

The zooplankton density at estuarine stations increases from Station P1 (inside the river) to P2 and P3 (at the river mouth). A possible reason for the high zooplankton abundance at station Z3 is that the zooplankton densities were higher in the Sg. Terengganu river and was transported down into the coastal area during ebb tide. 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 /10/.

The highest phylum diversity index however, is recorded at Station P5 ($H' = 1.26$) and the least diverse is at Station P1 ($H' = 0.64$) due to dominance by *Oithona* sp. *Oithona* spp. can be found in all three aquatic environments – marine, brackish and freshwater /16/. This is translated in the sampling result, where this species was found at all stations in abundance and was dominant in seven stations.

Similar to phytoplankton, the zooplankton density at marine stations does not correlate with nutrient and dissolved oxygen concentration in water. The density also does not correlate to the density of phytoplankton; the primary producer in the food chain.

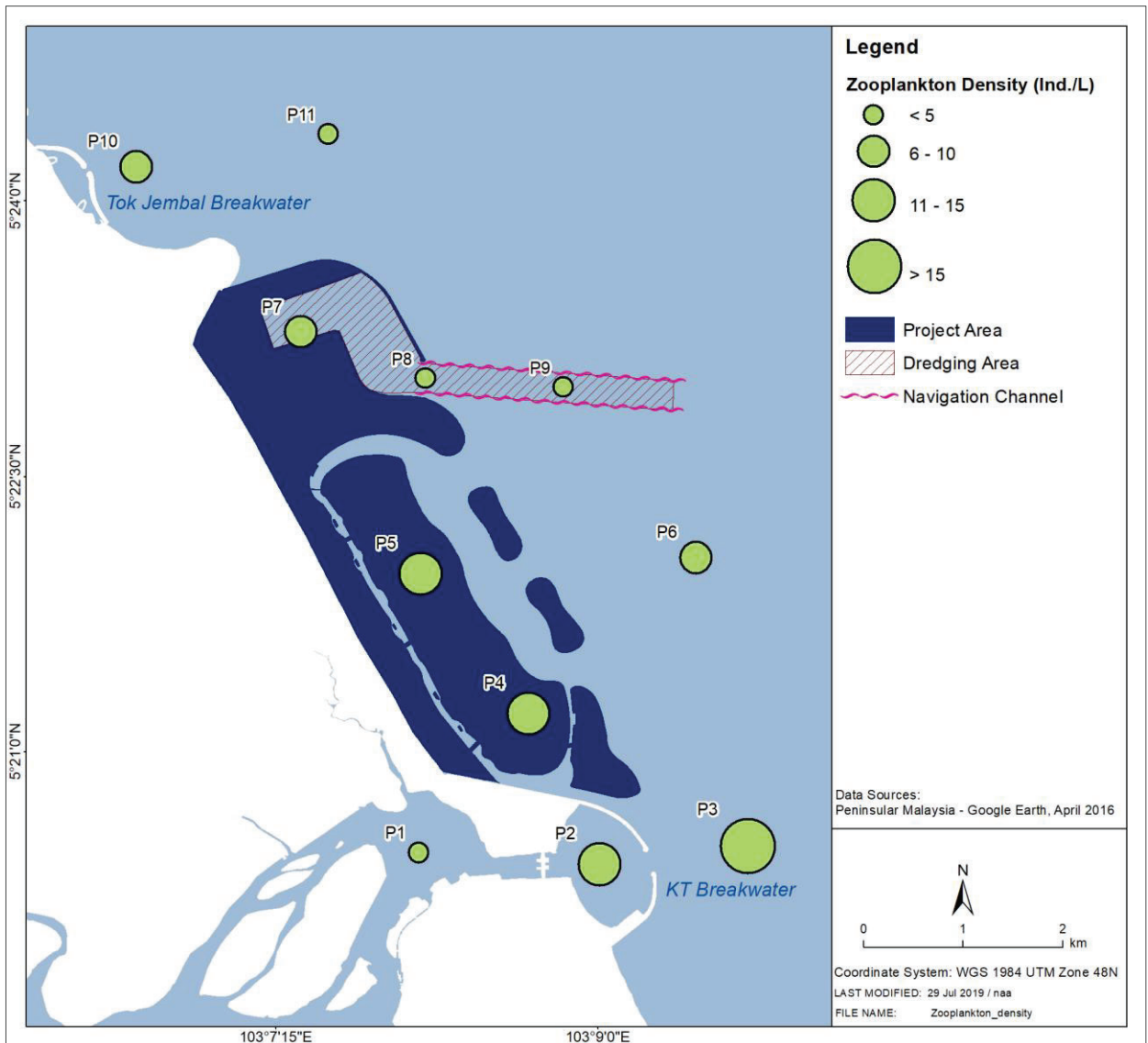


Figure 3.15 Mean zooplankton density (individuals/L) in the study area.

Taxa Composition

A total of eight zooplankton phyla was recorded across all sampling stations, dominated by phylum Arthropoda with 23 genera and seven groups identified up to order level as shown in Table 3.5. All other phyla were represented by less than four genera each.

Among all sampling stations, Station P4 recorded the highest number of taxa (34 taxa) followed by Station P7 (33 taxa). The lowest number of taxa is recorded at Station P9 with 23 taxa. Other than correlation in density, station P1, P2 and P3 also shows similar taxa composition and the composition is less diverse compared to marine stations. Zooplankton from phylum Arthropoda (Class Copepoda) is the dominant zooplankton at all sampling stations (Figure 3.16). This result coincides with other studies within Terengganu waters by Murthi (2005) and Bibi Shaheeda (2003) /17, 18/.

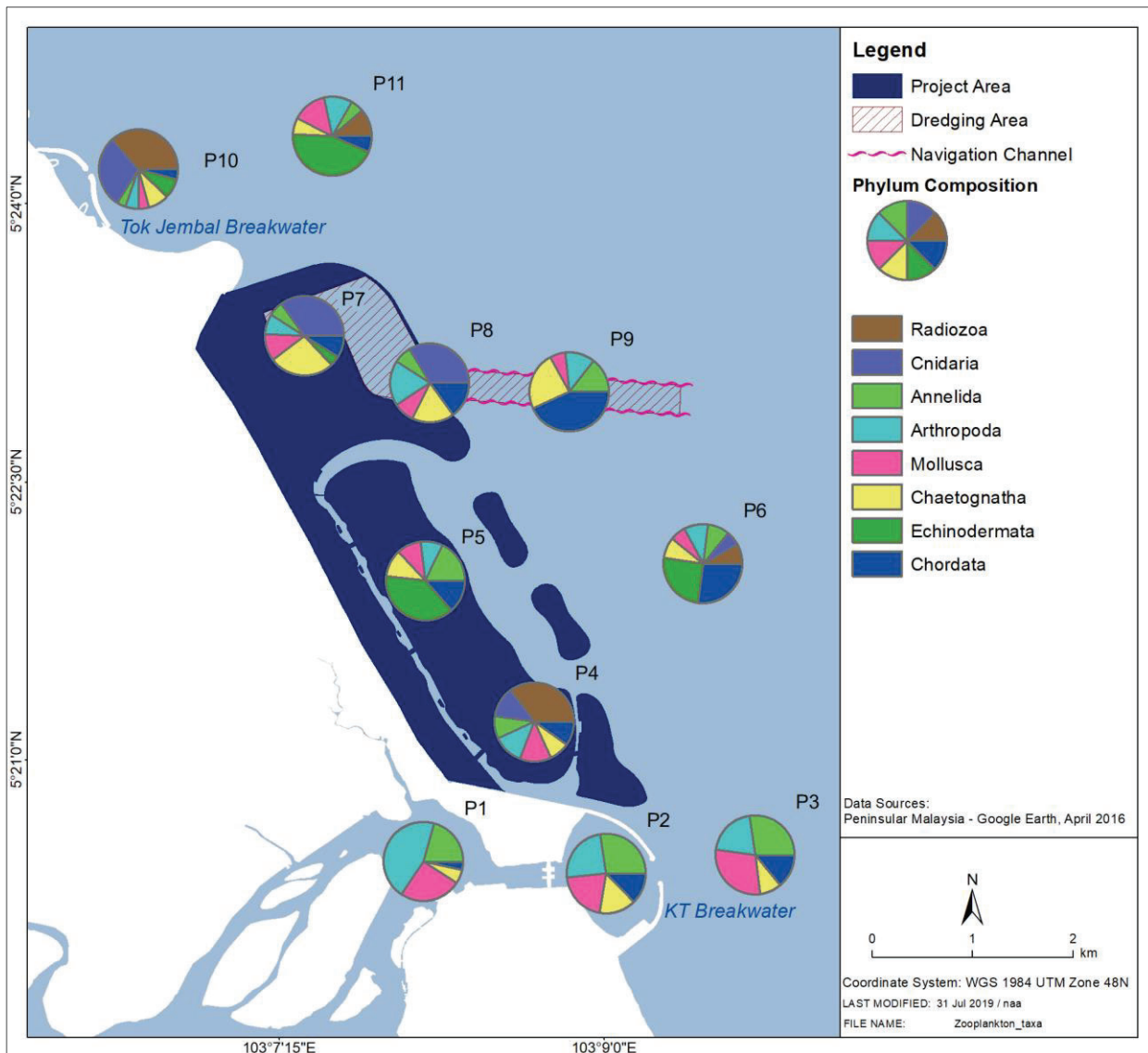


Figure 3.16 Zooplankton phylum composition of study area.

3.3 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. Zoobenthos can be differentiated using two categories; infauna and epifauna. Infauna are animals that live

in sediments (almost all worms and bivalves belong to this category), and epifauna are organisms that live on the surface of bottom sediments which includes crabs and gastropods /19/.

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 /20, 21/. 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 /21/. Due to the impact of Project activities to the habitat, it is necessary to establish the existing status of the benthic communities within the vicinity of the proposed Project.

3.3.1 Survey Methodology

3.3.1.1 Survey Location

Macrobenthos samples were collected using grab sampling of surface sediments at twelve (12) stations taking into account variations in water depths and substrate types (Figure 3.17). The station coordinates are shown in Table 3.6.

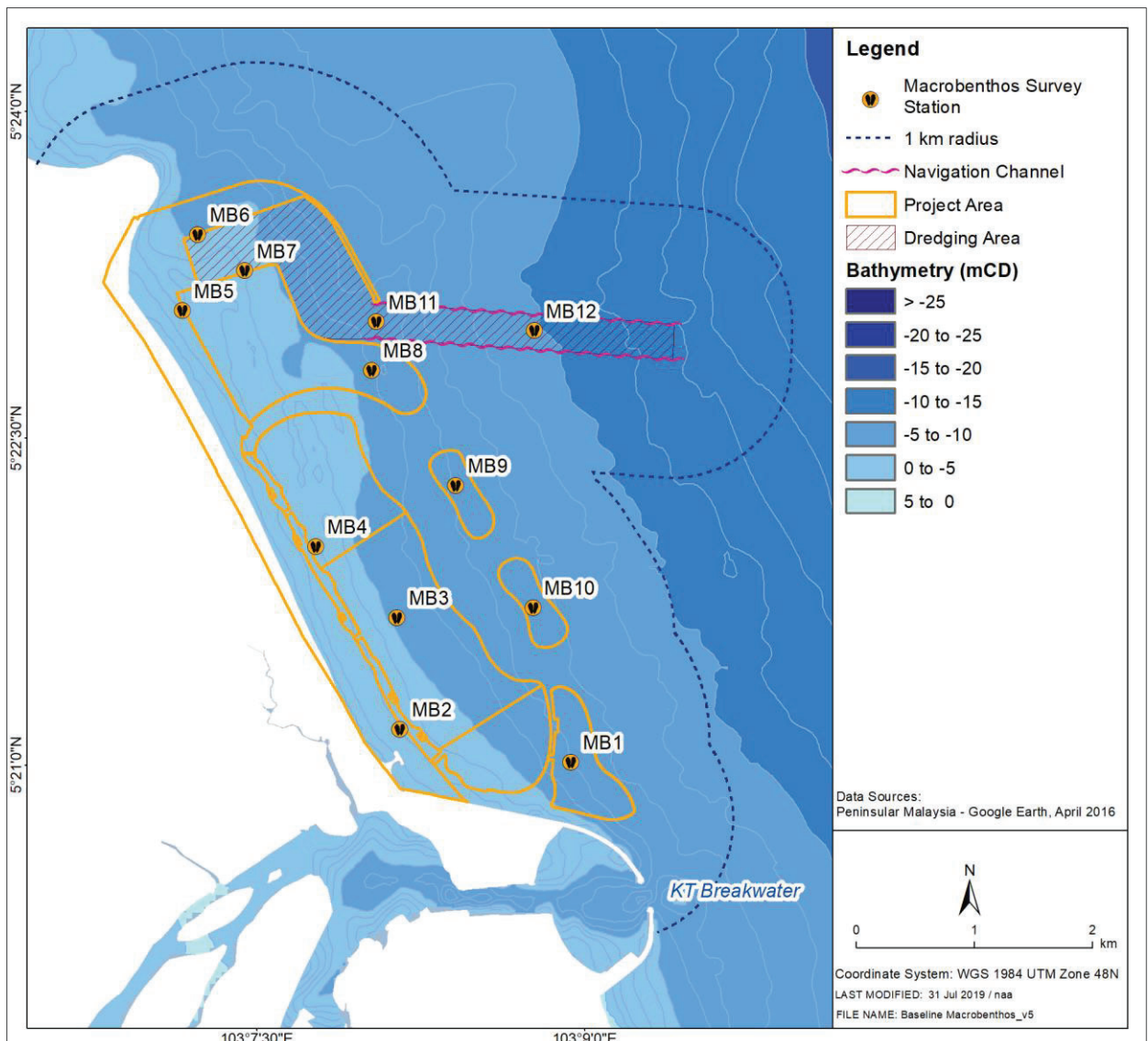


Figure 3.17 Macrobenoths sampling stations.

Table 3.6 Geographical coordinates in decimal degrees of the macrobenthos sampling stations.

Station ID	Longitude (E)	Latitude (N)	Remark	Depth (m)
MB1	103.14892	5.35006	Reclamation Footprint	7
MB2	103.13589	5.35278	Reclamation Footprint	3
MB3	103.13557	5.36099	Reclamation Footprint	5
MB4	103.12950	5.36672	Reclamation Footprint	3
MB5	103.11911	5.38467	Reclamation Footprint	3
MB6	103.12030	5.39054	Reclamation Footprint	5
MB7	103.12395	5.38774	Dredging Area	4
MB8	103.13347	5.38010	Reclamation Footprint	6
MB9	103.14007	5.37124	Reclamation Footprint	7
MB10	103.14598	5.36180	Reclamation Footprint	7
MB11	103.13391	5.38386	Dredging Area	6
MB12	103.14594	5.38310	Dredging Area	10

3.3.1.2 Sampling Method

Two replicate sediment samples were obtained at each station using a Van Veen grab, which takes approximately 0.0297 m² of sediment per grab. Grab sampling is the most common method of collecting seabed samples and semi-quantitative samples of macrobenthos within a short period of time.

The grab was lowered vertically to the seafloor from a stationary boat to retrieve seabed sediment samples (see Photo 3.20 and Figure 3.18). Through this method, approximately 10 cm of seabed sediment was collected. The sediment samples were stored inside plastic containers and preserved in 10% formalin solution before being sent to lab for identification to the lowest taxonomic class.



Photo 3.20 Van Veen Grab Sampler used to retrieve top sediment samples.

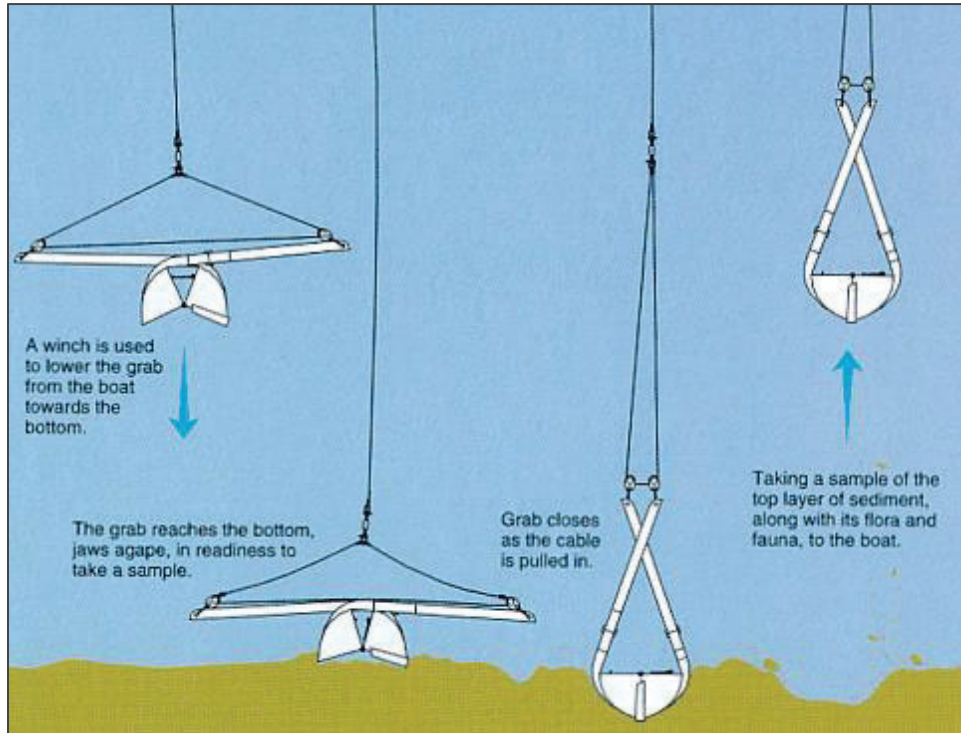


Figure 3.18 Diagrammatic representation of a Grab Sampler used for sediment sample collection

3.3.2 Results

The density, total taxa and diversity index of macrobenthos at the Project area and the concentration of macrobenthos by taxa and station are shown in Table 3.7 and Table 3.8 respectively. Refer to Appendix D for the lab results. Photo 3.21 to Photo 3.30 are photos of identified macrobenthos from the survey.

Table 3.7 Mean density, total taxa, mean diversity index and Pielou's index of two replicates of macrobenthos at surveyed area.

Station	Total Taxa	Mean Density (individuals/m ²)	Mean genus diversity index, H'	Mean Pielou's index, J'
MB1	15	1515.2	1.79	0.68
MB2	15	1026.9	2.09	0.79
MB3	12	1043.8	1.96	0.79
MB4	12	606.1	1.66	0.69
MB5	21	1212.1	2.45	0.82
MB6	7	319.9	1.59	0.89
MB7	5	336.7	1.08	0.78
MB8	15	622.9	2.41	0.91
MB9	18	1296.3	2.07	0.73
MB10	15	1649.8	2.02	0.77

Station	Total Taxa	Mean Density (individuals/m ²)	Mean genus diversity index, H'	Mean Pielou's index, J'
MB11	14	606.1	2.19	0.85
MB12	16	2575.8	2.06	0.74

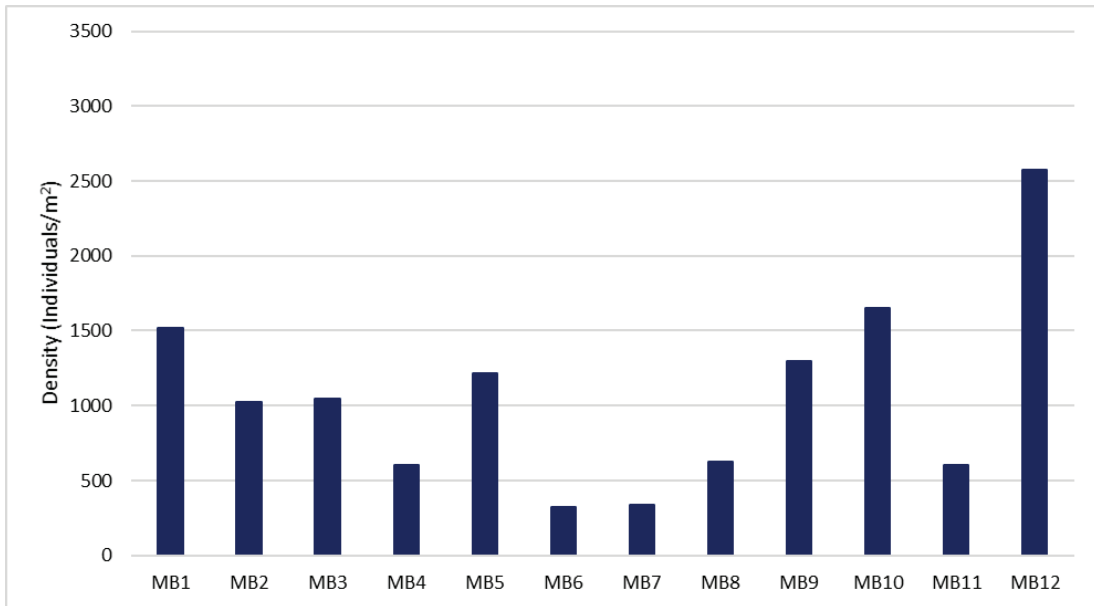


Figure 3.19 Mean macrobenthos density at all station in individuals/m².

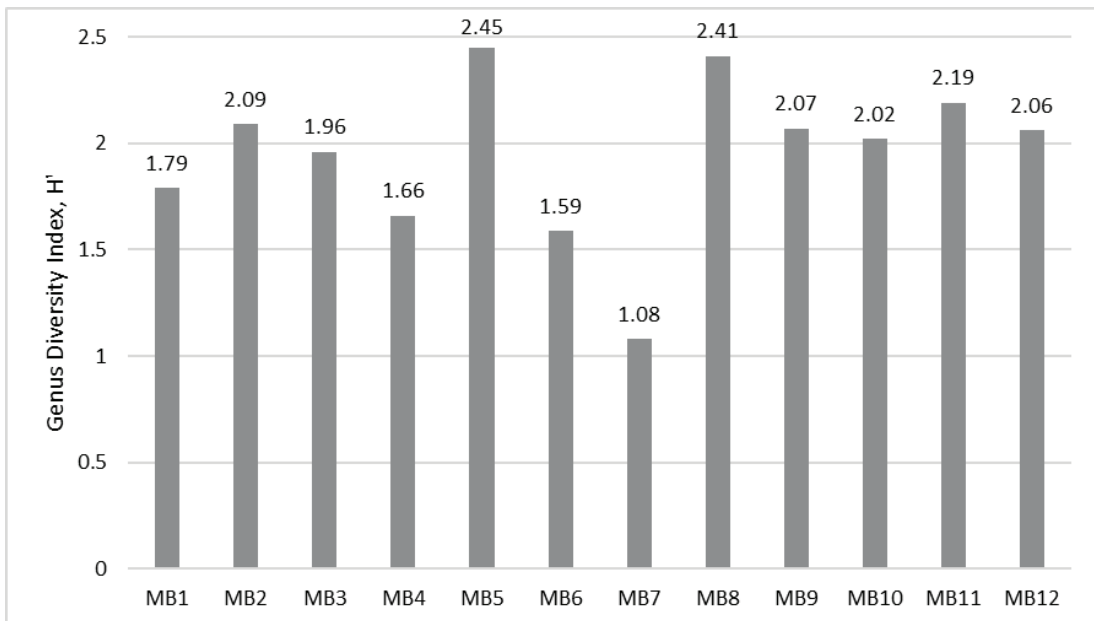


Figure 3.20 Mean genus diversity index for each station.

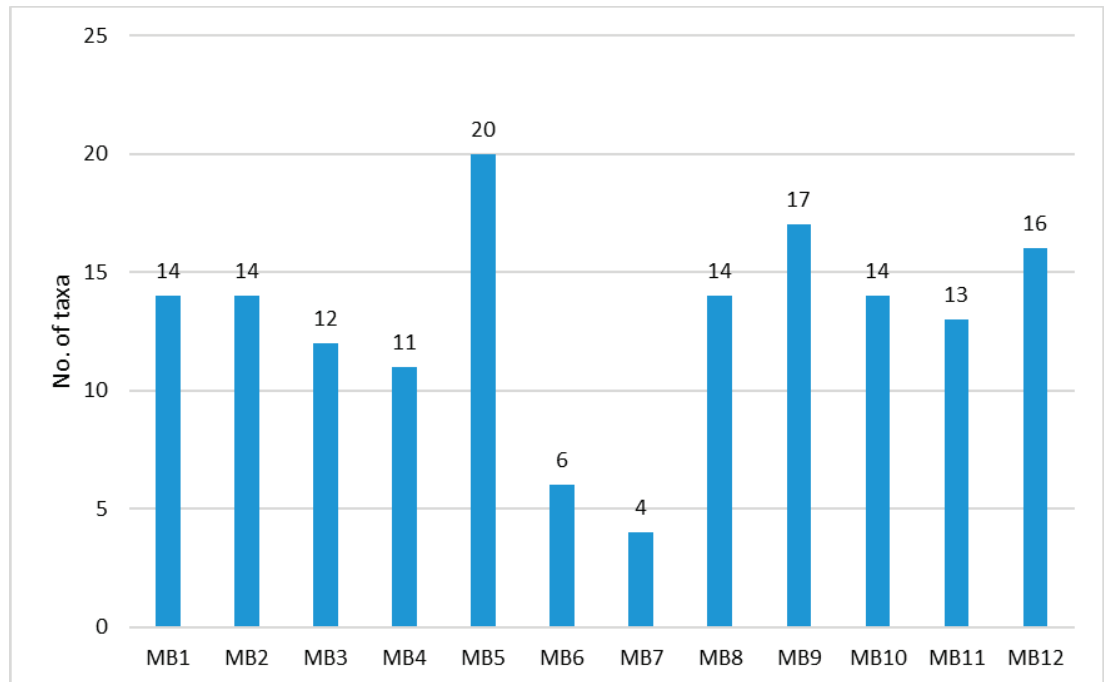


Figure 3.21 Total number of taxa for each station (excluding unidentified species).

Table 3.8 Mean density of macrobenthos in individuals/m² by station and genus.

Phylum	Genus	MB01	MB02	MB03	MB04	MB05	MB06	MB07	MB08	MB09	MB10	MB11	MB12	
Chordata	<i>Branchiostoma</i>	0.0	84.2	16.8	0.0	0.0	16.8	0.0	16.8	16.8	0.0	0.0	0.0	
	<i>Lumbrineris</i>	33.7	16.8	101.0	50.5	16.8	33.7	16.8	0.0	0.0	16.8	0.0	0.0	
Annelidae	<i>Onuphis</i>	0.0	0.0	33.7	0.0	0.0	0.0	0.0	16.8	0.0	33.7	16.8	0.0	
	<i>Glycera</i>	151.5	33.7	67.3	67.3	33.7	33.7	0.0	0.0	33.7	0.0	33.7	0.0	
	<i>Nephtys</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.8	0.0	0.0	0.0	
	<i>Micronephthys</i>	50.5	101.0	185.2	33.7	168.4	84.2	101.0	84.2	101.0	117.8	67.3	0.0	
	<i>Ditrupa</i>	740.7	151.5	235.7	319.9	353.5	84.2	117.8	84.2	505.1	505.1	202.0	993.3	
	<i>Timoclea</i>	0.0	16.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	<i>Tellina</i>	0.0	0.0	0.0	16.8	16.8	0.0	16.8	16.8	33.7	16.8	0.0	33.7	0.0
	<i>Soletellina</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.8	0.0
	<i>Codakia</i>	0.0	16.8	0.0	0.0	16.8	0.0	16.8	0.0	16.8	16.8	0.0	0.0	0.0
	<i>Yoldia</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.8	0.0	0.0	33.7
Mollusca	<i>Cyllichna</i>	16.8	67.3	16.8	16.8	67.3	0.0	0.0	16.8	33.7	269.4	0.0	50.5	
	<i>Gibberula</i>	0.0	16.8	0.0	0.0	16.8	0.0	0.0	16.8	33.7	0.0	0.0	16.8	
	<i>Nassa</i>	0.0	0.0	0.0	0.0	16.8	0.0	0.0	0.0	0.0	0.0	0.0	134.7	
	<i>Vexillum</i>	16.8	0.0	0.0	16.8	33.7	0.0	0.0	50.5	67.3	0.0	0.0	319.9	
	<i>Mitrella</i>	168.4	0.0	0.0	16.8	16.8	0.0	0.0	16.8	0.0	16.8	0.0	202.0	
	<i>Nassarius</i>	0.0	16.8	16.8	16.8	33.7	0.0	0.0	0.0	16.8	16.8	16.8	0.0	
	<i>Conus</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.8	0.0	0.0	0.0	0.0	
	<i>Diodora</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.8
	<i>Glossaulax</i>	16.8	16.8	0.0	0.0	33.7	0.0	0.0	0.0	67.3	16.8	0.0	33.7	67.3

Phylum	Genus	MB01	MB02	MB03	MB04	MB05	MB06	MB07	MB08	MB09	MB10	MB11	MB12
	<i>Heliculus</i>	33.7	0.0	0.0	16.8	84.2	0.0	0.0	0.0	0.0	16.8	16.8	117.8
	<i>Atys</i>	16.8	67.3	16.8	0.0	16.8	0.0	0.0	0.0	16.8	16.8	0.0	50.5
	<i>Terebralia</i>	0.0	0.0	0.0	0.0	33.7	0.0	0.0	0.0	33.7	0.0	33.7	0.0
	<i>Potamides</i>	101.0	0.0	33.7	0.0	50.5	0.0	0.0	0.0	84.2	101.0	33.7	269.4
	<i>Turritella</i>	101.0	370.4	303.0	16.8	134.7	0.0	0.0	16.8	235.7	303.0	50.5	252.5
	<i>Hypermastus</i>	0.0	0.0	0.0	0.0	33.7	0.0	0.0	0.0	0.0	33.7	0.0	0.0
	<i>Dentalium</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.8
	<i>Cavolinia</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	117.8	0.0	16.8
Arthropoda	<i>Athanas</i>	16.8	33.7	16.8	0.0	0.0	0.0	0.0	67.3	0.0	0.0	16.8	0.0
	<i>Alpheus</i>	16.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Echinodermata	Order <i>Clypeastroida</i> Genus 1	0.0	0.0	0.0	0.0	0.0	16.8	0.0	0.0	0.0	0.0	0.0	16.8
	<i>Amphioplus</i>	0.0	0.0	0.0	0.0	16.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified	Unidentified	33.7	16.8	0.0	16.8	16.8	50.5	84.2	101.0	67.3	101.0	67.3	0.0



Photo 3.21 *Athanas* sp.



Photo 3.22 *Branchiostoma* sp.

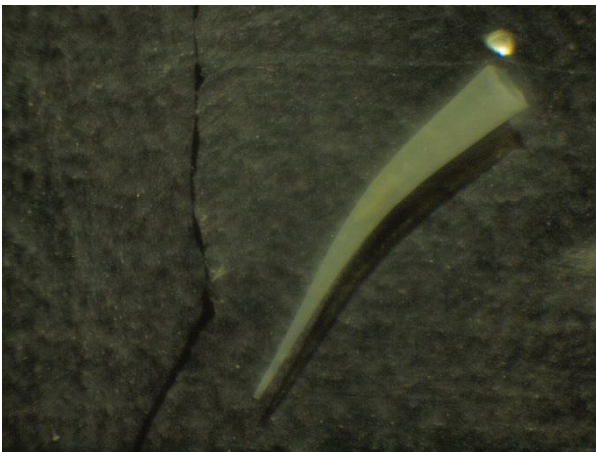


Photo 3.23 *Ditrupa* sp.



Photo 3.24 *Gibberula* sp. A



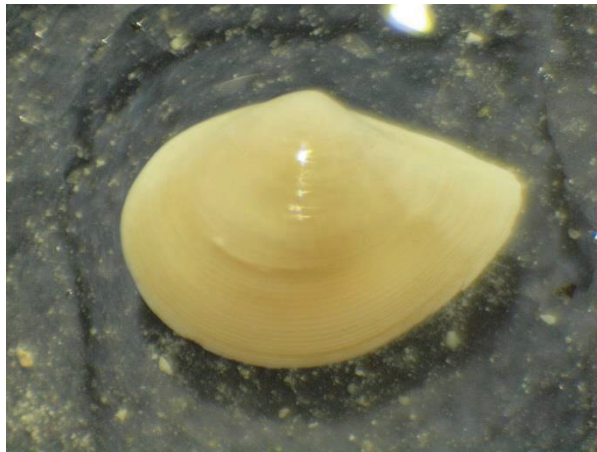
Photo 3.25 *Gibberula* sp. B



Photo 3.26 Unidentified 1



Photo 3.27 Unidentified 2

Photo 3.28 *Vexillum* sp. BPhoto 3.29 *Yoldia* sp. APhoto 3.30 *Yoldia* sp. B

3.3.3 Discussion

3.3.3.1 Abundance and diversity

Macrobenthos density is the highest at Station MB12 with more than 2,500 individuals/m² which comprised mostly of the annelids (Polychaeta), *Ditrupa* sp. Stations with relatively lower density were Station MB6 with 319.87 ± 166.66 individuals/m² and Station MB7 with 336.70 ± 95.23 individuals/m² (Figure 3.19).

A study by Ibrahim *et al.* at P. Karah, Terengganu recorded macrobenthos of ranging from 750 ind./m² to 3000 ind./m² /22/. The study also shows that macrobenthos were more dominant during pre-monsoon season (September to October) as compared to post-monsoon phase (April to May), which also supported by Lotfi *et al.* (1994) paper /23/. The present study which was conducted in September shows nearly similar density range. Another survey in March 2019 at similar stations recorded much higher density ranging from 168 to 16,375 ind./m² /13/.

Similar to the present study, the study by Ibrahim *et al.* revealed dominance of species from Polychaeta class /22/. The macrobenthos density does not shows any significant pattern with difference in depth. This is expected due to the shallow sampling area with less than 10m.

Total number of taxa ranged between 4 and 20 taxa. Station MB5 recorded the highest values of genus diversity index ($H' = 2.45$), followed by MB8 ($H' = 2.41$) (Figure 3.20). The unidentified individuals are not included in the calculation of diversity indices as they are from an unknown

number of taxa. The dominance of *Ditrupa* sp. individuals resulted in the lowest diversity of macrobenthos community at MB7 ($H'=1.08$).

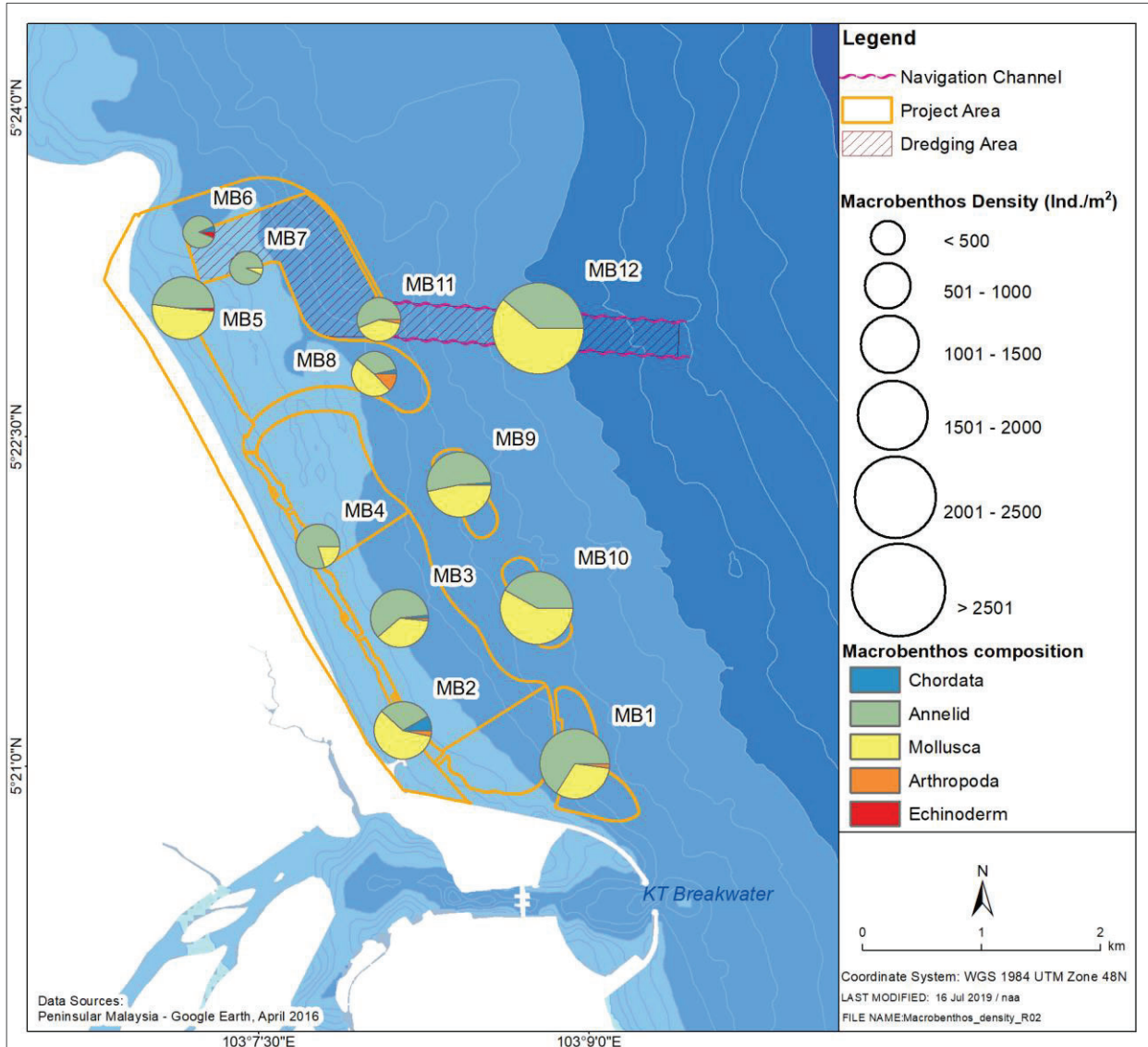


Figure 3.22 Mean macrobenthos density (individuals/m²) in the study area.

3.3.3.2 Taxonomic composition

There was a total of 23 macrobenthos genera identified from the survey, belonging to Chordata (1 genus), Annelida (6 genera), Mollusca (22 genera), Arthropoda (2 genera) and Echinodermata (2 genera) (Figure 3.21). Station MB5 had 15 mollusca genera, the highest number recorded among all stations. Mollusca was present in most of the station except Station MB6 while Annelida was present in all stations. Echinodermata only observed at three stations namely MB5, MB6 and MB12.

Figure 3.23 shows the percent frequency and dominance of the different classes recorded.

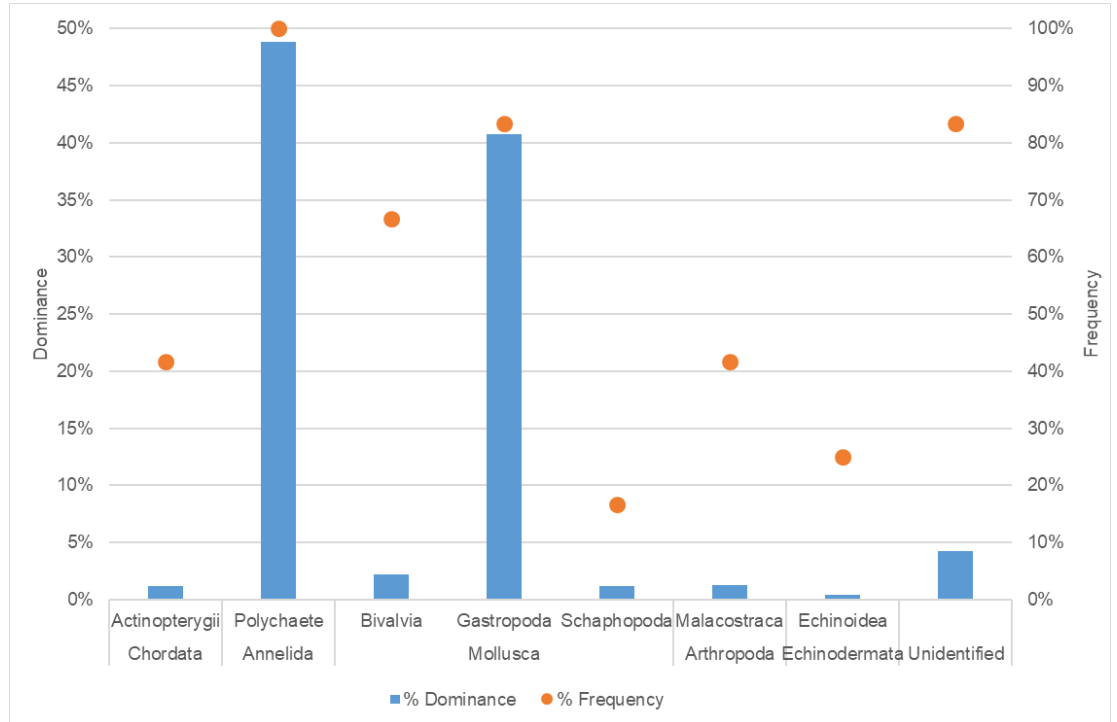


Figure 3.23 Percent dominance and frequency of the classes, including unidentified individuals.

3.4 Mangrove

The nearest mangrove area to the Project site is located inside Sg. Terengganu. The mangrove area was mapped based on satellite imagery. This mapping assessment determined that the only mangrove area within the study area was within a tributary of Sg. Terengganu. Mangroves also occur farther from the project site upstream Sg. Terengganu, where patches of mangrove trees were found scattered along the shoreline of Kuala Terengganu, P. Wan Man, P. Duyong and P. Pasir. Based on ground observation, most of it comprised of nipah trees.

3.4.1 Survey Methodology

3.4.1.1 Ground Truthing

Ground truthing was carried out at selected points along the mangrove area. Since the river was inaccessible by boat due to the size and depth of the river, general observations such as dominant species, signs of disturbance and so forth were only carried in the back mangrove areas. Back mangrove observation was carried out at seven locations as shown in Figure 3.24 and the corresponding coordinates are shown in Table 3.9.

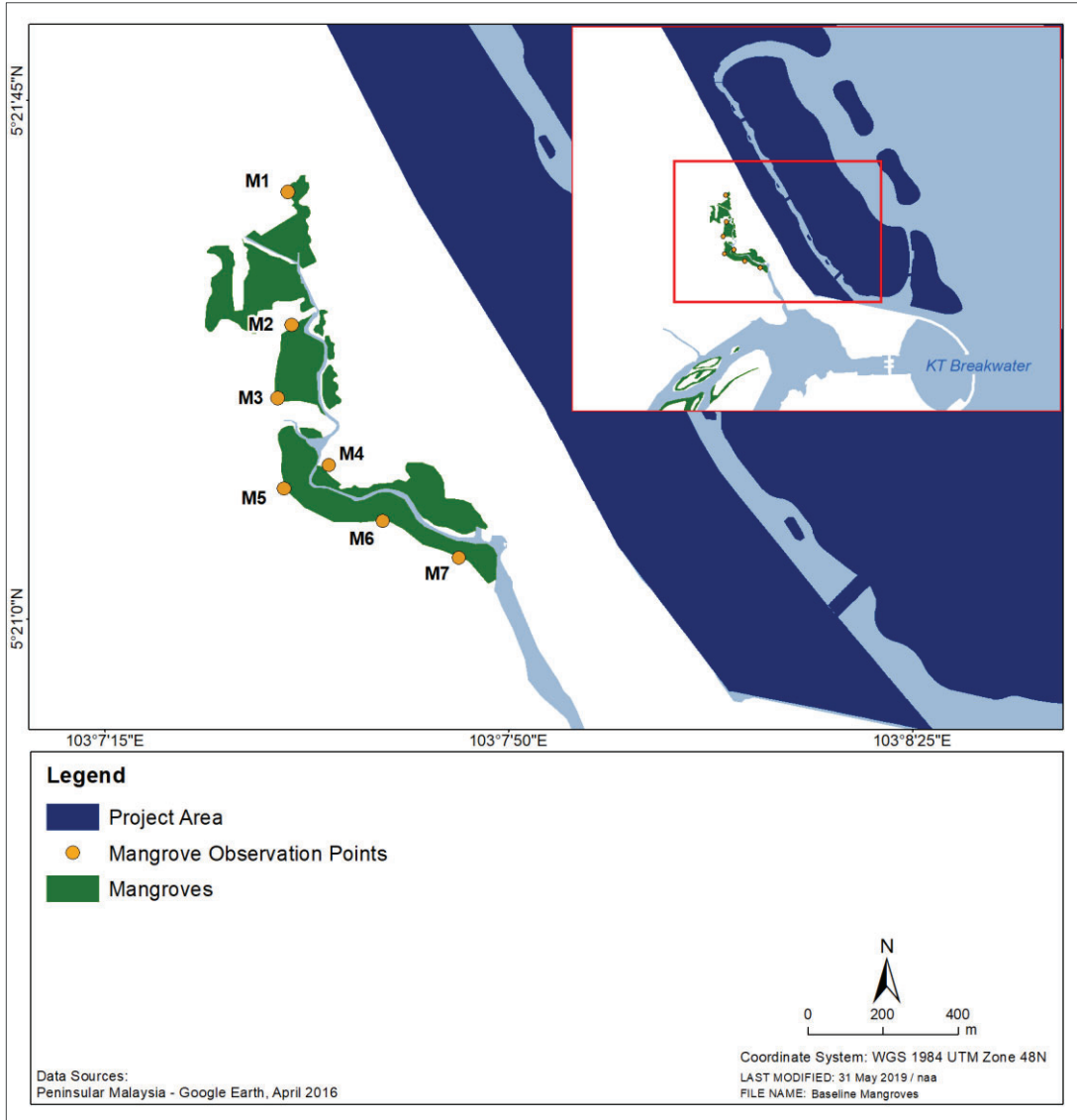


Figure 3.24 Back mangrove observation points.

Table 3.9 Coordinates of the mangrove observation points.

Station	Longitude (°E)	Latitude (° N)
M1	103.125231	5.360318
M2	103.125328	5.357103
M3	103.124988	5.355338
M4	103.126234	5.353711
M5	103.125162	5.353153
M6	103.127536	5.352373
M7	103.129382	5.351484

3.4.2 Results

At station M1, the dominant mangrove species is nipah (*Nypa fruticans*). A few back mangrove species such as *Acrostichum aureum*, a mangrove fern also locally known as piai raya, and mangrove associate, *Glochidion littorale* (Photo 3.31) were also observed in this area. The vegetation here seemed to be disturbed with signs of trees being chopped off. Other than mangrove plants, monitor lizards (Photo 3.32) were also observed at this station.

Further down the river, mangrove vegetation at stations M2 and M3 were similar. Dominated by nipah, the cover was dense at both sites with 70% of the area covered by mangrove vegetation. Frequently seen among nipah trees were the piai raya plants and occasionally sea hibiscus (*Hibiscus tiliaceus*). At station M2, *Sonneratia* sp. trees and creepers were observed among the nipah and piai raya trees. Meanwhile, the mangrove vegetation at station M3 seemed to be disturbed as well with signs of trees being chopped off. Fauna observed at station M3 included kingfisher (Photo 3.33), water monitor lizard as shown in Photo 3.32 (*Varanus salvator*) and hornets.

At station M4, nipah and *Sonneratia caseolaris* (locally known as berembang) are co-dominant species (Photo 3.34). At station M5, nipah trees are dominant. Similar to stations M2 and M3, some of the trees at these stations (M4 and M5) seemed to be chopped off as well (Photo 3.35).

Further downstream, station M6 is located near a residential area. The mangrove species found mostly here are nipah trees which is the same at station M7. Among the fauna observed here were crocodile and wild boar.



Photo 3.31 *Glochidion littorale* near station M1.



Photo 3.32 Water monitor lizard, *Varanus salvator* (in yellow circle) found near station M1 (top) and M3 (bottom).