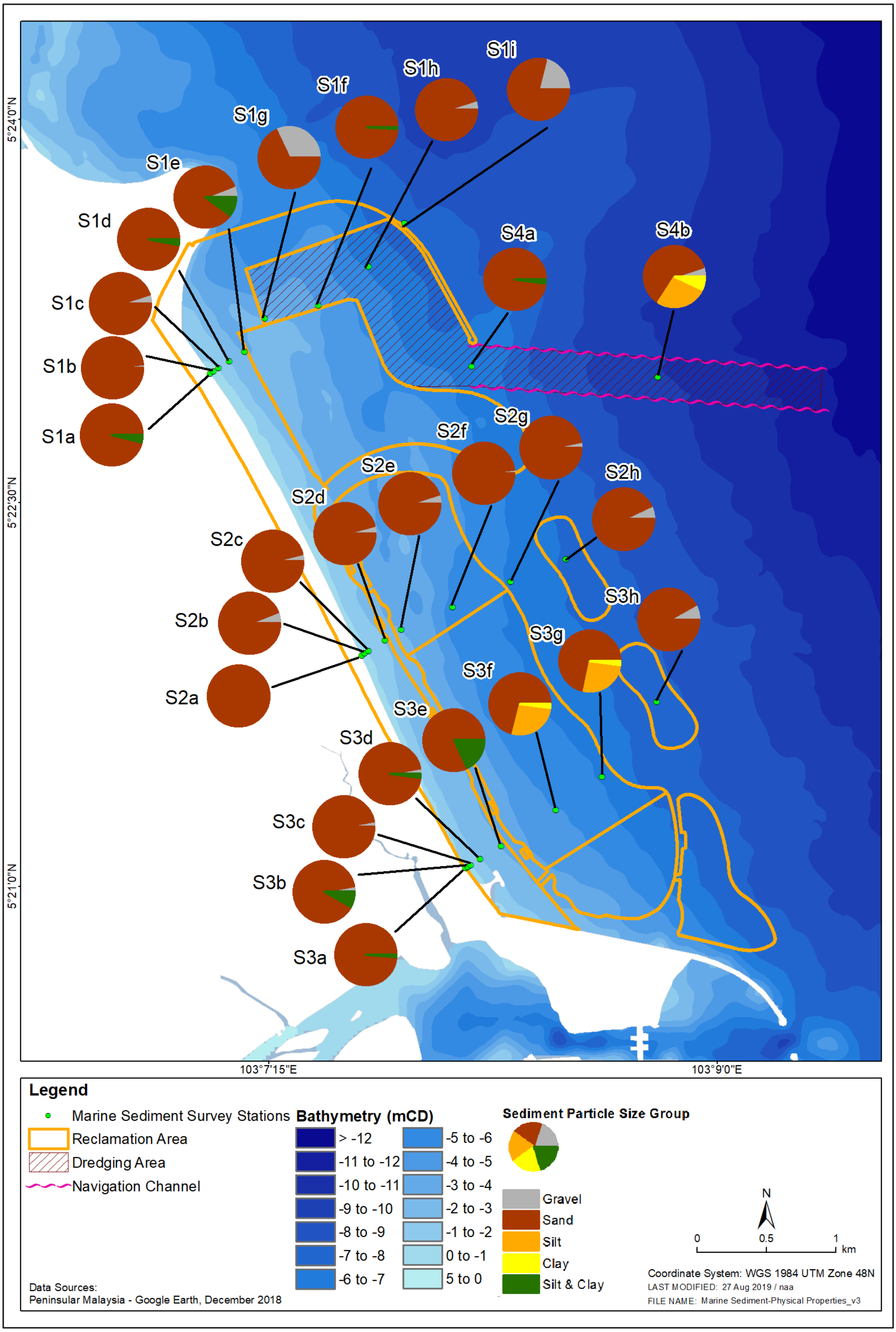


Figure 6.22 Percentage of sediment particle size groups at all sampling stations.

6.2.4.2 Chemical Content

Chemical analysis was carried out for five of the stations - S1f, S2e, S3h, S4a and S4b. Stations S1f, S4a and S4b lie within the dredging area. The results were then compared to the Dutch Standards /22/. The target values indicate the level below which risks to the environment are considered to be negligible. The intervention value is an indicative value where remediation may be urgent, owing to increased risks to public health and the environment.

The sediments are considered clean in terms of the standard which was developed to assess contaminated sediments. Metal concentrations fall well below the Dutch Standards and petroleum hydrocarbons are below the laboratory detection limit (Table 6.4).

Total organic carbon (TOC) provides indication of organic carbon present in sediment, which is mainly derived from anthropogenic sources or decomposition of plants and animals /23/. TOC in the sediments were low and ranged between 0.7% and 1.6% at the Project area which are similar to what was found in a study by Kamaruzzaman *et al*. (2010) where TOC in the Terengganu nearshore coastal area was between 0.60 % and 1.80 % during the pre-monsoon /24/.

Apart from lead, copper, chromium, iron, and manganese, other heavy metals analysed were below the laboratory detection limit. Only lead, copper, and chromium exceeded the Dutch Standards target value but were lower than the intervention value (Table 6.4). Concentrations of all the detected heavy metals were highest at Station S4b which could be associated with the higher number of fine particles (silt) present at this station.

Table 6.4 Chemical content in sediment against the Dutch Standards.

Parameter	Concentration	Dutch Standards	
		Target Value	Intervention Value
Total Organic Carbon (TOC) (%)	0.7 – 1.6	N.A.	N.A.
Total Petroleum Hydrocarbons (TPH) (mg/kg)	<1	N.A.	N.A.
TPH Fractions (C6-C9), (C10-C14), (C15-C26) and (C27-C36) (mg/kg)	<0.05	N.A.	N.A.
Cyanide (mg/kg)	<0.1	N.A.	N.A.
Cadmium (mg/kg)	<0.01	0.8	12
Mercury (mg/kg)	<0.02	0.3	10
Arsenic (mg/kg)	<0.01	0.9	55
Lead (mg/kg)	<0.01 – 62	55	530
Copper (mg/kg)	<0.01 - 21	3.4	96
Nickel (mg/kg)	<0.01	0.26	100
Chromium (mg/kg)	<0.01 - 62	<0.38	220
Iron (mg/kg)	27,362 - 127,213	N.A.	N.A.

Parameter	Concentration	Dutch Standards	
		Target Value	Intervention Value
Manganese (mg/kg)	230 - 1,577	N.A.	N.A.

Note: N.A. means not available.

6.2.5 Water Quality

The water quality in the nearshore region of the Project area is influenced by natural nearshore processes including biological and sediment fluxes as well as longshore and off shore transport, the outflows from rivers and drains, and in some locations, groundwater outflows.

The Malaysia Marine Water Quality Standards (MMWQS) /25/ have been used to classify the present water quality at the Project area. The MMWQS has three potential classes applicable to the present situation:

- Class 2: Fisheries (including Mariculture)
- Class 3: Industry, commercial activities and Coastal settlements
- Class E1: Estuary (Coastal Plain).

The coastal waters in the region of the Project area have been considered as Class 2 as the area has an active fishery. In terms of Sg. Terengganu, it is noted that Class E1 /25/ refers to estuarine waters representative of relatively undisturbed environment, whereas in this case, jetties and marinas, and land-reclamation activities are present near the Sg. Terengganu river mouth. The city of Kuala Terengganu extends along the Sg. Terengganu south riverbank, with consequent impacts from urban drainage, and there are also settlements present on the north riverbank. It is therefore more appropriate to refer to Class 3 standards for the water quality in the Terengganu rivermouth.

Two surveys around the Project area coincided with the inter-monsoon period which is generally characterised by relatively calm waters and little rainfall. The survey was conducted over two occasions – neap ebb and spring ebb tides at 11 stations, where two stations were in the estuarine environment (WQ1-WQ2), and nine stations were in the marine environment (WQ3-WQ11), see Figure 6.23. A summary of the water quality condition of the study area is given in Table 6.5.

In general, the water quality in Sg. Terengganu at the time of the surveys was generally good, with low suspended solids. However elevated ammonia levels were detected for samples at the river mouth, while faecal coliform counts were also high inside the river and the areas around the river mouth. Bacterial pollution in other stations around the Project area was however low, indicating rapid die-off and / or flushing of the riverine discharges, and also the absence of other sources along the coastline.

Oil and grease was below the laboratory detection limit in all areas, indicating low oil and grease pollution within the coastal waters despite certain stations being located within areas of high navigation activities.

No visible plumes were observed discharging from the river at the time of sampling, although the nearshore areas around the river mouth and within the Project area were observed to be more turbid than offshore. In-situ measurements of turbidity indicated slightly higher turbidity just off the river mouth, however this was not reflected in the results of the suspended sediments analysis. An example of turbid versus clear water observed during the survey is shown in Photo 6.5.

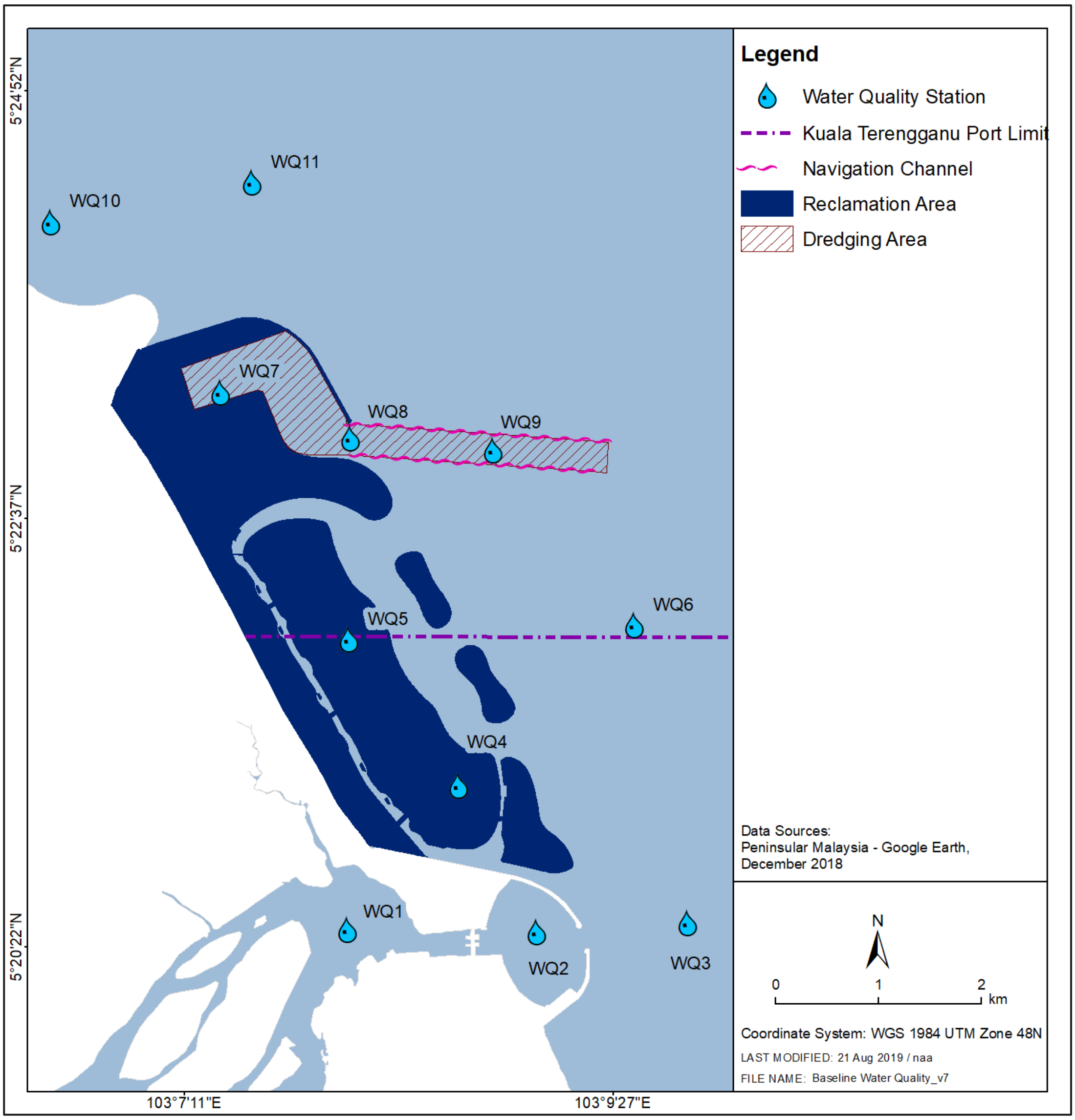


Figure 6.23 Water quality sampling stations.

Table 6.5 Summary of results for marine and estuarine water quality physical parameters around the project area.

Parameter	Marine	Freshwater/Estuarine
Temperature	• 28.5 – 30.2^{0}C	• 28.5 – 29.4^{0}C
Dissolved oxygen	• 5.4 – 6.3 mg/L • Above MMWQS Class 2 limit of 5 mg/L	• 4.7 – 5.2 mg/L • Above MMWQS Class 3 limit of 3 mg/L
Salinity	• 31 – 33 ppt	• Freshwater: 0.3 – 1.1 ppt

Parameter	Marine	Freshwater/Estuarine
	• Average of 18 ppt recorded at the station outside the Sg. Terengganu river mouth (WQ3).	• Estuarine: 3.2 – 28.1 ppt
Total suspended solids (TSS)	• 11 – 29 mg/L • Below the MMWQS Class 2 and 3 limits of 50 and 100 mg/L respectively (Figure 6.24).	• 14 – 39 mg/L • Below the MMWQS Class 3 limit of 100 mg/L (Figure 6.25).
Turbidity	• 1.6 – 7.1 NTU	• 6.5 – 19.6 NTU
Oil and grease	• Below detection limit	• Below detection limit
Biological oxygen demand (BOD)	• Average BOD range: 1.0 mg/L to 1.5 mg/L	• BOD range: 1.1 mg/L to 1.2 mg/L
Ammonia (NH_3-N)	• Exceeded Class 2 and Class 3 limits at nearly all marine stations • Ammonia concentration was noticeably higher during spring tide sampling compared to neap tide, and in particular the coastal as distinct to the offshore sites showed very high NH3-N	• Concentrations generally higher during spring tide, ranging between 0.04 mg/L to 0.77 mg/L • Neap tide range was smaller at 0.04 mg/L to 0.19 mg/L • WQ1 was below the MMWQS Class 3 limit of 0.32 mg/L while WQ2 exceeded the limit during spring tide
Nitrate (NO_3-N)	• Below MMWQS Class 2 limit	• Below Class 3 limit (0.7 mg/L)
Faecal coliform	• Generally low with less than 25 MPN/100mL at most stations	• Ranged from 130 – 920 MPN/100mL
Heavy metal (Cr, Cd, Cu, Ni, Fe, Pb, Mn, As and Hg)	• Below detection limit	• Below detection limit


Photo 6.5 Turbid water at station WQ3 which is approximately 1 km from the Sg. Terengganu river mouth (left) versus clear water at station WQ5 located approximately 1 km from the sandy shoreline of Teluk Ketapang beach (right) taken on 29 September 2017

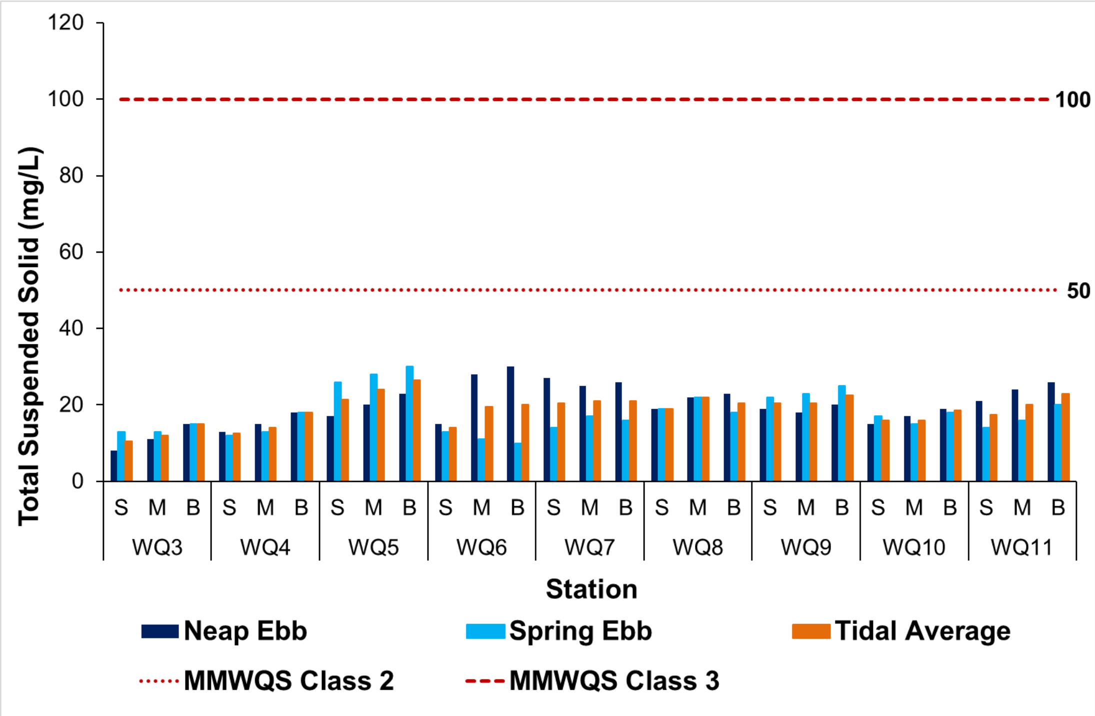


Figure 6.24 TSS concentration at marine water quality stations.

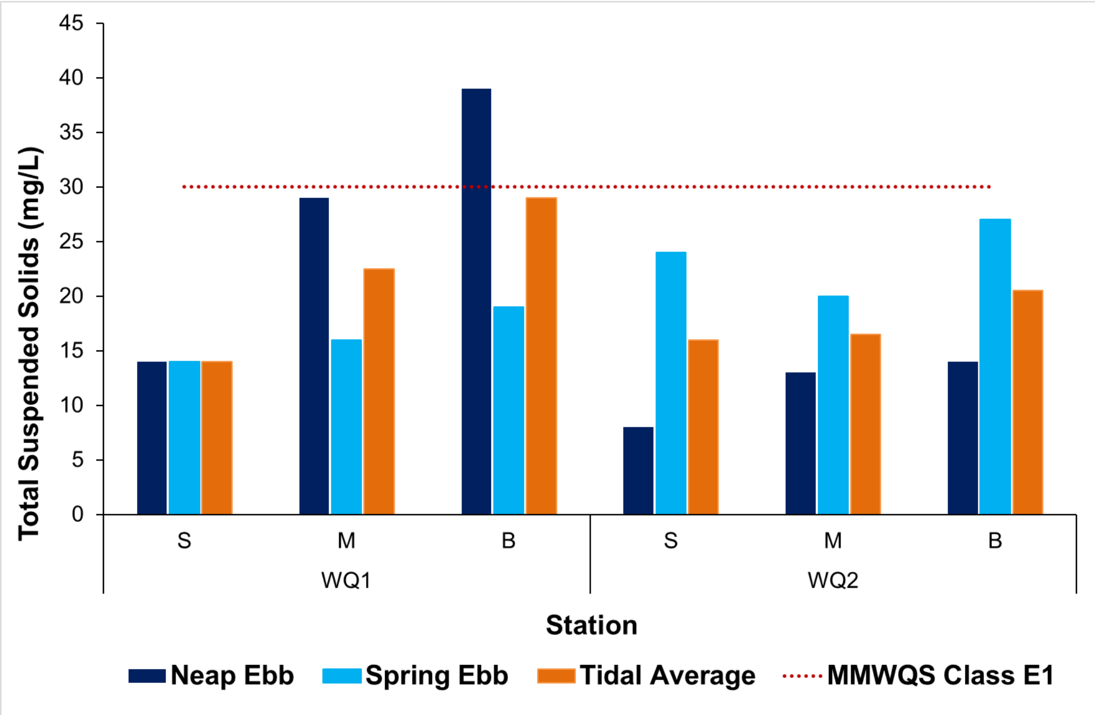


Figure 6.25 TSS concentration at estuarine water quality stations.

6.2.6 Air Quality

In order to assess the potential impacts of construction works to the air quality around the Project area, ambient air quality was sampled for five parameters (PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO) at six stations located near to sensitive locations within community sites. The results, shown in Figure 6.26, were compared to the New Malaysia Ambient Air Quality Standard 2013 (IT-2) (2018).

Findings of the survey indicate good air quality, as summarised below:

- PM_{10} levels ranged from 74 to 79 µg/m^3, below the air quality standard of 120 µg/m^3.
- $PM_{2.5}$ levels ranged from 40 to 46 µg/m^3, below the air quality standard of 50 µg/m^3.

Other parameters, NO_2, SO_2 and CO, were below the laboratory detection limits of 1.882 µg/m^3, 2.619 µg/m^3 and 2.86 mg/m^3 respectively at all stations. Refer to Appendix F for more details.

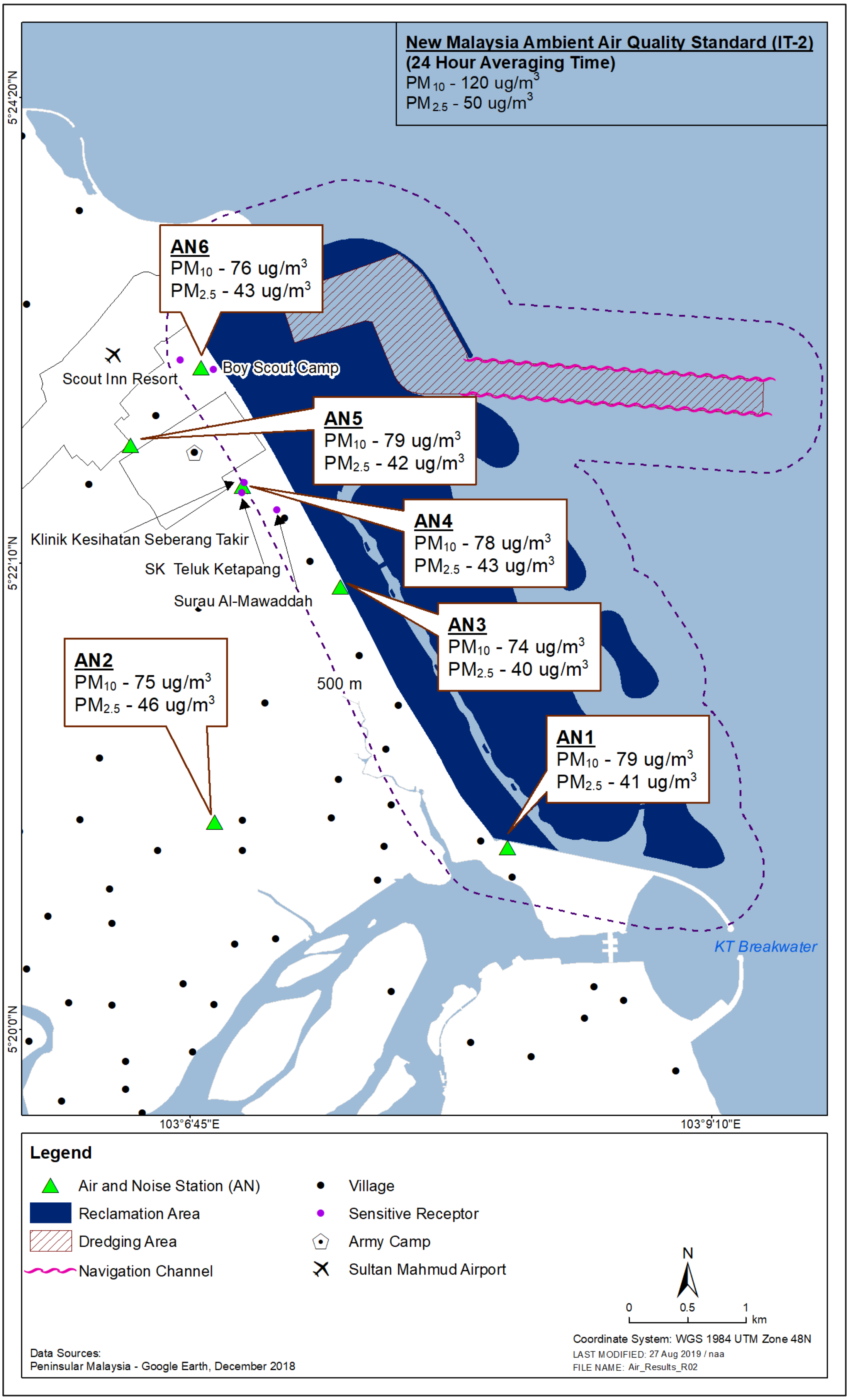


Figure 6.26 Results for ambient air quality within the vicinity of the Project.

6.2.7 Ambient Noise

Baseline ambient noise data were collected at the air quality stations as shown in Figure 6.26. The results were then compared to Schedule 1 of the Planning Guidelines for Environmental Noise Limits and Control, 2007 published by DOE for three types of landuse (Table 6.6).

Table 6.6 Maximum permissible sound level (L_{eq}) by receiving land use for planning and new developments.

Receiving Land Use Category	Day Time (0700 – 2200 hrs)	Night Time (2200-0700 hrs)
Noise Sensitive Areas, Low Density Residential, Institutional (School, Hospital), Worship Areas.	50 dB(A)	40 dB(A)
Suburban Residential Area (Medium Density) Areas (Public Spaces, Parks, Recreational Areas)	55 db(A)	45 db(A)
Urban Residential (High Density) Areas, Designated Mixed Development Areas (Residential – Commercial)	60 dB(A)	50 dB(A)

The baseline ambient noise results are shown in Table 6.7. The laboratory analysis certificates are provided in Appendix F. Results of the noise measurements are summarized as follows:

- The daytime LA_{eq} (0700-2200) ranged from 50.3 to 59.2 dB(A) while the night time LA_{eq} (2200-0700) ranged from 52.6 to 59.0 dB(A) for all stations. The range of LA_{eq} recorded is typical for urban environments.
- The highest daytime and night time LA_{eq} were recorded at AN5 and AN4 respectively, which are near the airport boundary, army camp, clinic, school and surau.
- The lowest daytime and night time LA_{eq} were recorded at AN1 and AN3 respectively.
- Of the urban residential areas (all stations except AN2 and AN4), the daytime LA_{eq} was below the stipulated permissible level of 60 dB(A). However, the night time permissible level of 50 dB(A) was exceeded.
- At AN2 (suburban), the daytime and night time LA_{eq} were above the stipulated permissible levels of 55dB(A) and 45dB(A) respectively.
- At AN4, the daytime and night time LA_{eq} were recorded above the stipulated permissible levels of 50 dB(A) and 40 dB(A) respectively (low density residential).
- Levels of L_{90} were below 56 dB(A) throughout the monitoring period at all stations.
- Levels of L_{10} were up to 62.3 dB(a) during daytime at all stations. However, L_{10} levels were above 60 dB(A) during night time at AN1, AN2 and AN4, indicating noise peaks occurred at these stations during night time.
- At AN5 and AN6, which are located closer to the airport, occasional high noise levels up to 73.1dB(A) observed throughout the monitoring period and they are likely caused by the aircraft noise.

Table 6.7 Baseline ambient noise results (dB(A)).

Station	Location / Type of Land Use	Parameter	Noise Level dB(A)		
			Daytime (0700 – 1900 hrs)	Evening (1900 – 2200 hrs)	Night time (2200 – 0700 hrs)
AN1	Village, Mosque / Urban	LA_{eq}	53.8	50.3	57.9
		L_{max}	70.4	57.4	64.3
		L_{min}	47.1	45.4	46.3
		L_{10}	55.4	52.0	60.7
		L_{90}	50.2	47.6	50.8
AN2	Village / Suburban	LA_{eq}	57.8	54.2	57.8
		L_{max}	65.0	61.0	65.3
		L_{min}	50.2	48.7	49.2
		L_{10}	59.7	56.4	60.1
		L_{90}	54.6	50.6	53.8
AN3	Village / Urban	LA_{eq}	56.7	54.9	52.6
		L_{max}	62.5	59.2	57.7
		L_{min}	48.7	47.9	47.3
		L_{10}	58.9	57.0	53.9
		L_{90}	53.6	51.1	50.3
AN4	School, Clinic, Village, Army Camp / Sensitive	LA_{eq}	58.4	58.9	59.0
		L_{max}	69.2	68.3	65.0
		L_{min}	49.9	51.3	49.2
		L_{10}	60.3	62.3	61.4
		L_{90}	54.7	53.0	55.5
AN5	Village, Airport, Army Camp / Urban	LA_{eq}	59.2	56.8	54.9
		L_{max}	70.3	66.2	73.1
		L_{min}	53.5	52.4	42.2
		L_{10}	61.3	58.1	52.6
		L_{90}	55.6	53.2	46.8
AN6	Airport, Homestay/Resort, Boy Scout Camp / Urban	LA_{eq}	52.6	50.8	53.3
		L_{max}	69.8	55.9	67.9
		L_{min}	27.6	44.1	29.9
		L_{10}	54.7	52.7	55.6
		L_{90}	39.6	47.2	43.4

6.3 Biological Environment

The existing biological environment consists of both terrestrial and marine environments encompassing different types of habitats. In order to capture the diversity of habitats and to also ensure their adequate representation, the biological environment is described within the following boundaries:

- Marine ecology – focuses on the area within 5 km from the Project area. This area includes the entire Project area on the shoreline between the northern breakwater at the Kuala Terengganu river mouth and Sultan Mahmud Airport. Regional sensitive receptors are however considered.
- Terrestrial ecology – 1 km from the Project area for mangroves and 200 m from Project area for terrestrial vegetation.

Table 6.8 details the data collection activities and sources for the biological environment; further details are available in Appendix E.

Table 6.8 Details of data collection for biological environments.

Component	Data Type	Source	Date of Collection
Marine Habitat Mapping	Primary	Side scan and splash tow cam	29 September 2017- 1 October
Plankton	Primary	11 sampling stations	29 September 2017
Macrobenthos	Primary	12 sampling stations	3 October 2017
Mangrove	Primary	Ground survey	30 September 2017
Fish Fauna	Primary	5 sampling stations	Neap: 2 October 2017 Spring: 4 October 2017
Terrestrial Ecology	Primary	Ground survey	1 October 2017

6.3.1 Marine Benthic Habitats

Benthic habitat mapping within and around the Project area recorded primarily bare sandy substrates except for several algal patches and three concrete fish aggregating device (FADs), see Figure 6.27. The survey covered an extent of 1 km radius from the Project area (Figure 6.27) and utilised a combination of side scan sonar survey and underwater towed video camera transects. An example of the images captured underwater is shown in Photo 6.6. Further details on the surveys are provided in Appendix E. It should be noted that microphytobenthos, although not measured, will occur through throughout the predominantly sandy area within the boundaries of the assessment area, whereas the nearest macrophytobenthos, such as coral reefs, seagrass or seaweed beds, are reported at the Pulau Kapas marine park around 17 km from the Project (Figure 6.28).

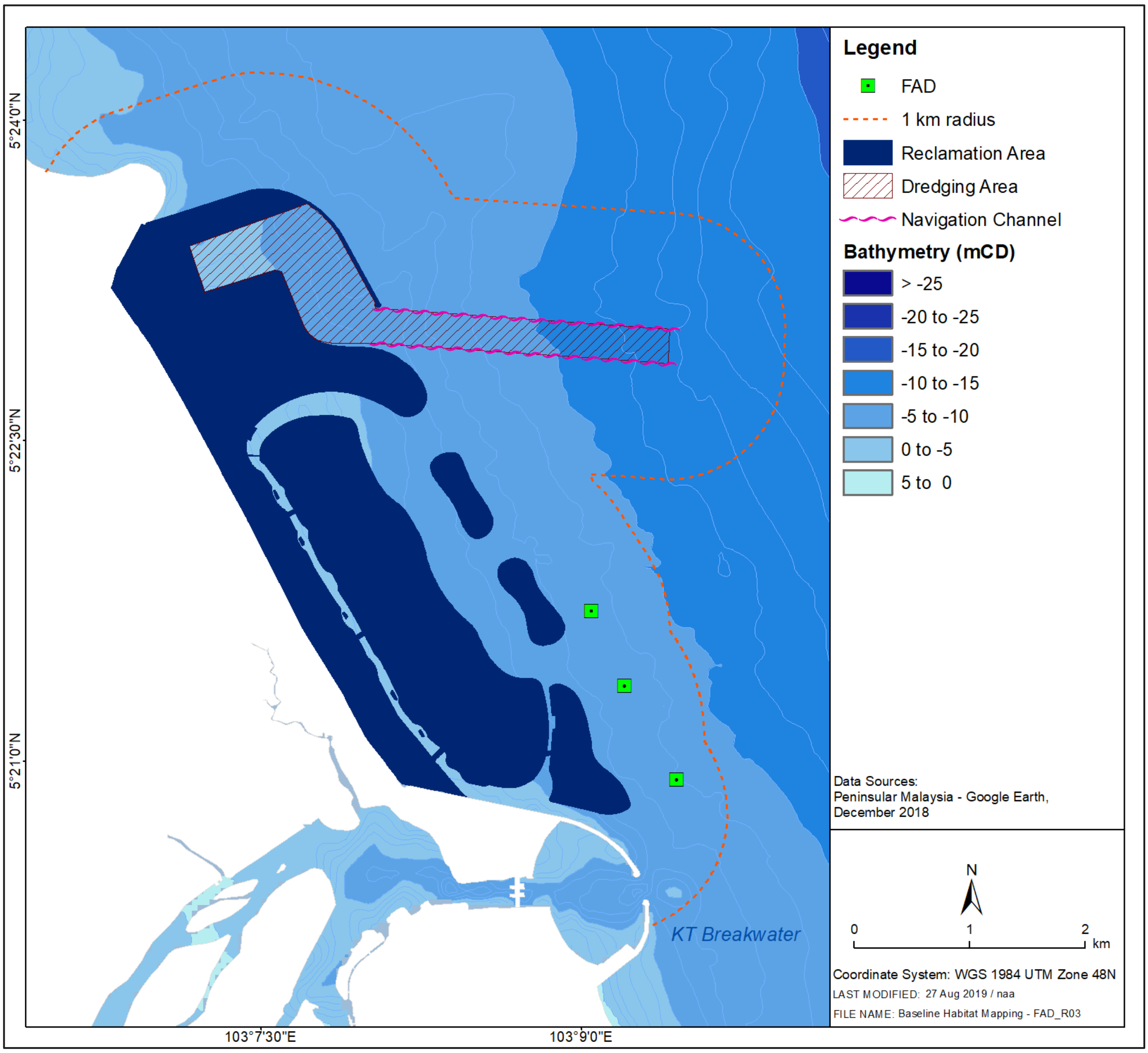


Figure 6.27 Locations of the fish aggregating devices (FADs) and survey extent.

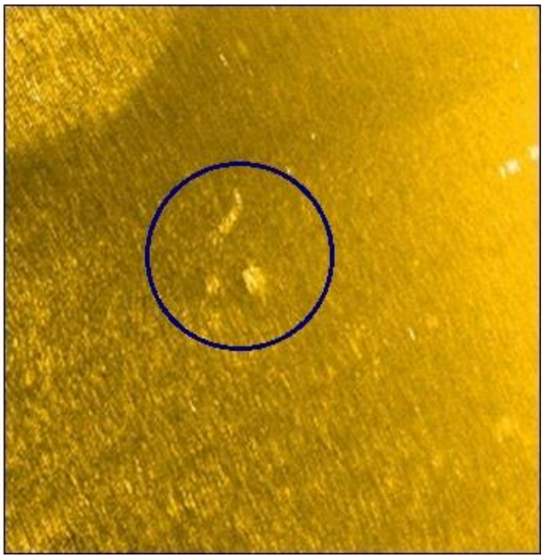


Photo 6.6 Soft corals and barnacles associated with concrete FAD (left) and a screen shot of FAD (concrete) identified from the side scan mosaic.

> **FAD VIDEO**
>
> Scan this QR code to watch a video of the FAD.
>
> If your smartphone does not have a reader, download one at get.neoreader.com

Further afield, FADs were identified around 3 km north of the Project area which include tyres, concrete blocks and unjam (Photo 6.7 to Photo 6.10). The concrete block FAD serves as an efficient soft coral and algae attachment surface as evidenced from the photos. Normally soft coral, coralline algae and other organisms e.g. barnacles are among the earliest to attached to the concrete surfaces /26/ as observed on the FADs in this study. Hard corals will only attach when the condition is optimal and coral larvae is present; no evidence of hard coral colonisation was observed on the FADs in the study area. Schools of juvenile fishes were also observed around the FADs.

In addition, more than 30 other FADs have been reported in the area as shown in Figure 6.28. These FADs include those reported by a local fisherman during the course of the field surveys and documented by the Department of Fisheries in 2008. These FADs and comprise of tyres, sunken boats and concrete /27/.

Photo 6.7 Unjam FAD.

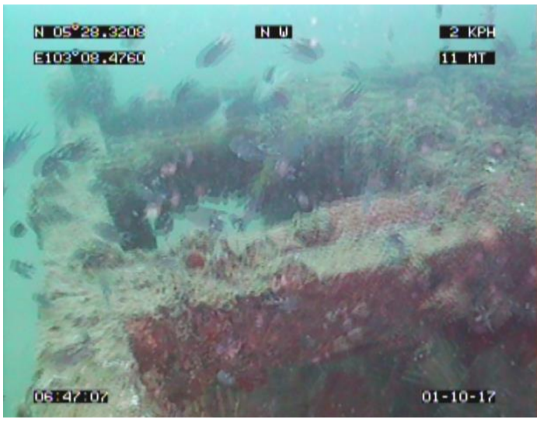


Photo 6.8 Concrete FAD covered with algae.

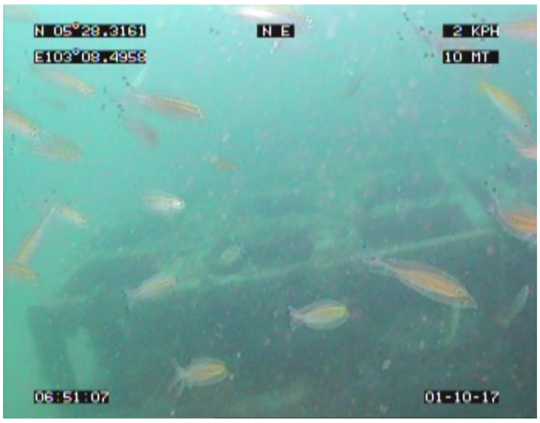


Photo 6.9 Concrete FAD.

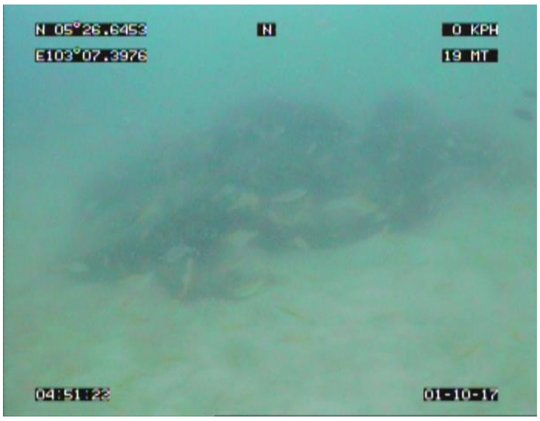


Photo 6.10 Tyre FAD that are separated and scattered.

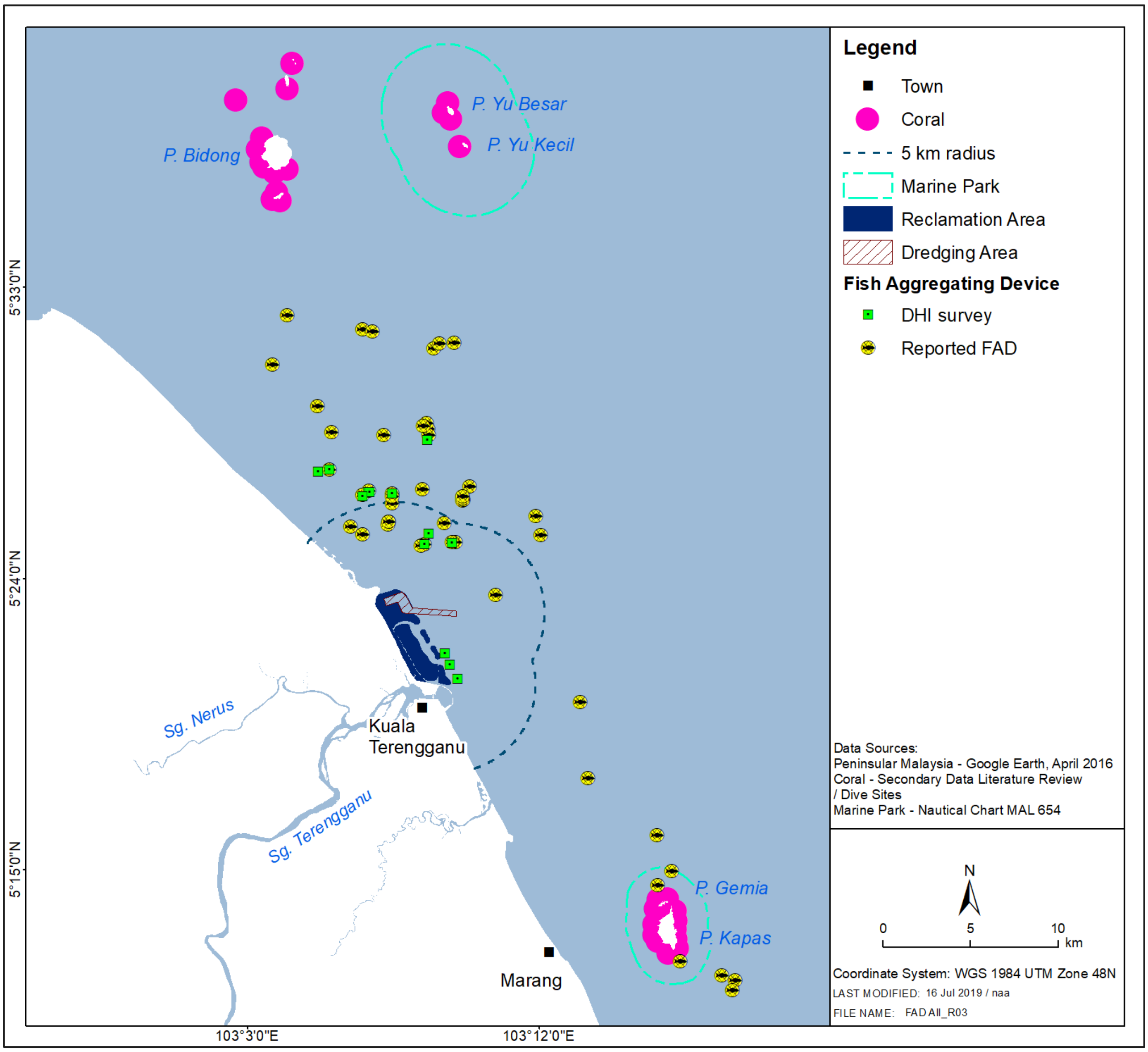


Figure 6.28 Marine benthic habitat around the Project area.

6.3.2 Macrobenthos

The soft-bottom benthic community includes a wide range of organisms from bacteria to plants (phytobenthos) and animals (zoobenthos) from different levels of the food web. Some of the major factors responsible for the diversity and spatial distribution of macrobenthos in a particular area are usually sediment texture, water quality, and food availability (nutrient concentration) /28/. Silty sediment is known to sustain more macrofaunal diversity and density compared to sand-dominated sediments, whereas clay-silt substrates are known to support more epifauna /29/. The sediment at the Project area is dominated by sand (>90% at most stations), with higher fines in the deeper areas of the Project area (up to 20% fine sediments). The habitat in the Project area is subtidal, ranging from 0 to -8 m CD.

Subtidal mobile sandbanks and exposed intertidal sands are found in high energy areas which are characterised by: medium to coarse sand, which generally indicates high permeability and high porosity (depending on compaction), low organic content, high oxygen content and therefore low reducing conditions, low carbon to nitrogen ratio, small microbial population and low sediment stability /30/. The biodiversity of these sedimentary biotope complexes is influenced by habitat stability and sediment type.

Macrobenthos sampling was conducted at 12 stations within the Project area as shown in Figure 6.29, during the inter-monsoon period between the Southwest and Northeast monsoons. Several studies along the Terengganu coastal areas and islands show that macrobenthos density is higher prior to the Northeast monsoon season (September – October) compared to the post-Northeast monsoon season (April – May) /31,32,34/. Hence, it can be inferred that the sampling results represent the best-case scenario, when the benthic community is high in density.

The average macrobenthos density at the site was 1,067 with a range between 320 to 2,500 individuals/m^2. The macrobenthos density in a 1996 study /31/ along the east coast of Peninsular Malaysia (along Kelantan to Johor waters) is much lower with 67.6 individuals/m^2 compared to the current study. Another study at an island around 20 km north of the Project area in 2006, shows similar macrobenthos density ranging from 700 individuals/m^2 to 2,000 individuals/m^2 for non-coral area and during pre-monsoon (similar season to current study) /34/. Another more recent survey around the Project area in March 2019 (inter-monsoon period between Northeast to Southwest monsoons) recorded a much higher density ranging from 168 to 16,375 ind./m^2 /44/.

An overview of the density at each of the 12 survey stations is shown in Figure 6.29. As illustrated in Figure 6.29, higher macrobenthos density was recorded at stations with finer sediment (more than 20% of fine sediment) i.e. MB12 (offshore navigation channel area), MB5 and MB2 as compared to stations with lower percentage of fine sediment.

A total of 33 taxa were identified from the survey in the following order of Phylum: Mollusca (22 taxa) > Annelida (6 taxa) > Arthopoda (2 taxa) and Echinodermata (2 taxa) > Chordata (1 taxa). Annelida was the most abundant phylum in terms of number of individuals, accounting for 50.5% of the total macrobenthic density and was comprised solely of polychaetes as indicated in Figure 6.30; this was followed closely by Mollusca (46.5%) which also made up a large part of the fauna. The molluscs were dominated by gastropods, with only small numbers of bivalves and schaphapods (Figure 6.30). The other phyla made up only 3.0% of the total density.

The high density of annelids (comprised solely of polychaetes) is attributed to the sandy characteristic of the marine sediment (refer to Section 6.2.4) at the Project area which provides higher interstitial space for the organisms to harbor /33/. Consistent with the present study, is a study by Ibrahim *et al.* at P. Karah, Terengganu which also found a predominance of polychaetes in the sandy sediments /34/.

The total number of taxa per station ranged between 5 and 21 taxa and the site genus diversity index (H') is 2.45. Examples of macrobenthic organisms recorded are shown in Photo 6.11.

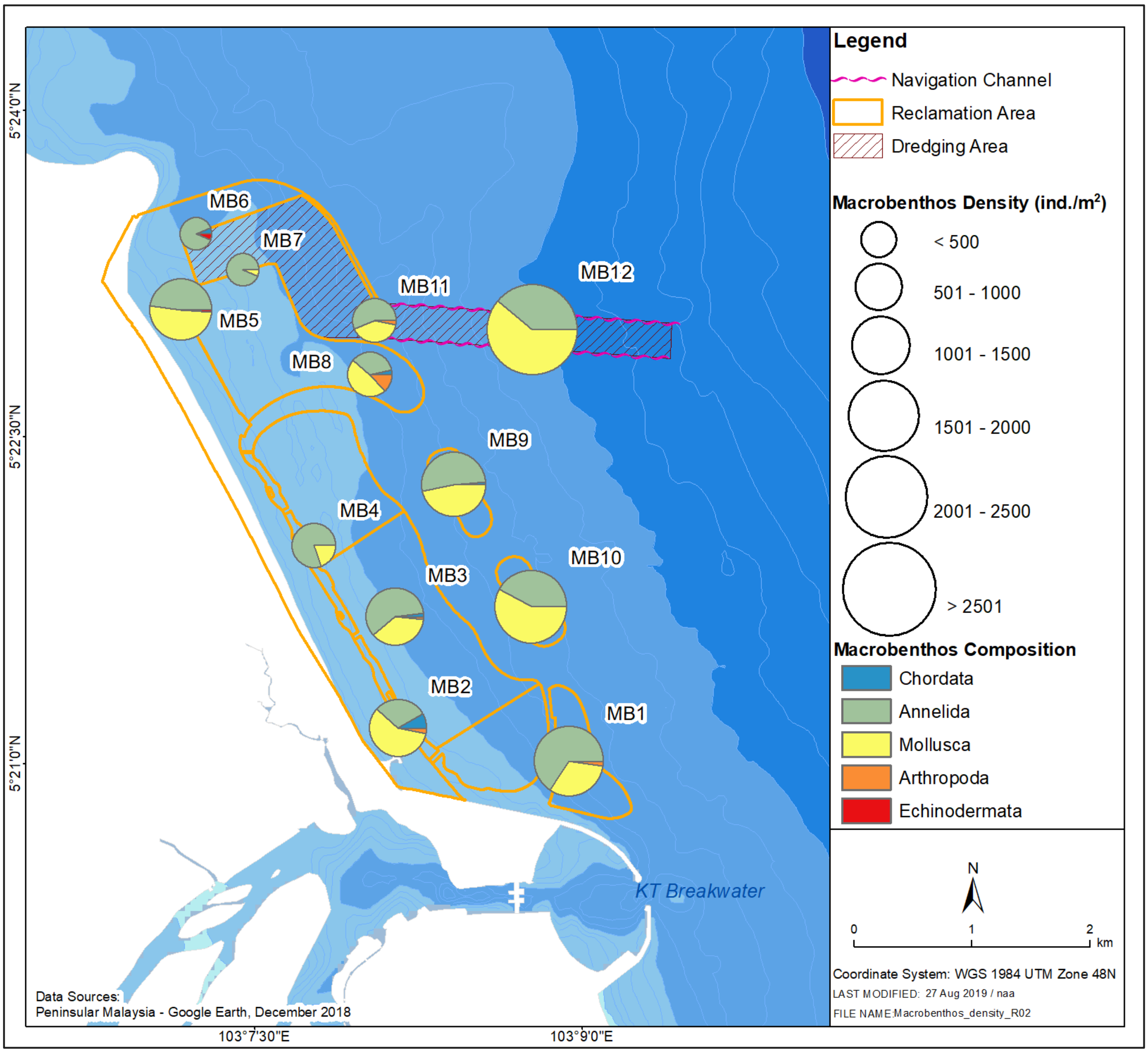


Figure 6.29 Mean macrobenthos density (individuals/m^2) in the study area.

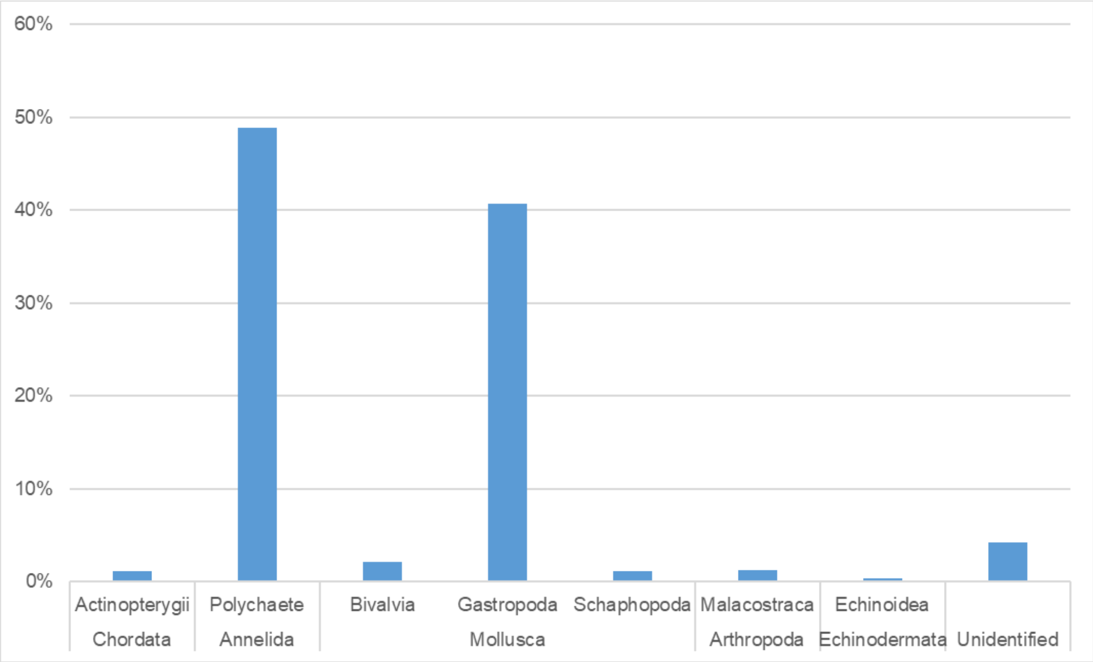


Figure 6.30 Percent dominance of the classes, including unidentified individuals.

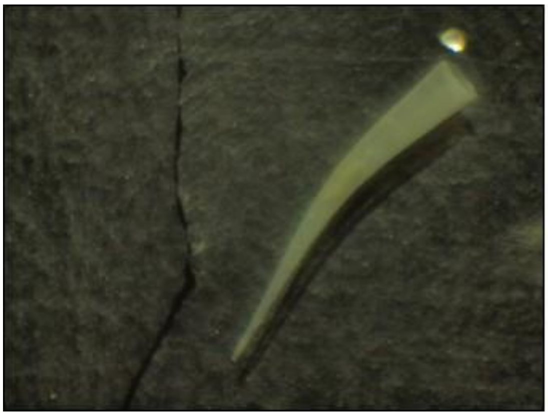


Photo 6.11 *Ditrupa* sp. (left) and *Athanas* sp. (right).

6.3.3 Plankton

Plankton are broadly classified into two groups: the phytoplankton (plants) and the zooplankton (animals). They are microscopic organisms found in the water column, although there is a transition of some species in shallow water from the benthos and into the water column on a diurnal basis. Plankton form a major link in aquatic food webs and often include the larvae of many species of animals ranging from corals to fish. The biological productivity of marine ecosystems in general is largely dependent on the primary production by phytoplankton which are subsequently consumed by heterotrophs such as zooplankton, fish, marine mammals and benthos.

These planktonic communities are generally influenced by various environmental factors such as light and nutrients whereas spatial variation is largely influenced by hydrodynamic processes such as water currents, tides and wind. For example, tide can influence the species diversity especially for sampling stations at estuarine/rivermouth as more freshwater species will flush out during ebb tide.

For this study, phytoplankton and zooplankton sampling was carried out at 11 stations during neap ebb tide (two samples were taken at each station as replicates) during the inter-monsoon period to obtain data on diversity and abundance. Data analysis also includes indices to determine genera/phyla diversity and evenness. Complete methodology and findings can be found in Appendix E.

6.3.3.1 Phytoplankton

Only two groups of phytoplankton were identified around the Project area, namely Bacillariophyta (15 genera) and Miozoa (3 genera), with a total of 18 genera. Bacillariophyta constituted 97.2% of the total phytoplankton density followed by Miozoa (2.8%). This is not surprising as Bacillariophyta is known to be a predominant group of phytoplankton in the marine environment /35/.

The total number of genera (from 22 samples – two replicates per station) was lower in estuarine waters (11 genera from two stations) compared to marine waters (18 genera from nine stations). This is due to the absence of several marine phytoplankton genera in the estuarine stations i.e. Bacteriastrum, Ditylum, Eucampia and Planktoniella. However, several purely marine genera were still present at these stations (e.g. Rhizosolenia, Thalassionema, Guinardia), suggesting that the low number of genera at estuarine station could be caused by the difference in sampling effort; only two stations for estuary and nine stations for marine.

Both marine and estuarine stations were dominated by *Chaetoceros*, see Figure 6.31. Three genera of phytoplankton with harmful algae blooms (HABs) species were identified in the study area, namely *Ceratium, Chaetoceros* and *Dinophysis*. Some species from genus *Ceratium* and *Chaetoceros* are harmful and *Dinophysis* dinoflagellates are known to produce okadaic acid which can cause diarrhetic shellfish poisoning /36,37,38,39/. However, it should be highlighted that these phytoplankton could not be determined to species level hence it is not certain if the phytoplankton sampled are harmful, bloom-forming species and the density were well below bloom densities of 20,000 cells/L reported by Usup *et al*. (2002) /40/ and 41,000 cells/L reported by Yap *et al.* (2004) /41/.

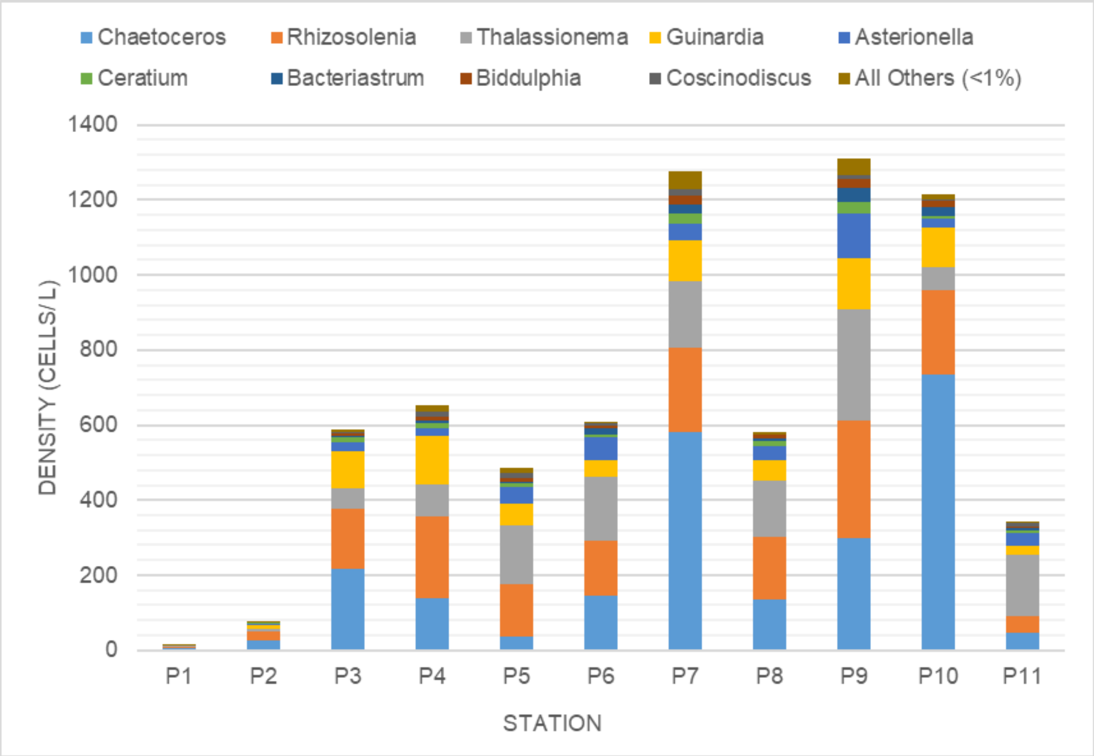


Figure 6.31 Distribution of key genera over the study area. Stations P1 and P2 are in Sg. Terengganu estuary. "All others" comprise nine genera which are represented by less than 1% of the total cells/L.

As shown in Figure 6.32, mean phytoplankton density is clearly higher in the marine environment (Stations P3 to P11) compared to the estuarine environment (Stations P1 and P2). The average density in the estuary was 45 cells/L and in the marine stations 784 cells/L. The lowest total phytoplankton abundance of merely 14.16 cells/L was recorded at Station P1, approximately 2 km upstream of the breakwater entrance, while the maximum of 1,309.85 cells/L was recorded at Station P9.

The densities recorded in this study are lower than those reported elsewhere along the east coast of Peninsular Malaysia, where the highest density recorded was 16,000 cells/L for similar sampling season (i.e. inter-monsoon) /42,43/. However, several differences in the sampling technique should be noted as these may account for some of the differences: the plankton net mesh size used in the prior studies was smaller (20 µm compared to the present study of 40 µm); the sampling technique employed was also different (using Van Dorn water sampler); and the total sample effort/volume of water filtered is less (10 L/25 – 50 L compared to an estimated 577 L for this study). Another survey in the study area using the same methods as the present survey was conducted in March 2019 (inter-monsoon, post NE monsoon), where up to 21,997 cells/L were recorded, with an average of 7,705 cells/L /44/. This highlights the high variability in phytoplankton communities within the same site over different sampling occasions.

Phytoplankton community structure is dependent on several environmental conditions such as temperature, salinity, light, nutrient availability and presence of grazers /45,46/. Based on the water quality results, one plausible cause for the lower phytoplankton densities at estuarine stations is the salinity gradient, where marine phytoplankton cannot survive in freshwater. Salinity gradient was reported to be one of the main factors for the distribution and diversity of phytoplankton communities in estuaries and coastal waters /47,48,49/. Mixing of freshwater phytoplankton species with marine species was observed at almost all stations as the sampling was conducted during ebb tide (river discharges flowing to the coast).

Higher turbidity values at estuarine stations as compared to marine stations were also recorded, suggesting that light could be one of the limiting factors in phytoplankton growth at the study area.

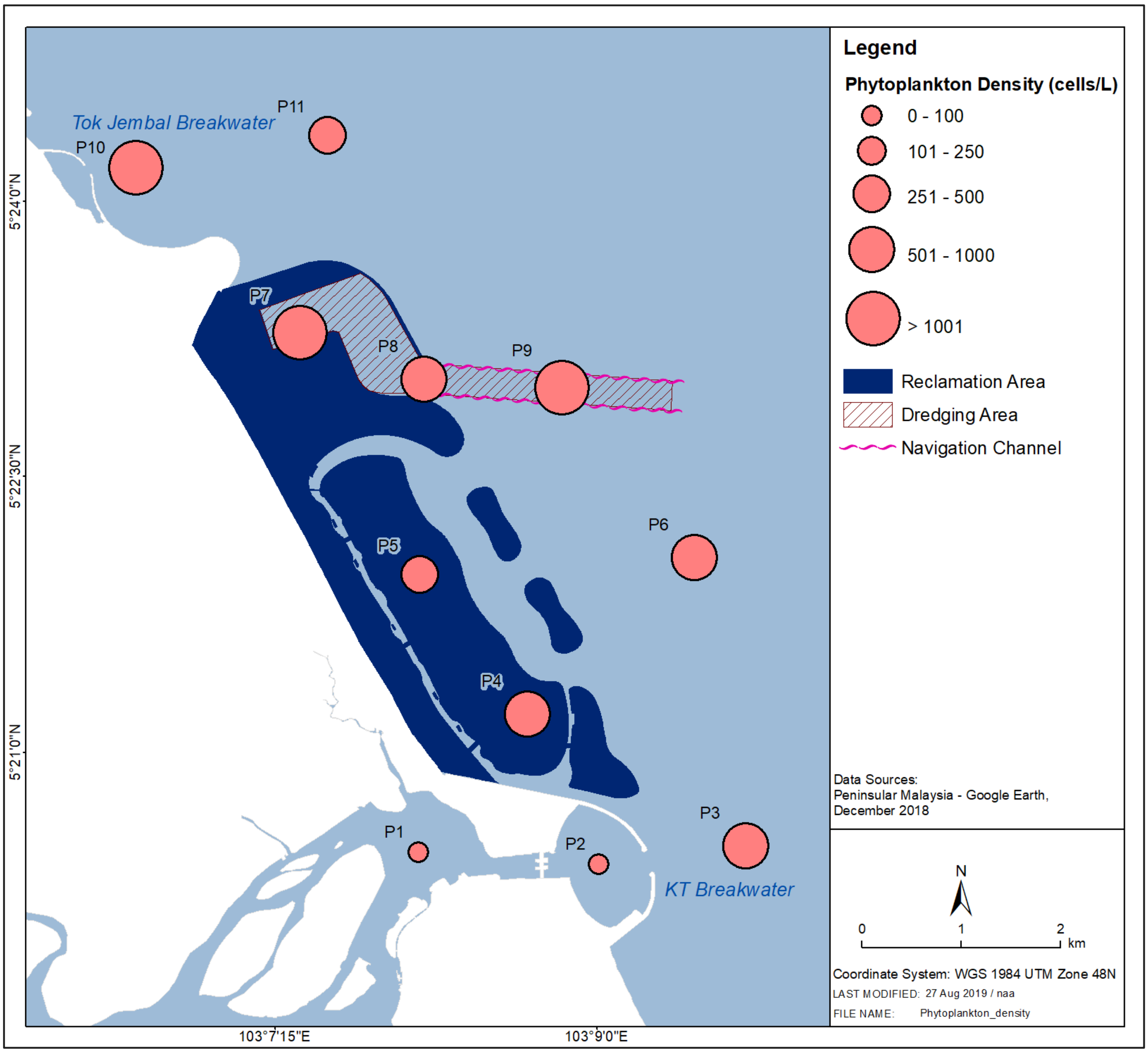


Figure 6.32 Mean phytoplankton density (cells/L) in the study area.

6.3.3.2 Zooplankton

Abundance & Diversity

Zooplankton abundance ranged between 2.65 to 15.67 ind./L at stations Z1 (in the estuary) and Z3 (off the river mouth) respectively. A possible reason for the high zooplankton abundance at station Z3 is that the zooplankton densities were higher in the Sg. Terengganu river and were transported down into the coastal area during ebb tide. The density gradient from Z1 to Z2 and Z3 (lowest to highest) supports this hypothesis. Collecting samples during ebb tide, is sampling water/plankton that has spent at least the past six hours in the estuary/river, thus reflects estuarine/river condition /50/.

The variation of zooplankton density between sampling stations is low, with a small difference between the maximum (Station Z3, 15.67 ± 12.33 ind./L) and minimum (Station Z1, 2.65 ± 0.82 ind./L) zooplankton density (Figure 6.33). A study by Jivaluk (1999) in east coast of Peninsular Malaysia waters recorded lower density of zooplankton (for season similar to current study), ranging from 0.036 to 3.413 ind./L /51/. Another survey conducted at the Project area in March 2019 (post-northeast season compared to current study carried out in the pre-Northeast monsoon period), recorded lower density with maximum of 1.82 ind./L /44/.

Similar to phytoplankton, the abundance and distribution of zooplankton are influenced by biological-physical factors /52/. The distribution of zooplankton at the river mouth of Sg. Terengganu is possibly influenced by tide (river outflow/inflow) and salinity gradient. However, it is unclear what factors contributed to the distribution of zooplankton in marine stations as no correlation between zooplankton abundance and known limiting factors such as water quality and availability of food (phytoplankton) could be found. It is to be noted that variation associated with the natural patchiness of plants and animals can be 10- or 100-fold greater than the variation in physical characteristics, such as sediment type or water temperature /50/.

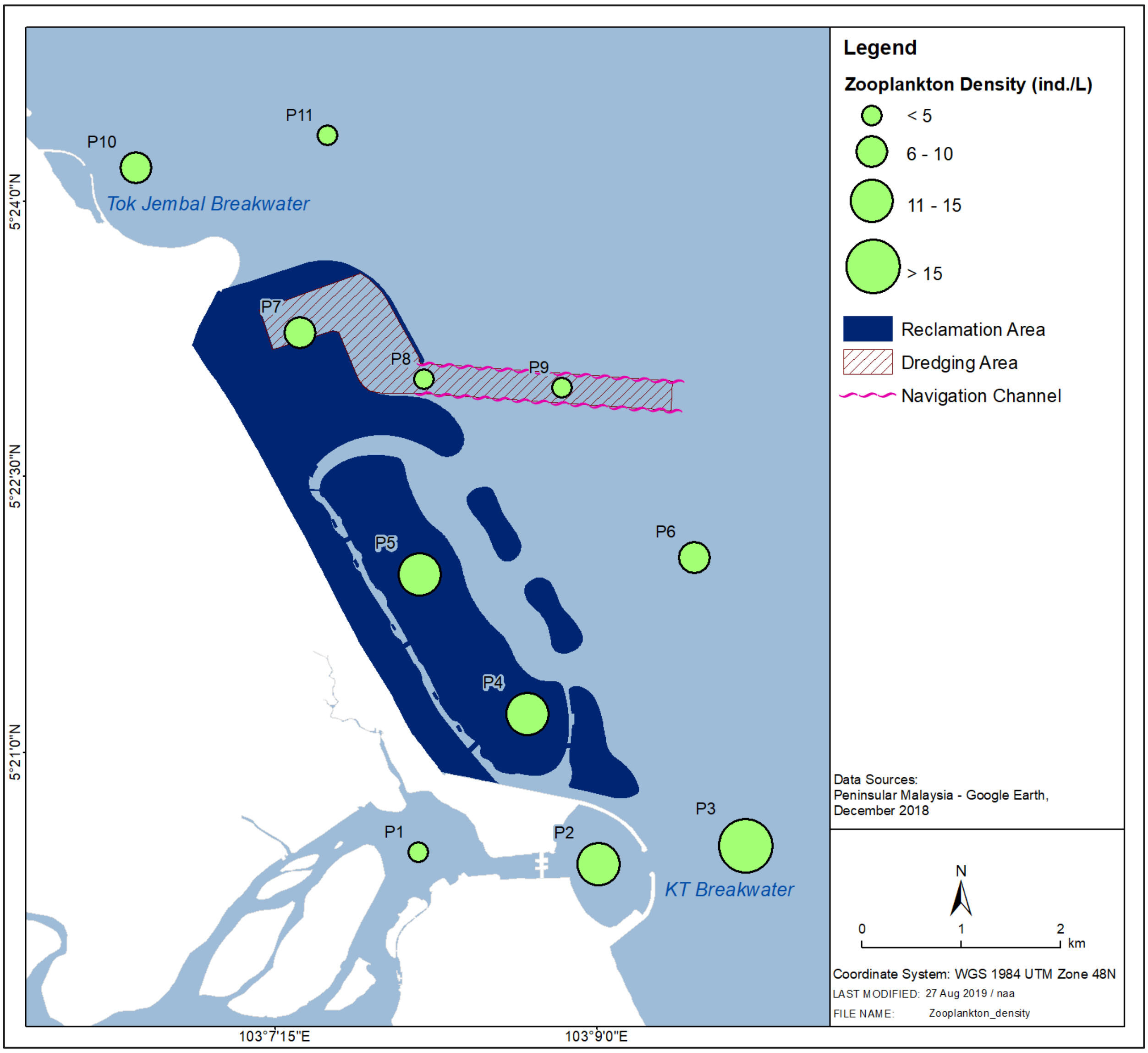


Figure 6.33 Mean zooplankton density (individuals/L) in the study area.

Taxa Composition

A total of eight zooplankton phyla were identified around the Project area which comprised of a total of 42 taxa. The dominant group was Arthropoda (55% of total density) which comprised mainly of copepods. On a global scale, the dominance of copepods in the zooplankton community have also been reported in other studies /53,54/. Other phyla include Annelida (14.5%), Chordata (0.02%), Chaetognatha (0.12%), Cnidaria (18.3%), Mollusca (0.14%), Echinodermata (0.04%) and Radiozoa (11.6%).

Lucifer protozoea (prawn), bivalve spat, and gastropod spat were found at all stations with between 6.1% to 8.3% of density, which is a relatively high abundance considering the dominant species comprises 12.6% of individuals. It is to be noted however, that these spat and protozoea are common in coastal areas /51/. The spat of certain species of bivalve are known to be source of food for crustaceans /55/.

Zooplankton from phylum Arthropoda (Class: Copepoda) was the dominant zooplankton at all sampling stations. This result coincides with other studies within Terengganu waters by Murthi (2005) and Bibi Shaheeda (2003) /56,57/. Examples of zooplankton present in the study area is shown in Photo 6.12.

The highest phylum diversity index was recorded at Station Z5 (H' = 1.26) and the least diverse is at Station Z1 (H' = 0.64). *Oithona* spp. was found at all stations in abundance and was dominant in seven stations (Figure 6.34). This genus can be found in all three aquatic environments – marine, brackish and freshwater /58/.

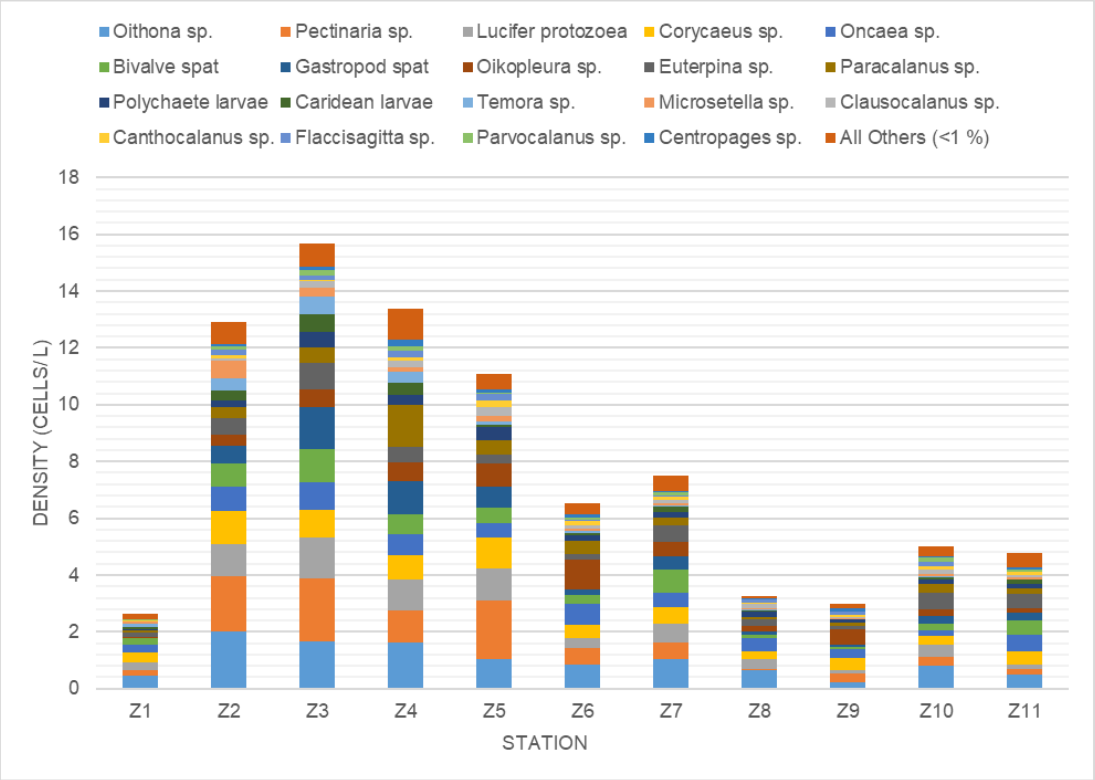
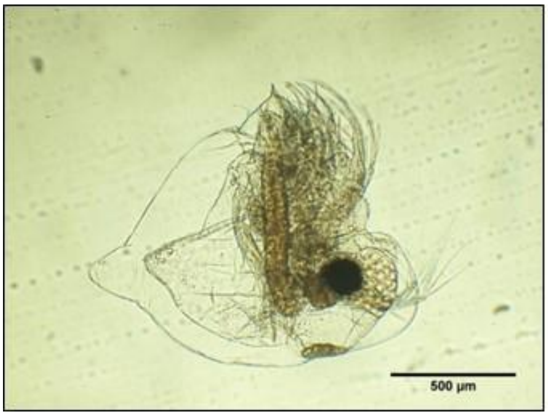


Figure 6.34 Distribution of key genera/classes over the study area. Stations P1 and P2 are in Sg. Terengganu estuary. "All others" comprise 23 genera/class which are represented by less than 1% of the total cells/L.



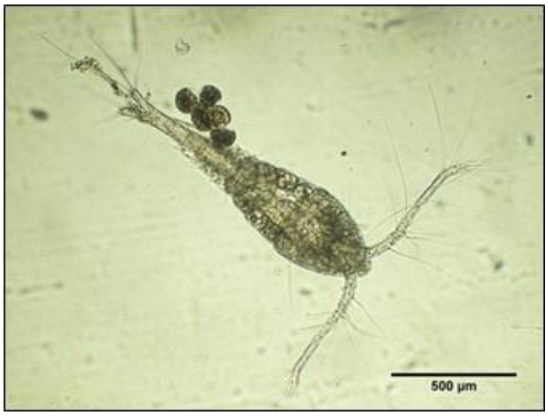


Photo 6.12 *Evadne* sp. (left) and *Oithona* sp. (right).

6.3.4 Fish Fauna

The most prominent fish fauna habitat within 1 km from the Project area has been identified as Fish Aggregating Devices (FAD) and Sg. Terengganu. The establishment of FADs has been demonstrated in many locations across the world to be an effective way to increase the supply of fish to the fishing communities /59/. At the time of writing, LKIM and Department of Fisheries have not been able to confirm when these FADs were installed and whether any monitoring of effectiveness has been carried out. While FADs are expected to increase the fish fauna population in the area, there is an anecdotal information from the local fisherman that the FAD efficacies might be reduced due to improper usage of the FADs which render the FAD to be ineffective. According to the source, among the improper usage of FAD includes deploying the net too close to the FAD which increases the potential of the net to 'blanket' the FAD.

Estuaries are considered a highly suitable area for fish fauna to spawn, develop and grow during early life mainly due to high organic matter as a food source to the fish community /60/. In Sg. Terengganu, the presence of mangroves along the river banks also increases the fish habitat value.

For the present study, fish fauna sampling was conducted at five stations in the nearshore coastline around the Project area (Figure 6.35) to determine the species, abundance and diversity of fish fauna. The stations covered areas within the Project area, off the river mouth and north of the Project in the nearshore waters off Tok Jembal. It is noted that the area is predominantly sandy as described in Section 6.2.4.1 which in general can also function as a nursery ground to fish fauna. However, structured habitats (including mangroves, coral, underwater grasses, biogenic reefs, marshes, etc.) generally significantly enhance juvenile density relative to unstructured habitats /61/.

Five trammel nets approximately 25 m long and 1.5 m wide with a mesh size of 2.0 cm and two outer net panels with mesh size of 7.0 cm were used. The five nets were strung together in series (total length is 125 m) and deployed for one hour during neap and spring tides. The trammel net is effective for this form of fish fauna sampling as the method captures both demersal and pelagic fish /62/. Sampling was carried out in October 2017 which is pre-NE monsoon.

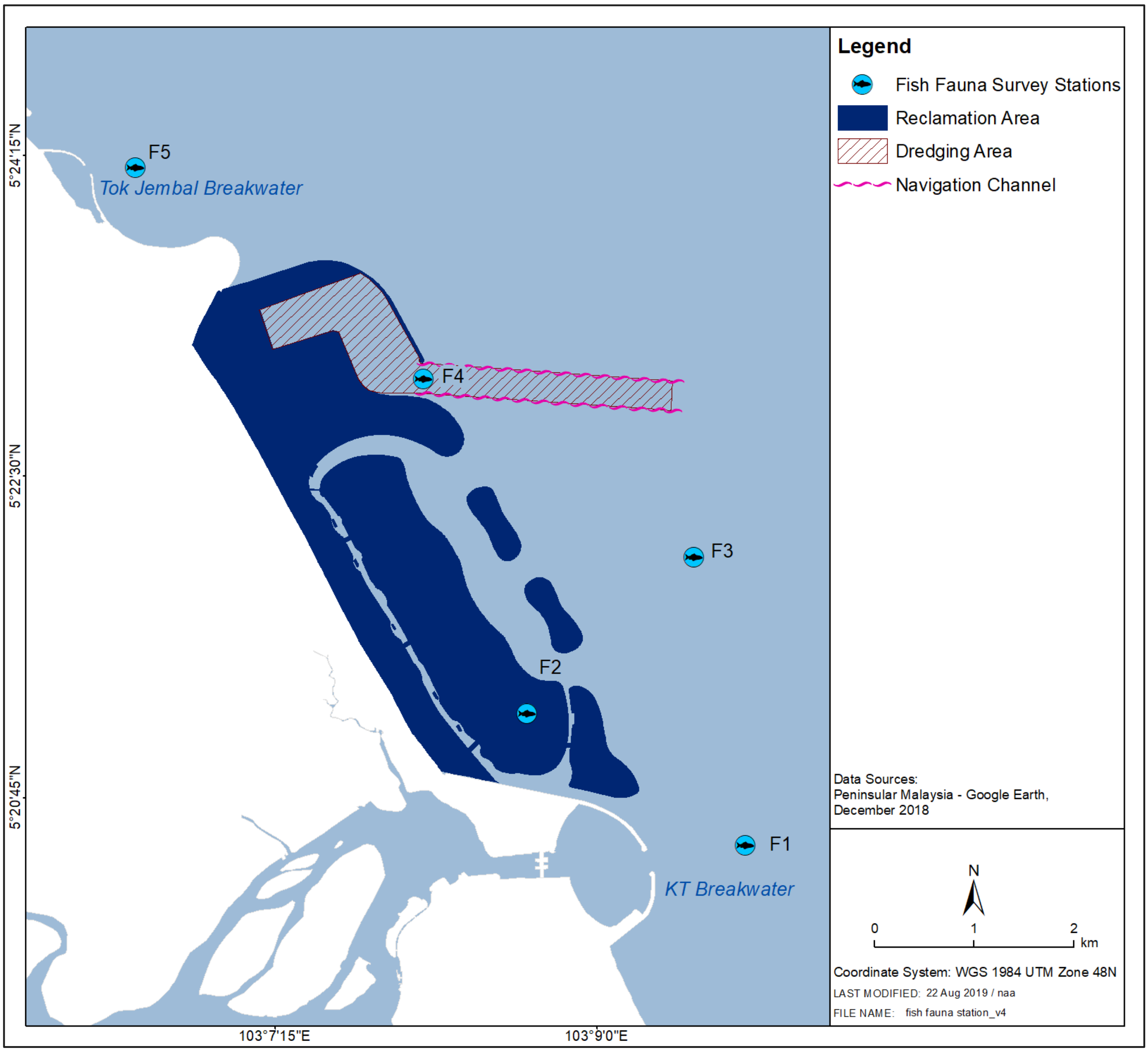


Figure 6.35 Fish fauna sampling stations.

6.3.4.1 Fish Diversity & Abundance

The highest number of species was recorded during neap tide (10 species) whereas spring tide sampling recorded five species only. Fish diversity was higher at Station F1, which is located off the Kuala Terengganu breakwater entrance. Recreational fishers were observed fishing around the breakwater structure, which may indicate that the breakwater structure is inhabited by a high number of fish fauna as this structure provides shelter and surfaces for organisms to settle on /63/.

Fish fauna abundance was also higher during neap tide where a total 55 individuals comprised of 49 fish, five crabs and one squid were caught over the five stations. Fish fauna caught during spring tide was about four times less than neap tide, with only 13 individuals caught. No fish was caught at Station F4 during both survey campaigns (Figure 6.36).

A separate survey was carried out in March and April 2019 (post NE monsoon) /44/ at the same locations. In this study, 17 species were recorded during spring tide whereas only two species were recorded during neap tide (totalling 18 species across both tides). Total abundance was also higher during spring tide compared to neap tide with 54 and three individuals respectively which is the opposite of what was recorded during the pre-monsoon survey. During the neap tide, no fish fauna was caught at stations F1, F3 and F5, compared to stations F2 and F3 during spring tide. A summary of the fish fauna caught is shown in Table 6.9.

Table 6.9 Abundance and total number of species recorded during the sampling. Note that the species listed for juvenile fishes are not exhaustive and are only for species where their maturity stage was able to be determined.

Data	Pre NE Monsoon (October 2017)		Post NE Monsoon (March/April 2019)	
	Neap	Spring	Neap	Spring
Abundance				
Fish	49	12	1	51
Crab	5	1	2	2
Lobster	-	-	-	1
Squid	1	-	-	-
Juvenile fishes	Station F2 • Ikan Cermin • Ikan Biji Nangka	Station F1 • Ikan Duri	-	Station F4 • Ikan Kekek Station F5 • Ikan Bilis • Ikan Cencaru • Ikan Duri • Ikan Gelama Gigi Jarang • Ikan Kekek • Ikan Kembung Borek • Ikan Lidah Sisik Besar • Ikan Selar • Ikan Tenggiri Batang • Three Spot Swimming Crab
Total no. of species	10	5	2	17

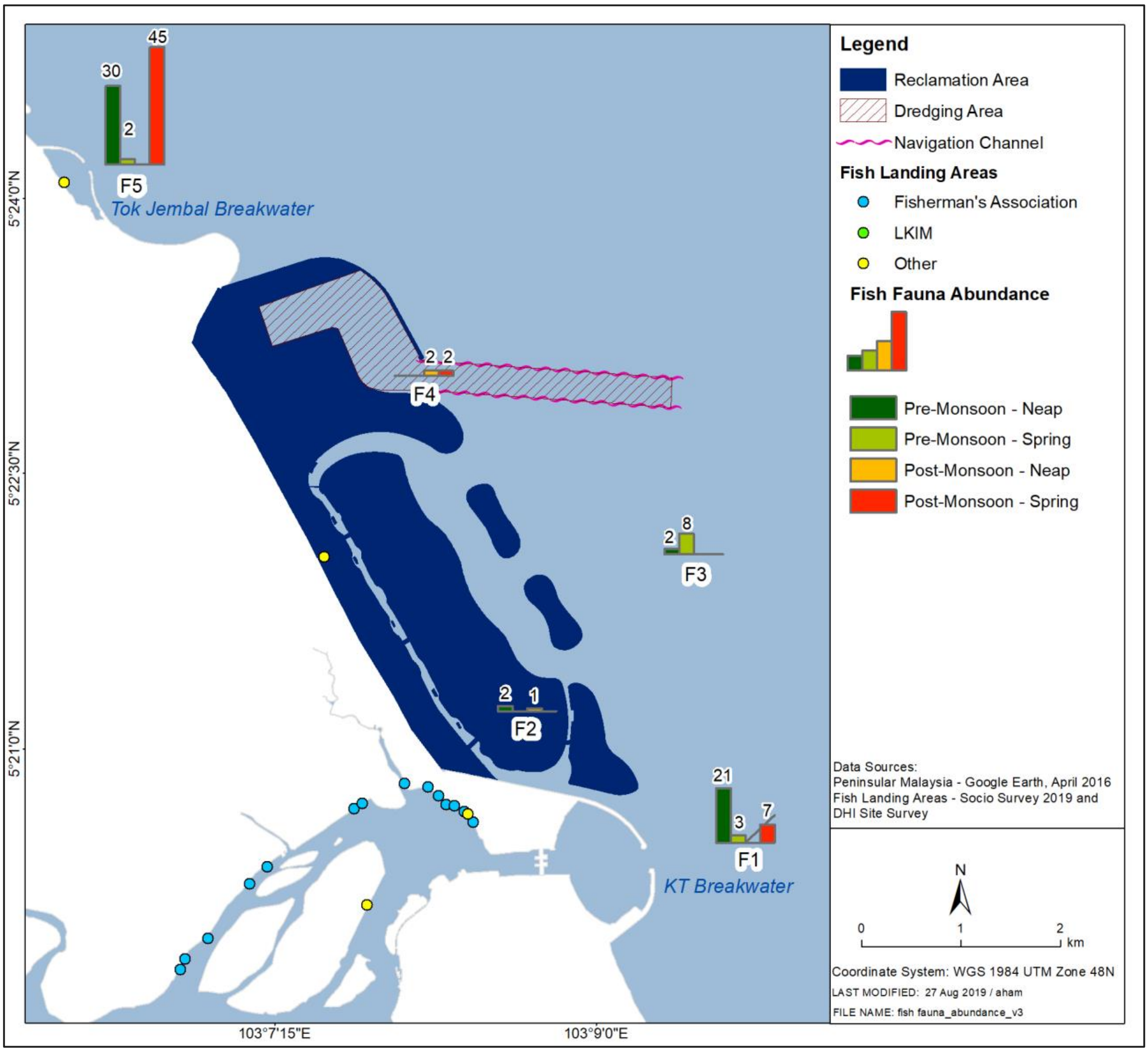


Figure 6.36 Fish fauna abundance during neap and spring. No fish fauna was caught at Station F4 for pre-monsoon and none at Station F3 for post-monsoon.

6.3.4.2 Species Composition

The species caught in the highest number was *Leiognathus brevirostris* locally known as Ikan Kekek with 48 individuals (70.6 % of the total fish caught). This was followed by *Valenciennea puellaris*, a type of goby, with only five individuals (7.4 %) (Figure 6.37). The other species were represented by only one to three individuals. Another study conducted at the same study area in 2019 showed results consistent with this survey, with *Leiognathus brevirostris* (Ikan Kekek) as the most abundant species /44/. On the other hand, Ikan Cencaru was the most caught during the post-monsoon survey (19 individuals; 33.3 % of total fish caught) with all of them caught during spring tide. This was followed by Ikan Empiriang Kasai (14.0 %), Ikan Kerong Batu (8.8 %), andIkan Selar (7.0 %).

Most of the fish fauna caught were adult, with a total of two species of juveniles caught during neap tide (Ikan Cermin and Ikan Biji Nangka, an individual each) and one species of juvenile was during spring tide (Ikan Duri, two individuals). Some examples of fish fauna caught are shown in Photo 6.13 and Photo 6.14. Data from the post-monsoon survey showed higher number of juveniles which includes Ikan Kekek, Ikan Bilis, Ikan Cencaru, Ikan Duri, Ikan Gelama Gigi Jarang, Ikan Kembung Borek, Ikan Lidah Sisik Besar, Ikan Selar, Ikan Tenggiri Batang, and the Three Spot Swimming Crab.

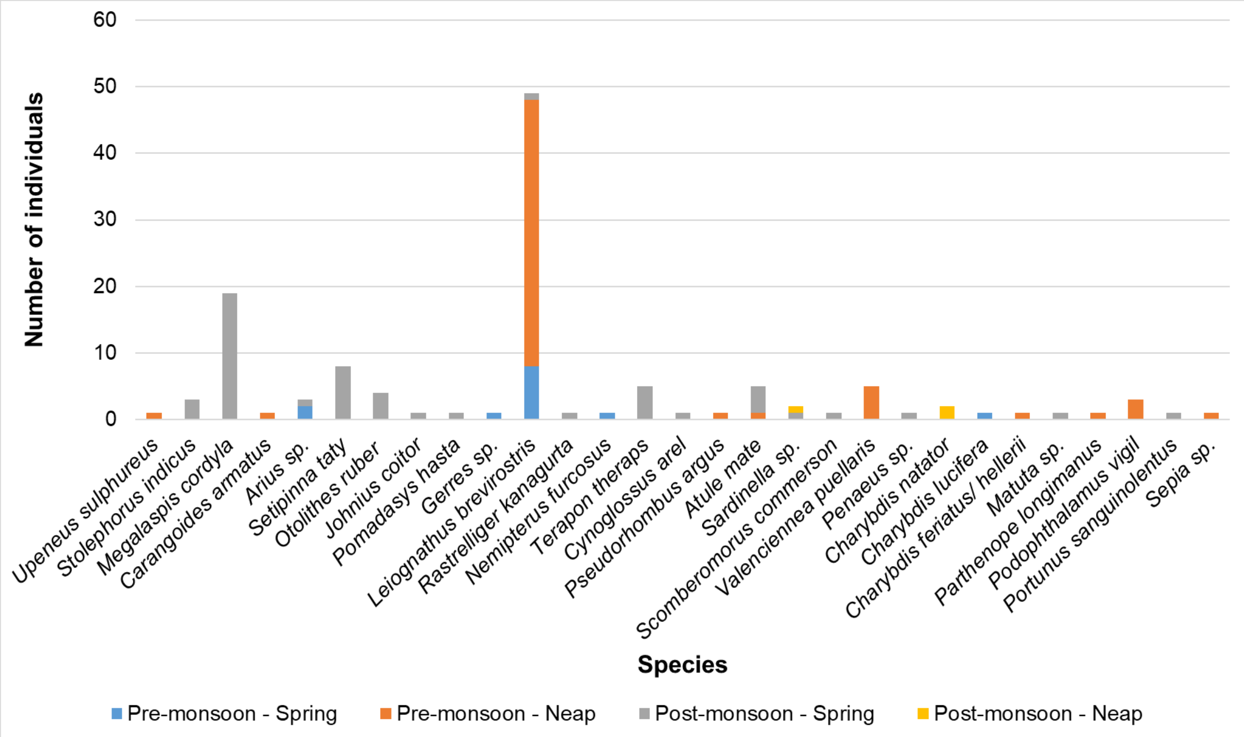


Figure 6.37 Species composition recorded throughout the survey including data from separate survey carried out in 2019.

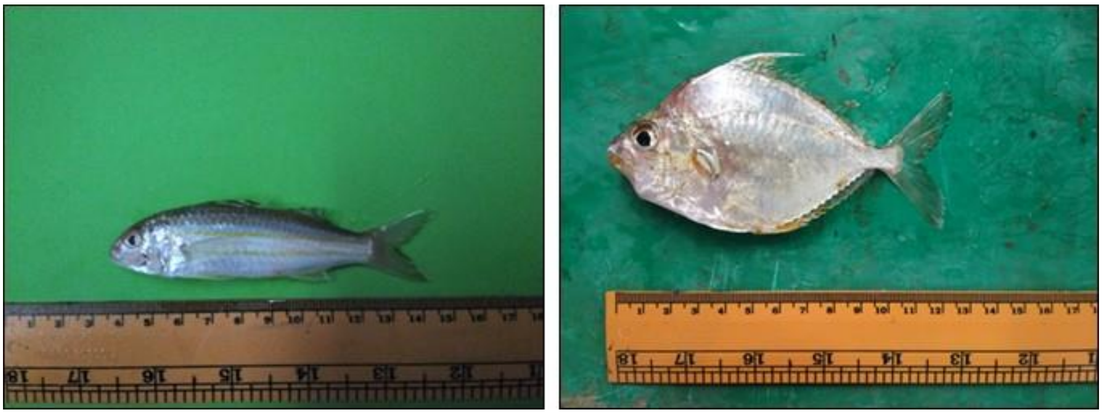


Photo 6.13 Juvenile Ikan Biji Nangka, *Upeneus moiluccensi* (left) and Ikan Kekek, *Leiognathus brevirostris* (right) caught during neap tide.

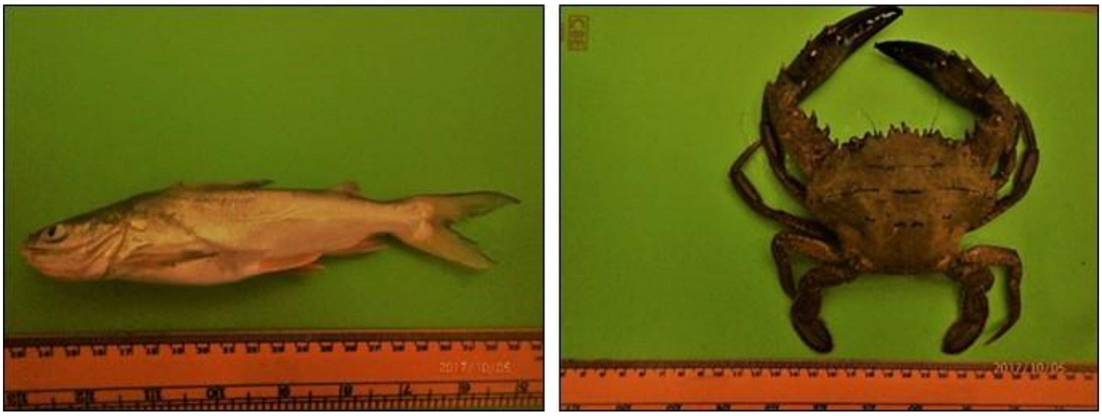


Photo 6.14 Ikan Duri, *Arius* sp. (left) and Ketam Batu, *Charybdis lucifera* (right) caught during spring tide.

Most of the fish caught during both occasions were consistent with the fish genera recorded in a previous 2011 study located at the coastal area of Kuala Terengganu /64/. The majority of species caught were demersal and this could be due to the sampling method where trammel nets submerge at the seafloor. Nonetheless, as this method is effective for fish fauna sampling /62/, pelagic fish were also caught. While LKIM Terengganu has stated that February to April is a high season for prawn and squid, the local fishermen informed during the post-monsoon survey in March-April 2019 that the high season had already ended.

6.3.5 Marine Megafauna

Marine megafauna consists of the larger marine animals which are commonly found within a marine area and comprise of several groups such as sharks, cetaceans, seabirds and marine turtles /65/, all of which have been recorded in the South China Sea, where the Project is located.

Based on literature review, seabirds and large cartilaginous fish (sharks, rays, skates) have been documented at the islands (e.g. Redang and Bidong island) /64,66/ which are located more than 20 km from the Project area. A study by Matsunuma *et al.* (2011) revealed that 18 species of cartilaginous fish can be found in Terengganu waters /64/. However, it is unclear the specific area where the fishes were caught as the data obtained was based on capture fisheries data (fish market survey). Due to these reasons, seabirds and cartilaginous fish are not detailed in this section.

6.3.5.1 Sea Turtles

Although two species of sea turtles (i.e. green turtles and hawksbill turtles[5]) nest on beaches in Terengganu, the Kuala Terengganu District Fisheries Office confirmed during consultations in December 2016 that there are no nesting sites located within 10 km of the Project area. The closest nesting area to the Project area is at Kapas Island, located approximately 17 km away (Figure 6.38).

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[5] The green turtle is classified by the IUCN Red List of Threatened Species as *endangered* while the hawksbill is *critically endangered*.

However, in year 2017, a green turtle nesting was reported in a news article /67/. To verify the report, consultation with the Rantau Abang Turtle Centre (personal communication with En. Mohammad Firdaus bin Abdullah on 08 July 2019) revealed that there are isolated cases of incidental nesting at Pantai Seberang Takir by sea turtles. These nestings are however not monitored by the Department of Fisheries as the nesting numbers are very low (one nesting in year 2018).

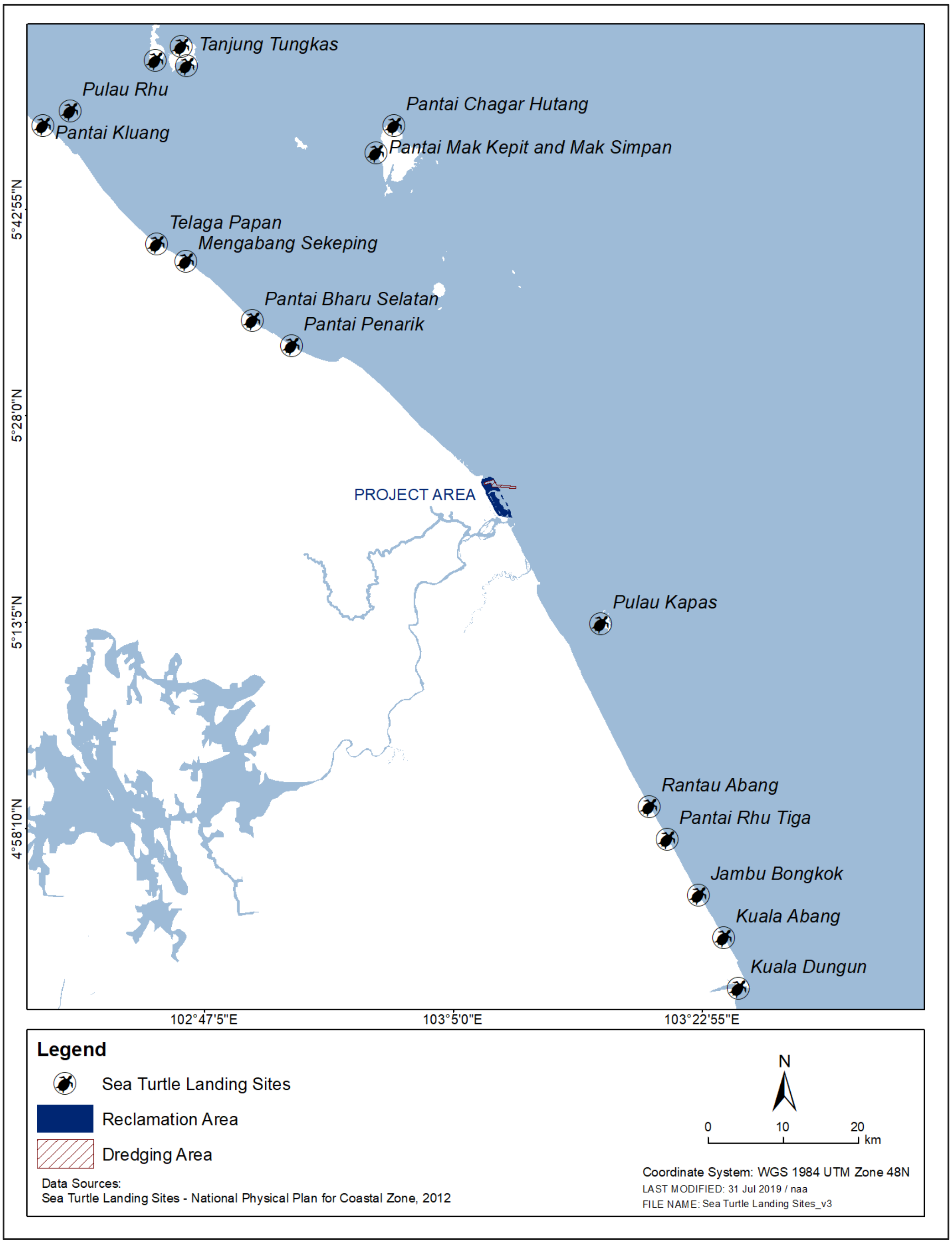

Figure 6.38 Sea turtle landing sites in Terengganu (Source: NPP-CZ).

6.3.5.2 Marine Mammals

Based on a compilation of information from various sources, several live sightings and stranding of cetacean species have been observed along the coast of Terengganu. These include dugong (*Dugong dugon*), Pygmy sperm whale (*Kogia breviceps*), Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), False killer whale (*Pseudorca crassidens*) and Indo-Pacific humpback dolphin (*Sousa chinensis*) /68/. The approximate locations of these sightings are shown in Figure 6.39.

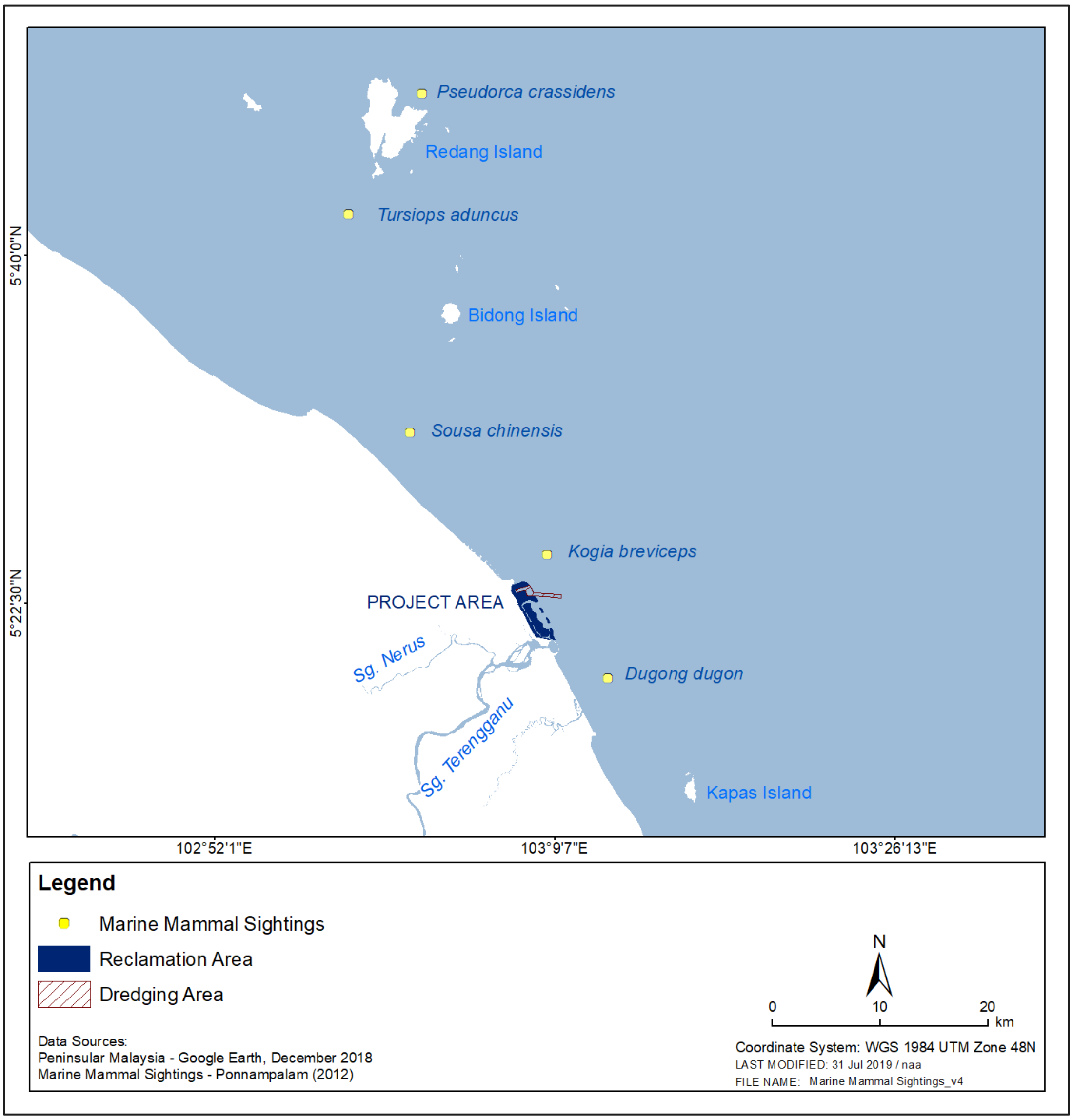

Figure 6.39 Approximate locations of marine mammal sightings near the Project area.

6.3.6 Terrapins

Terrapins nest on sandy beaches but live mainly in estuaries, mangrove creeks and other areas influenced by tidal actions. Two species of terrapins, which are classified as *critically endangered* by IUCN, are found in Peninsular Malaysia – the painted terrapin (*Batagur borneoensis*) and the river terrapin (*B. baska*). No painted terrapins are reported to nest in the vicinity of the Project area; the nearest nesting sites are reported at Sg. Setiu (52 km north of the Project) and Sg. Dungun (67 km south of the Project).

As shown in Figure 6.40, river terrapins are found in Sg. Terengganu, where they are known to nest at Pasir Temir and Pasir Lubuk Kawah, sites protected under the state legislation. These sites are located more than 30 km upstream of the mouth of Sg. Terengganu. Pasir Lubuk Kawah was known to be the most productive nesting beach for river terrapins but erosion due to upstream development of a dam led to nesting numbers plummeting. More recent data, however, showed that nest numbers have increased and ranges between 80 to 97 nests annually from years 2009 to 2013 /69/.

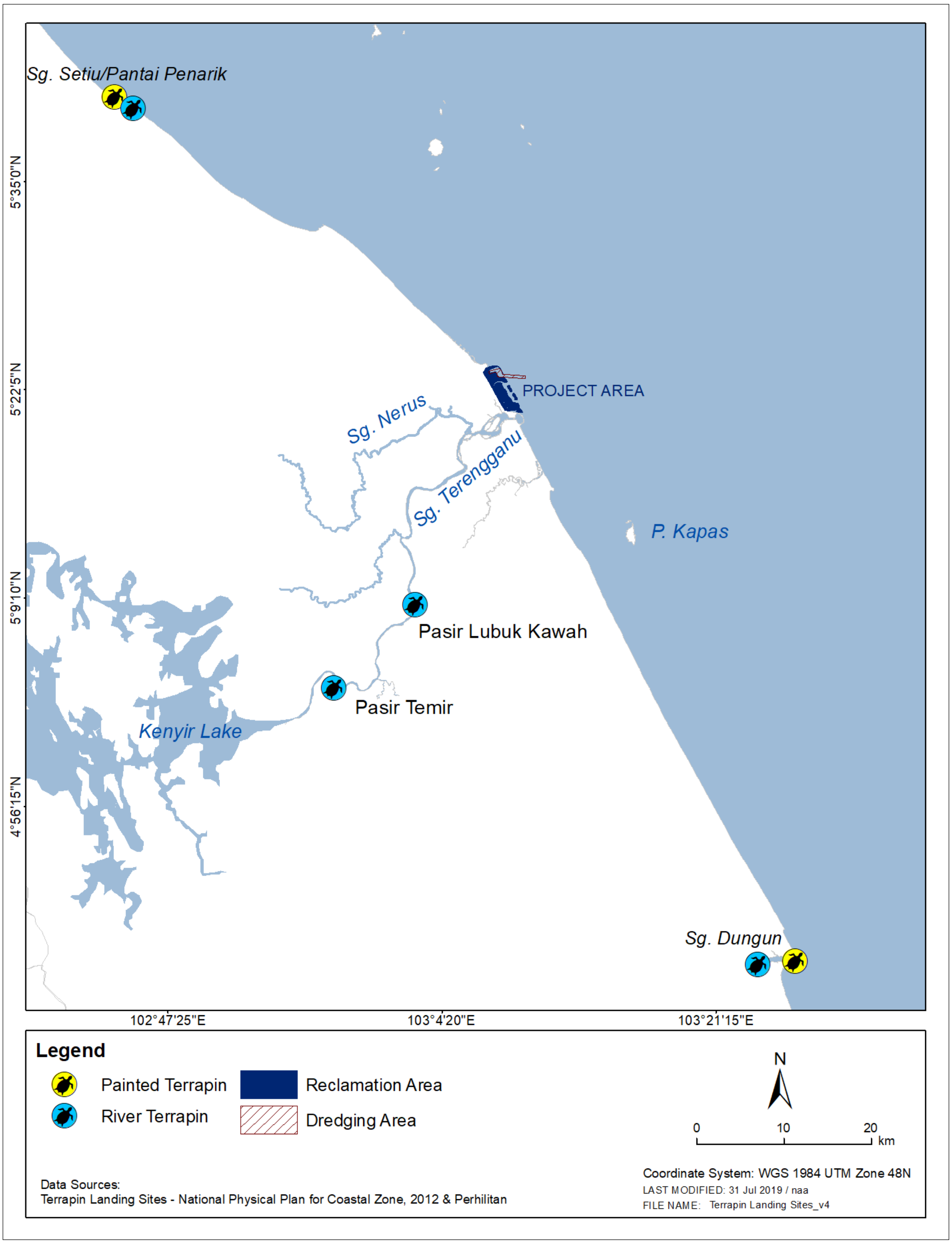

Figure 6.40 Terrapin landing sites in Terengganu.

6.3.7 Mangrove

The Project area is an open sandy coastline, hence there are no coastal fringing mangroves. The nearest mangrove area within 1 km from the reclamation area is located inside Sg. Terengganu, along a tributary of Sg. Terengganu which runs parallel to the shoreline approximately 300 m inland (Figure 6.41).

The mangroves along this tributary cover an area of approximately 15.7 ha, mostly dominated by nipah (*Nypa fruticans*). Another mangrove species found along the tributary was pokok berembang (*Sonneratia caseolaris*) combined with mangrove associates piai raya (*Acrostichum aureum*), monkey apple (*Glochidion littorale*) (Photo 6.15) and sea hibiscus (*Hibiscus tiliaceus*). The mangrove vegetation in most areas were highly disturbed.

Mangroves are also present farther upstream in Sg. Terengganu, where patches of mangroves comprising mainly of nipah trees can be found scattered along the shorelines of Kuala Terengganu, Pulau Wan Man, Pulau Duyong and Pulau Sekati (Figure 6.41).

Mangroves are known to serve many functions such as nursery grounds, food, shelter and habitat for a wide range of animals. During the assessment, fauna observed include the kingfisher, monitor lizard (Photo 6.16), hornets, crocodile and wild boar. Other mangrove-related fauna that have been reported in other studies include shrimps, mud crabs, horseshoe crabs, skinks, eagles, cormorants and others /70,71/.

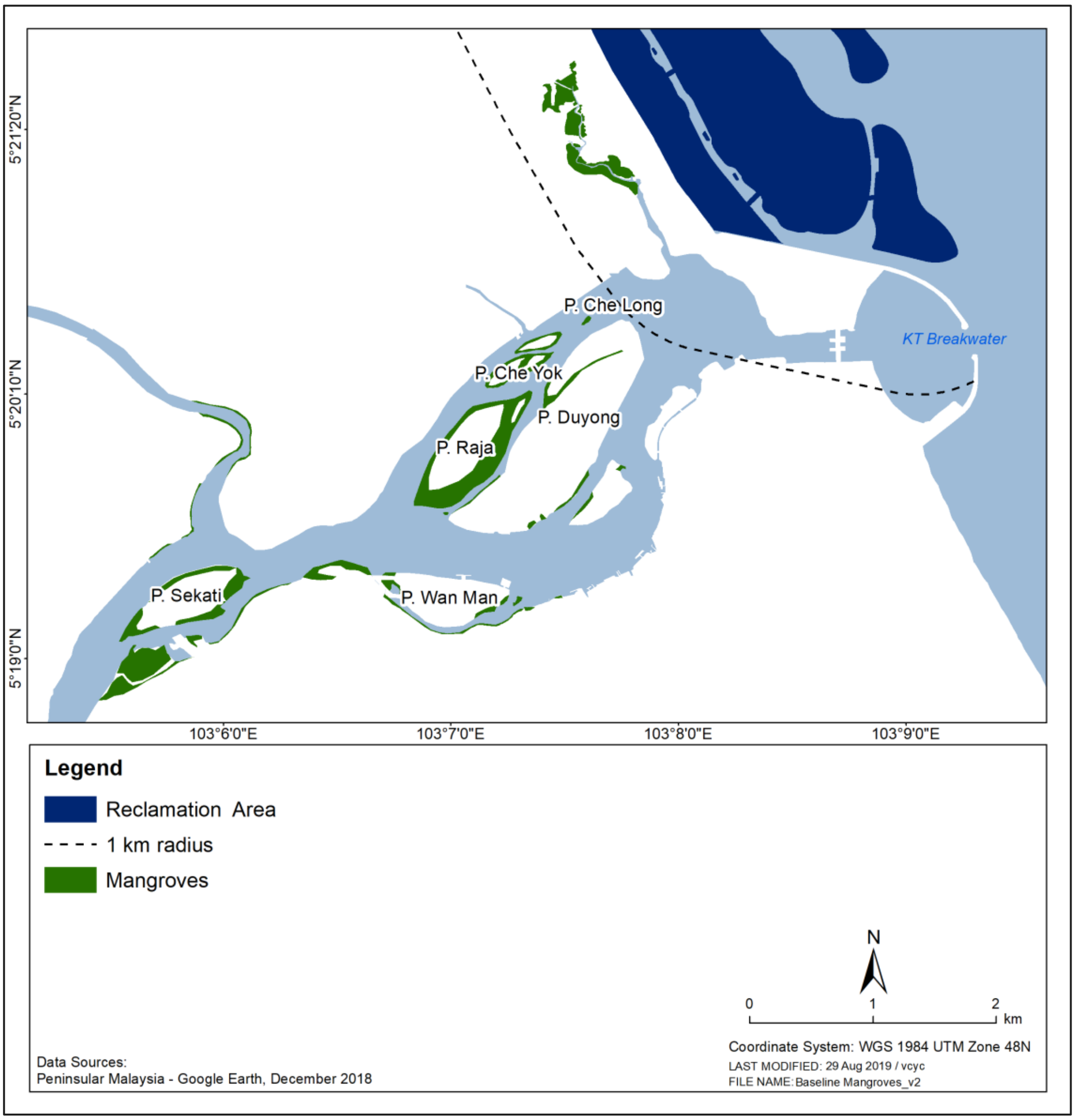

Figure 6.41 Mangrove areas located in Sg. Terengganu.

Photo 6.15 *Glochidion littorale* near station M1 (left) and disturbed *Nypa fruticans* at station M4 (right).

Photo 6.16 Kingfisher (left) and monitor lizard (right) observed during the mangrove assessment.

6.3.8 Terrestrial Ecology

The terrestrial ecology within 200 m of the reclamation area is predominantly sparse woodland and herbaceous. Sparse woodland and woodland areas primarily comprise *Casuarina* sp. trees which appear to have been planted, see Photo 6.17. The purpose could either be for beautification or soil stabilisation.

Shrubland comprise common species such as rhu (*Casuarina* sp.), screw pine (*Pandanus* sp.), coconut (*Cocos nucifera*) and sea almond (*Terminalia catappa*) trees (see Figure 6.42, Table 6.10). The type or species of plants observed are typical of this environment where the landuse is a mix of open spaces, landscaped recreational areas and residential.

Table 6.10 Vegetation composition within 200m from Project area.

Vegetation Type	Area (ha)	Percentage
Herbaceous	13.3	30
Shrubland	5.1	11
Sparse Woodland	18.4	41
Woodland	8.1	18
Total	44.9	

Photo 6.17 Clockwise from top left: Large areas covered with creepers and grasslands which are categorised as herbaceous type vegetation; coconut (*Cocos nucifera*) saplings observed in some areas; Shrubland, with 0.5- 5 m tall shrubs and trees comprising less than 10% cover; Rows of planted *Casuarina* sp. trees classified woodland (trees with generally more than 25% canopy cover).

Figure 6.42 Vegetation type present within 200 m of the reclamation area.

6.4 Human Environment

The human environment section provides an overview of the population, economic activities and land and sea-uses pertinent to the study area to provide the social context for evaluating the impacts of the Project on the human environment. As described in Chapter 1, the EIA study area for the human environment is 5 km radius from the Project area.

The information presented here was obtained from both primary data and available secondary data as summarised in Table 6.11. Further details on the results of socioeconomic survey carried out are provided in Appendix I.

Table 6.11 Details of data collection for human environment.

Component	Data Type	Source	Date of Collection
Land use	Primary, secondary	• Ground survey • Local Plan	• 30 September 2017 • 2 – 5 October 2017
Socioeconomics	Primary	Socio survey	• 28 – 30 March 2018 • 12 – 15 March 2019
Fisheries activities	Primary	• Socioeconomic survey • Data from DOF	
Tourism and recreation	Primary and secondary	• Socioeconomic survey • Data from agencies • Published studies	
Perception	Primary	• Socioeconomic survey • FGD • Townhall	• 28 – 30 March 2018 • 12 – 15 March 2019 • 12 June 2019 (FGD) • 28 June 2019 (Townhall)
Cultural heritage	Secondary	Published studies	NA
Marine traffic	Primary	• Data from agencies • Ferry, vessels and ports operators.	8 July 2019 – 31 July 2019

Administratively, the Project is in the Kuala Nerus District, which encompasses four mukims (i.e. Mukims Kuala Nerus, Batu Bakit, Pulau Redang and Pakoh) as shown in Figure 6.43. The EIA study area of 5 km from the Project also encompasses the Kuala Terengganu District south of Sg. Terengganu, comprising its mukims including Bandar Kuala Terengganu, Batu Buruk, Batu Rakit, Manir, Bukit Besar, Cabang Tiga, Losong (see Figure 6.43).

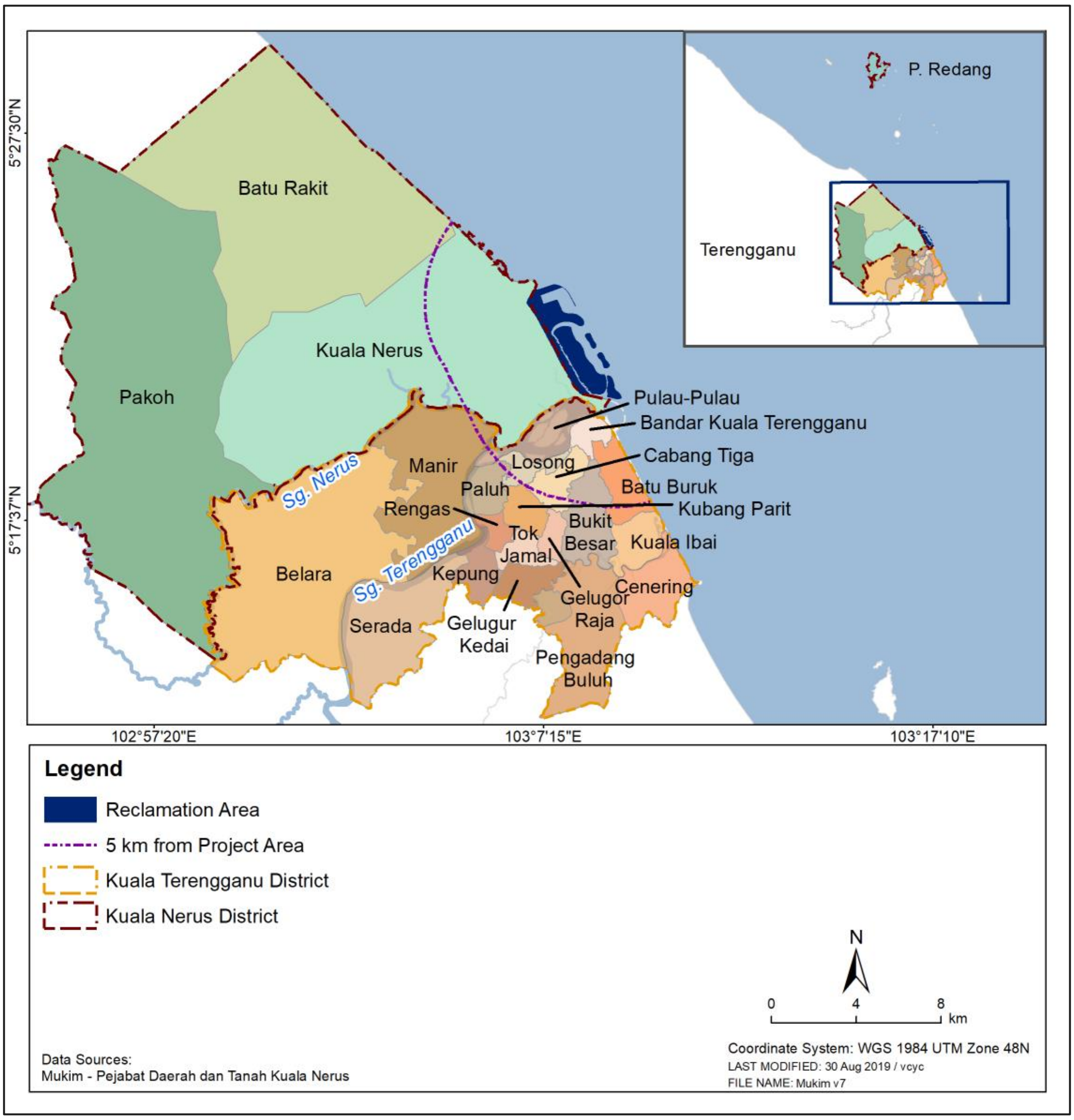

Figure 6.43 Districts and *mukims* around the Project.

6.4.1 Land Use

Based on the Kuala Terengganu District Local Plan 2010, land use within the 5 km boundary from the Project consists of unplanned and planned residential areas along the coast, urban land uses within the Kuala Terengganu town area and less developed areas further inland with plots of unused land.

The immediate land use adjacent to the Project is the beach stretch of Pantai Teluk Ketapang, Seberang Takir (Photo 6.18) which is popular for recreational activities such as swimming, picnics and playing kites. Pantai Teluk Ketapang stretches approximately 5 km from the north at Kampung Teluk Ketapang down to Kampung Seberang Takir. The southern end of the beach is also referred to as Pantai Seberang Takir, however there is no set boundary and for the purpose of this report the entire stretch of beach is referred Pantai Teluk Ketapang. Visitors however mostly utilise the northern section of the beach, a stretch of approximately 1 km. This is further discussed in Section 6.4.5.1. The coastal road adjacent to the Project site (Jalan

Pantai Teluk Ketapang) has been upgraded with works completed in May 2019 (Photo 6.19).

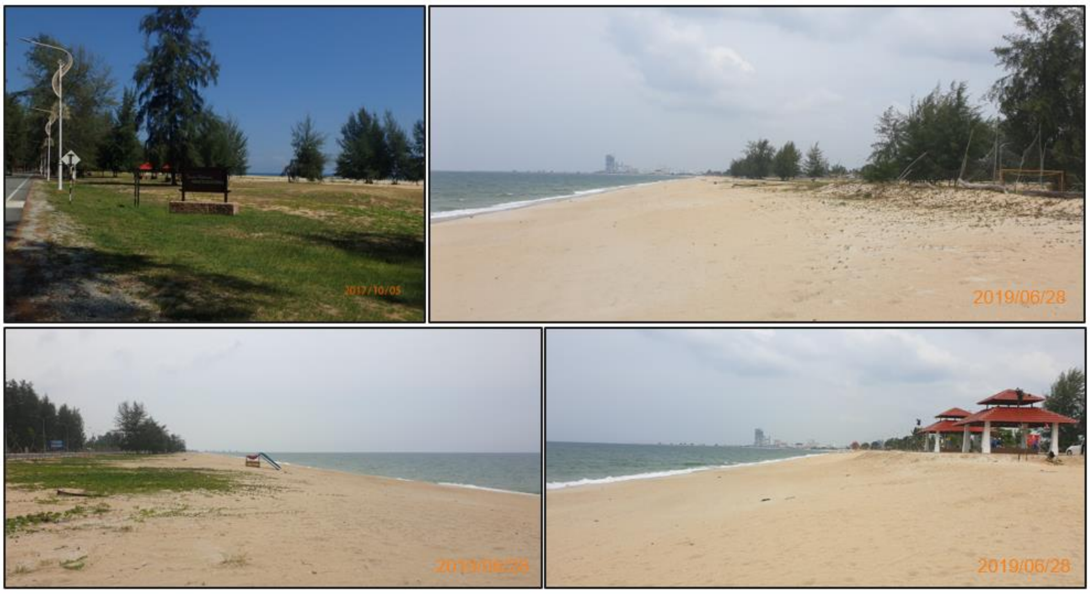

Photo 6.18 Pantai Teluk Ketapang.

Photo 6.19 New coastal road along Pantai Teluk Ketapang (photo taken in June 2019).

The dominant land use within 1 km of the Project is dense residential settlements and tourism-based facilities (e.g. hotel and homestays) as shown in Figure 6.44. Three key land uses features in the region are the Sultan Mahmud Airport (~176 ha), the army camp (~87 ha) and Universiti Malaysia Terengganu campus (~74 ha) (Photo 6.20). Community facilities such as hospitals, clinics, mosque; church and temple are scattered within the residential areas. Figure 6.45 and Figure 6.46 show the existing land use types and features within 5 km of the Project.

Photo 6.20 Sultan Mahmud airport (top) and Universiti Malaysia Terengganu (bottom).