T6.11 Baseline water quality results (spring tide) (cont'd)

Parameter	Unit	WQ3 (Estuarine)		WQ4 (Estuarine)	WQ7 (Marine)		WQ13 (Marine)	
		Ebbing	Flooding	Flooding	Ebbing	Flooding	Ebbing	Flooding
		Surface	Surface	Surface	Surface	Surface	Surface	Surface
pH		7.86	7.57	8.72	8	7.79	8.02	7.9
Temperature	°C	29.2	28.9	27.3	30.6	29.2	30.2	28.8
DO	mg/L	1.6	1.4	5.4	2.8	1.4	1.4	1.1
Salinity	ppt	1.84	15.06	0.04	4.48	4.25	1.88	2.96
Conductivity	uS/cm	3,808	24,906	81.6	8,152	7,753	3,598	551
Turbidity	NTU	6	6	4	4	6	5	6
TSS	mg/L	17	19	6	13	14	10	15
COD		20	14	15	18	19	18	13
BOD		7	5	5	7	7	6	6
Oil & Grease		<1	<1	<1	<1	<1	<1	<1
TOC		2.5	0.7	0.8	2.8	2.7	0.7	0.4
Chlorophyll-A		<0.5	0.7	<0.5	<0.5	<0.5	<0.5	0.6
Ammoniacal Nitrogen (NH_3.N)		0.01	0.05	0.33	0.03	0.23	0.05	0.11
Nitrate		0.91	0.22	0.27	2.86	0.17	2.43	0.46
Phosphate		0.27	0.34	9.29	0.43	0.04	0.48	0.33
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002
Arsenic (As*)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead (Pb)		<0.001	<0.001	<0.001	0.002	0.001	<0.001	<0.001
Copper (Cu)		<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.001
Manganese (Mn)		0.022	0.030	0.005	0.103	0.138	0.076	0.047
Nickel (Ni)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010
Iron (Fe)		0.26	0.17	0.12	1.04	0.66	0.58	0.71
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1	<1
Faecal Coliform		1,700	7,200	6,100	79,000	900	69,000	135,000

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.12 Baseline water quality results (neap tide)

Parameter	Unit	WQ1 (Marine)						WQ2 (Marine)					
		Ebbing (27.0 m)			Flooding (25.9 m)			Ebbing (19.0 m)			Flooding (19.1 m)		
		Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom
pH		8.57	8.52	8.47	8.60	8.55	8.55	8.52	8.55	8.53	8.53	8.47	8.51
Temperature	°C	30.0	29.7	29.7	30.0	29.7	29.6	30.2	29.6	29.6	30.0	29.3	29.5
DO	mg/L	4.71	5.01	4.41	5.11	5.02	4.70	4.91	5.28	5.61	5.27	4.44	5.15
Salinity	ppt	31.92	32.03	32.05	31.93	31.97	32.06	31.94	31.90	32.02	31.92	32.25	31.91
Conductivity	uS/cm	49,087	49,216	49,248	49,103	49,124	49,255	49,110	49,044	49,179	49,083	49,505	49,036
Turbidity	NTU	1	4	8	1	1	11	<1	<1	<1	<1	<1	5
TSS	mg/L	10	12	16	8	10	20	7	6	6	9	7	15
COD		16	18	20	18	17	16	19	19	15	15	16	17
BOD		4	6	8	5	4	4	8	7	4	4	4	5
Oil & Grease		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
TOC		0.4	0.3	0.4	0.1	0.5	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Chlorophyll-A		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3.N)		0.08	0.10	0.36	0.08	0.12	0.09	0.08	0.09	0.10	0.20	0.07	0.11
Nitrate		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05
Phosphate		<0.01	0.02	0.022	<0.01	0.01	0.02	0.12	0.02	0.02	0.01	0.02	0.02
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As*)		0.003	0.002	0.003	0.002	0.001	0.001	0.003	0.001	0.001	0.002	0.001	0.002
Lead (Pb)		<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.015	<0.001
Manganese (Mn)		0.001	0.004	0.019	<0.001	0.002	0.013	<0.001	<0.001	<0.001	<0.001	0.002	0.011
Nickel (Ni)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron (Fe)		0.03	0.16	0.30	0.16	0.15	0.33	0.09	0.07	0.03	0.14	0.11	0.22
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Faecal Coliform		<1	2,000	400	500	74,000	1,100	<1	4,500	700	<1	<1	200

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.12 Baseline water quality results (neap tide) (cont'd)

Parameter	Unit	WQ5 (Marine)		WQ6 (Marine)		WQ8 (Marine)					
		Ebbing (1.8 m)	Flooding (1.6 m)	Ebbing (1.2 m)	Flooding (0.9 m)	Ebbing (7.2 m)			Flooding (7.0 m)		
		Surface	Surface	Surface	Surface	Surface	Middle	Bottom	Surface	Middle	Bottom
pH		8.61	8.72	8.86	8.56	8.69	8.65	8.64	8.07	8.34	8.31
Temperature	°C	31.3	29.7	32.0	29.4	30.5	30.1	30.0	29.4	29.6	29.7
DO	mg/L	6.63	5.62	8.90	5.55	6.94	6.32	6.11	5.28	4.70	5.11
Salinity	ppt	31.25	31.26	30.11	28.53	31.36	31.56	31.61	30.86	31.05	31.08
Conductivity	uS/cm	48,221	48,207	46,691	44,380	48,346	48,595	48,639	47,592	47,868	47,916
Turbidity	NTU	1	1	4	23	<1	4	1	2	2	1
TSS	mg/L	8	9	13	11	5	14	9	10	11	10
COD		16	14	18	16	15	16	15	18	16	17
BOD		4	4	4	5	7	7	8	8	7	7
Oil & Grease		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
TOC		0.9	1.0	1.5	1.2	0.7	0.7	1.0	0.9	1.1	1.2
Chlorophyll-A		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3.N)		0.15	0.10	0.33	0.34	0.12	0.09	0.14	0.14	0.47	0.39
Nitrate		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.001	<0.01	<0.01	<0.01
Phosphate		0.04	0.03	0.06	0.08	0.02	0.03	0.02	0.05	0.03	0.03
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As*)		0.003	0.001	<0.001	0.002	0.002	0.002	0.001	0.002	0.001	0.002
Lead (Pb)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)		0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001
Manganese (Mn)		0.007	0.007	0.005	0.017	0.003	0.003	0.017	0.006	0.009	0.007
Nickel (Ni)		0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
Iron (Fe)		0.08	0.03	0.10	0.25	0.03	0.08	0.17	0.07	0.06	0.08
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Faecal Coliform		4,600	62,00	100	2,600	3,400	3,600	600	70	1,000	57,000

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.12 Baseline water quality results (neap tide) (cont'd)

Parameter	Unit	WQ9 (Marine)						WQ10 (Marine)	
		Ebbing (10.2 m)			Flooding (11.0 m)			Ebbing (3.5 m)	Flooding (3.6 m)
		Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Surface
pH		8.57	8.55	8.58	8.44	8.54	8.49	8.73	8.53
Temperature	°C	29.6	29.6	29.7	29.6	29.7	29.6	30.8	29.6
DO	mg/L	5.65	5.61	5.57	5.10	5.22	5.10	6.56	4.58
Salinity	ppt	31.22	31.21	31.22	31.22	31.23	31.22	31.44	31.26
Conductivity	uS/cm	48,090	48,088	48,110	48,095	48,121	48,100	48,474	48,164
Turbidity	NTU	1	<1	<1	<1	2	2	1	3
TSS	mg/L	7	5	7	8	10	9	8	11
COD		20	18	18	12	14	13	16	17
BOD		7	7	7	4	5	4	4	4
Oil & Grease		<1	<1	<1	<1	<1	<1	<1	<1
TOC		0.4	0.5	1.0	0.3	0.7	0.3	0.5	0.4
Chlorophyll-A		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3.N)		0.08	0.13	0.14	0.09	0.18	0.09	0.13	0.31
Nitrate		<0.01	<0.01	<0.01	0.08	<0.01	<0.01	<0.01	<0.01
Phosphate		0.01	0.01	0.03	0.03	0.01	0.01	0.02	0.02
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As*)		0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Lead (Pb)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese (Mn)		0.002	0.003	0.003	<0.001	0.004	0.005	0.003	0.008
Nickel (Ni)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron (Fe)		0.07	0.07	0.10	0.02	0.11	0.08	0.17	0.17
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1	<1	<1
Faecal Coliform		500	<1	100	<1	3,200	400	100	300

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.12 Baseline water quality results (neap tide) (cont'd)

Parameter	Unit	WQ11 (Marine)						WQ12 (Marine)					
		Ebbing (9.1 m)			Flooding (9.3 m)			Ebbing (6.4 m)			Flooding (5.7 m)		
		Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom
pH		8.62	8.62	8.61	8.66	8.63	8.64	8.62	8.62	8.61	8.66	8.63	8.64
Temperature	°C	30	30.0	30.0	30.0	29.9	29.9	30	30.0	30.0	30.0	29.9	29.9
DO	mg/L	5.86	5.47	5.56	5.46	5.93	5.86	5.86	5.47	5.56	5.46	5.93	5.86
Salinity	ppt	31.77	31.74	31.78	31.75	31.77	31.82	31.77	31.74	31.78	31.75	31.77	31.82
Conductivity	uS/cm	48,875	48,828	48,887	48,851	48,881	48,936	48,875	48,828	48,887	48,851	48,881	48,936
Turbidity	NTU	<1	<1	1	1	<1	1	<1	<1	1	1	<1	1
TSS	mg/L	6	6	7	10	7	10	6	6	7	10	7	10
COD		16	15	16	16	15	14	16	15	16	16	15	14
BOD		4	4	4	4	4	4	4	4	4	4	4	4
Oil & Grease		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
TOC		0.2	0.4	0.5	0.4	0.4	0.3	0.2	0.4	0.5	0.4	0.4	0.3
Chlorophyll-A		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3.N)		0.08	0.14	0.11	0.08	0.08	0.09	0.08	0.14	0.11	0.08	0.08	0.09
Nitrate		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphate		<0.01	0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.01	<0.01	<0.01	0.02	<0.01
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As*)		0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.002	0.001	0.002
Lead (Pb)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese (Mn)		0.001	0.001	0.002	0.002	<0.001	0.001	0.001	0.001	0.002	0.002	<0.001	0.001
Nickel (Ni)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron (Fe)		0.06	0.04	0.06	0.11	0.09	0.07	0.06	0.04	0.06	0.11	0.09	0.07
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Faecal Coliform		<1	2,200	5,900	<1	6,000	400	<1	2,200	5,900	<1	6,000	400

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.12 Baseline water quality results (neap tide) (cont'd)

Parameter	Unit	WQ14 (Marine)		WQ15 (Marine)			
		Ebbing (0.6 m)	Flooding (1.0 m)	Ebbing (3.5 m)		Flooding (4.2 m)	
		Surface	Surface	Surface	Bottom	Surface	Bottom
pH		8.53	8.56	8.59	8.58	8.57	8.57
Temperature	°C	31.3	34.0	30.7	30.7	30.8	30.7
DO	mg/L	4.49	5.37	6.01	5.16	6.26	6.2
Salinity	ppt	28.89	30.00	30.78	30.77	30.76	30.76
Conductivity	uS/cm	45,056	46,593	47,532	45,723	47,634	47,504
Turbidity	NTU	40	40	2	3	3	3
TSS	mg/L	26	26	8	13	4	14
COD		18	20	15	16	13	16
BOD		6	7	5	5	4	5
Oil & Grease		<1	<1	<1	<1	<1	<1
TOC		0.9	0.8	0.2	0.6	0.3	0.6
Chlorophyll-A		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3.N)		0.51	0.60	0.25	0.23	0.48	0.48
Nitrate		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphate		0.30	0.24	0.03	0.04	0.03	0.04
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As*)		0.002	0.002	0.002	0.002	0.002	0.002
Lead (Pb)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese (Mn)		0.028	0.030	0.003	0.003	0.003	0.004
Nickel (Ni)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron (Fe)		0.01	0.01	0.03	0.03	0.06	0.02
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1
Faecal Coliform		400	900	2,400	600	500	<1

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.12 Baseline water quality results (neap tide) (cont'd)

Parameter	Unit	WQ16 (Marine)				WQ17 (Marine)				WQ18 (Marine)	
		Ebbing (4.2 m)		Flooding (4.0 m)		Ebbing (4.2 m)		Flooding (4.0 m)		Ebbing (3.8 m)	Flooding (3.9 m)
		Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Surface
pH		8.69	8.70	8.67	8.68	8.31	8.42	8.50	8.55	8.70	8.41
Temperature	°C	30.6	30.6	30.6	30.6	30.5	30.5	30.3	30.2	32.0	31.4
DO	mg/L	7.05	7.10	7.08	7.3	6.66	6.67	6.01	6.06	11.0	7.1
Salinity	ppt	30.56	30.56	30.50	30.58	30.58	30.62	30.61	30.65	27.54	27.68
Conductivity	uS/cm	46,763	47,237	47,540	47,235	47,288	47,312	47,915	47,862	43,112	43,274
Turbidity	NTU	3	3	3	2	3	2	3	3	12	9
TSS	mg/L	14	4	3	11	5	14	13	5	6	4
COD		17	12	11	12	10	10	13	13	12	10
BOD		5	4	3	4	3	3	4	4	4	3
Oil & Grease		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
TOC		0.5	1.1	0.4	0.9	0.5	0.9	0.3	0.4	1.2	0.6
Chlorophyll-A		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3.N)		0.54	0.48	0.42	0.46	0.46	0.52	0.61	0.32	0.29	0.22
Nitrate		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphate		0.04	0.04	0.03	0.04	0.04	0.05	0.04	0.06	0.04	0.05
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As*)		0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Lead (Pb)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.004
Copper (Cu)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002
Manganese (Mn)		0.005	0.005	0.004	0.004	0.002	0.003	0.003	0.003	0.009	0.010
Nickel (Ni)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002
Iron (Fe)		0.04	0.02	0.02	0.02	0.02	0.06	0.05	0.04	0.15	0.21
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Faecal Coliform		<1	<1	<1	<1	<1	<1	700	<1	<1	<1

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.12 Baseline water quality results (neap tide) (cont'd)

Parameter	Unit	WQ3 (Estuarine)		WQ4 (Estuarine)	WQ7 (Marine)		WQ13 (Marine)	
		Ebbing	Flooding	Flooding	Ebbing	Flooding	Ebbing	Flooding
		Surface	Surface	Surface	Surface	Surface	Surface	Surface
pH		7.85	7.02	8.74	8.05	8.49	7.13	7.25
Temperature	°C	30.1	28.7	26.2	30	27.3	30.3	28.2
DO	mg/L	2.40	1.22	5.10	2.3	1.5	0.96	0.46
Salinity	ppt	1.24	20.23	0.03	0.79	0.26	5.53	7.76
Conductivity	uS/cm	2,667	32,531	74.1	1,587	549	9,908	13,518
Turbidity	NTU	37	3	2	43	43	37	4
TSS	mg/L	34	46	6	42	54	34	26
COD		14	54	64	18	18	29	34
BOD		4	18	19	9	6	9	9
Oil & Grease		<1	<1	<1	<1	<1	<1	<1
TOC		7.9	6.5	0.7	5.0	3.9	4.7	3.3
Chlorophyll-A		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3.N)		3.18	7.00	0.07	1.16	0.06	4.32	5.15
Nitrate		<0.01	<0.01	1.11	2.27	<0.01	<0.01	1.71
Phosphate		6.11	6.21	0.19	0.88	0.13	1.40	2.46
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As*)		0.003	0.002	<0.001	0.007	0.006	0.002	0.001
Lead (Pb)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)		0.009	0.004	<0.001	<0.001	<0.001	0.015	0.003
Manganese (Mn)		0.037	0.035	0.007	0.077	0.066	0.042	0.028
Nickel (Ni)		<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.002
Iron (Fe)		0.69	0.45	0.15	1.00	1.21	0.64	0.55
E. coli	cfu/100 ml	27,000	44,000	<1	1,100	3,300	14,900	50,000
Faecal Coliform		79,000	660,000	57,000	25,000	114,000	420,000	1,140,000

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.13 Malaysia Marine Water Quality Criteria and Standard (MWQCS)

Parameter	Class 1	Class 2	Class 3	Class E
Beneficial Uses	Preservation, marine protected areas, marine parks	Marine life, fisheries, coral reefs, recreational and mariculture	Ports, oil & gas fields	Mangroves estuarine and river-mouth water
Temperature (˚C)	≤ 2°C increase over maximum ambient	≤ 2°C increase over maximum ambient	≤ 2°C increase over maximum ambient	≤ 2°C increase over maximum ambient
Dissolved Oxygen (mg/L)	>80% saturation	5	3	4
Total suspended solids (mg/L)	25 mg/L or ≤ 10% increase in seasonal average, whichever is lower	50 mg/L (25 mg/L) or ≤ 10% increase in seasonal average, whichever is lower	100 mg/L or ≤ 10% increase in seasonal average, whichever is lower	100 mg/L or ≤ 30 % increase in seasonal average, whichever is lower
Oil and grease (mg/L)	0.01	0.14	5	0.14
Mercury* (µg/L)	0.04	0.16 (0.04)	50	0.5
Cadmium (µg/L)	0.5	2 (3)	10	2
Chromium (VI) (µg/L)	5	10	48	10
Copper (µg/L)	1.3	2.9	10	2.9
Arsenic (III)* (µg/L)	3	20 (3)	50	20 (3)
Lead (µg/L)	4.4	8.5	50	8.5
Zinc (µg/L)	15	50	100	50
Cyanide (µg/L)	2	7	20	7
Ammonia (unionised) (µg/L)	35	70	320	70
Nitrite (NO_2) (µg/L)	10	55	1000	55
Nitrate (NO_3) (µg/L)	10	60	1000	60
Phosphate (µg/L)	5	75	670	75
Phenol (µg/L)	1	10	100	10
Tributyltin (TBT) (µg/L)	0.001	0.01	0.05	0.01
Fecal coliform (Human health protection for seafood consumption) – Most Probable Number (MPN)	70 faecal coliform 100mL-1	100 faecal coliform 100mL-1 and (70 faecal coliform 100mL-1)	200 faecal coliform 100mL-1	100 faecal coliform 100 mL-1 and (70 faecal coliform 100mL-1)
Polycyclic Aromatic Hydrocarbon (PAHs) ng/g	100	200	1,000	1,000

6.2.7.3 Discussions

The discussion for the water quality results shall be done according to the results and findings relating to marine water and estuarine water.

6.2.7.3.1 Marine Water

Water quality at the coastal region was moderate, but not exactly pristine. DO levels generally remain between 4 to 6 mg/L throughout. Nutrients such as ammoniacal nitrogen (NH_3-N), nitrate-nitrogen (NO_3-N) and phosphate were detected at WQ1 (near Pulau Kendi) and WQ2, albeit still at low levels and only during spring tide. NH_3-N levels were less than 0.5 mg/L, NO_3-N less than 1.5 mg/L and phosphate less than 0.5 mg/L. These imply sufficient dispersion although at these levels, the risk of algae blooms was still present. Faecal coliform here was also elevated particularly during spring tide, reaching as high as 600,000 cfu/100 mL.

Similar circumstances were also seen at WQ10, WQ11, WQ12, WQ15, WQ16 and WQ17 as NO_3-N went up to 4.76 mg/L (WQ11). Levels of NH_3-N and phosphate however were slightly lower, not exceeding 0.7 mg/L for either parameter. Faecal coliform levels also dissipated, albeit only slightly and still remained unsuitable for body contact.

The elevated NO_3-N trend was also apparent at WQ8 and WQ9, particularly during spring tide, reaching almost as high as 3.7 mg/L. Phosphate did not exceed 0.5 mg/L. During neap tide, the levels again dissipated.

Although *E. coli* was undetected, the faecal coliform count still remained in the thousands. Hence the coastal region can be deemed as unsuitable for body contact activities.

Turbidity measurements were made *in situ*. The readings at the rest of the stations are considerably low with suspended solids values below 25 mg/L.

The oil and grease (O&G) parameter indicates the oil level present in the water body. If it is present in substantial amounts (at greater than about 10 mg/L), it will form a layer on the water surface. This may cause several impacts such as reducing the ability of oxygen dissolution into water which is harmful to aquatic life. The O&G levels recorded in the surrounding waters at the Project area showed concentrations at less than 1 mg/L at all stations. The values are all similar at all depths during spring and neap tides.

Iron has no stated limit in MWQCS. There is no particular pattern of the heavy metals concentration within the water column, signifying that the metals are of background concentrations in sea water and not due to any localised sources.

6.2.7.3.2 Estuarine Water

The water quality at the estuarine of Sungai Gertak Sanggul (WQ3) was not exactly pristine, although some local fishermen still cast their nets here to catch fish bait. While the water was clear (reflected by the low turbidity during neap and spring tides), there were instances when organic parameters such as BOD, NH_3-N and phosphate increased, particularly during neap tide. BOD here went as high as 18 mg/L, whereas NH_3-N was between 3.18 to 7.00 mg/L. The elevated organics translated to low DO; of less than 2.5 mg/L during all tidal cycles. The contamination was likely due to organic (potentially sewage) contribution from surrounding sources. This was reflected by the high *E. coli* count of between 27,000 to 44,000 cfu/100

mL, which was also in tandem with high presence of faecal coliform. Such circumstances are decidedly unsuitable for body contact. There is even a pig farm in the vicinity.

It is also to be noted that most pollutants dissipated during spring tide (except faecal coliform which still remained unsuitable for body contact). The pollutants likely dispersed to the coastal region.

This may be a cause for concern, as the flushing of pollutants could be disrupted by the presence of the proposed development. There is even potential for accumulation along the strait if the water becomes stagnant (e.g. intertidal). Build-up of nutrients, such as NH_3-N, NO3-N and phosphate presents the risk of algae blooms and even eutrophication, with nitrogen species being the limiting nutrient for marine environments. This potential impact needs to be mitigated by ensuring the hydrodynamics of the region is not impeded due to the presence of the islands.

Similar observations were also apparent for Sungai Gemuruh (station WQ4) although these were not as bad as Sungai Gertak Sanggul. BOD (19 mg/L) and faecal coliform (57,000 cfu/100 mL) were high during neap tide but dissipated during spring tide. Phosphate on the other hand, increased during spring tide, being up to 9.29 mg/L. Local fishermen were also observed casting nets to catch fish bait here.

The organics at Sungai Teluk Kumbar (WQ13) was moderate, exhibiting mid-range BOD between 6 to 9 mg/L. However, NH_3-N was very elevated during spring tide, between 4.32 to 5.15 mg/L. This indicated faecal (sewage) contamination was apparent, but not prevalent; at least in terms of organics. The faecal coliform levels of up to 1,140,000 cfu/100 mL reaffirmed this. These are levels entirely not appropriate for body contact.

At Sungai Bayan Lepas (WQ7), elevation in BOD and NH_3-N was again apparent though not as prevalent as at Sungai Gertak Sanggul or Sungai Teluk Kumbar. BOD here ranged between 6 to 9 mg/L during spring tide as NH_3-N went up to 1.13 mg/L during ebbing. Poor re-aeration coupled with the organic contamination lead to low DO levels during neap and spring tides, registering about 1.4 to 2.8 mg/L. Sewage was a main suspect as faecal coliform went as high as 114,000 cfu/100 mL at this location.

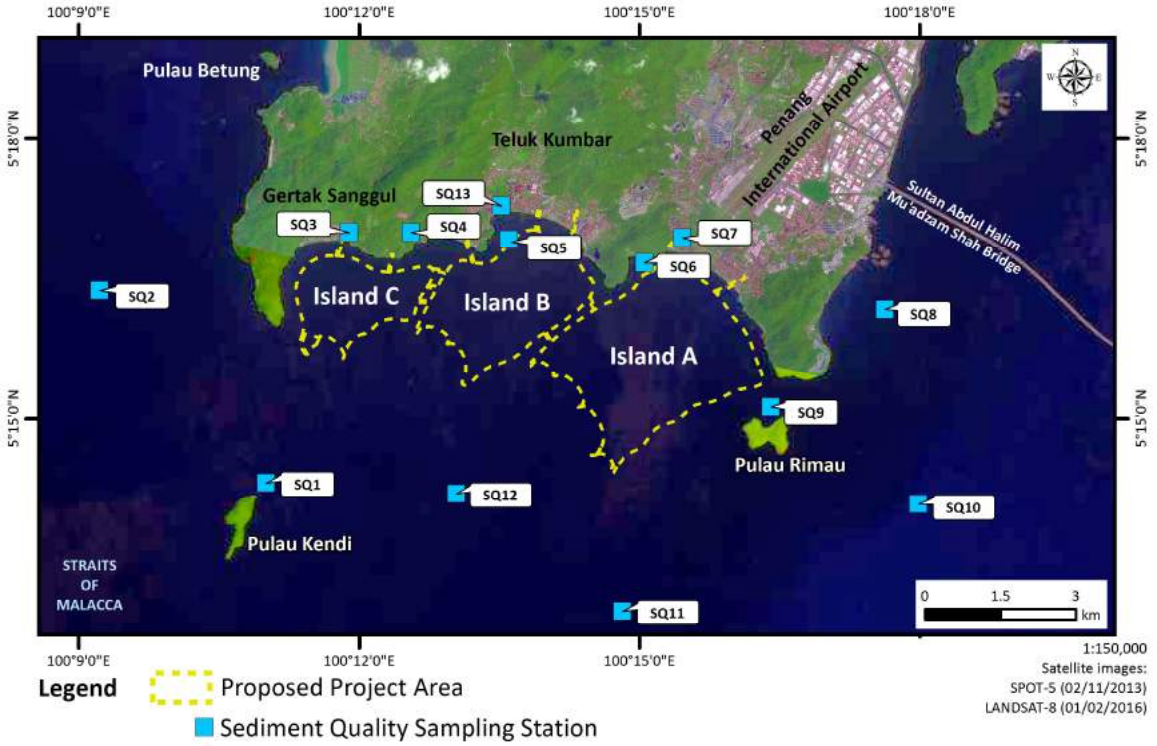
That being so, these river systems exhibited signs of faecal contamination as indicated by the occasional increase in nutrients, *E. coli* and faecal coliform.

With the exception of manganese, iron and arsenic, heavy metals remained largely undetected in most of the river systems. Arsenic could have originated from the soil, which was due to the inherent geomorphology.

TSS and turbidity levels were also low for the most part. The measured turbidity showed that the highest levels recorded were at WQ7 which is located at the outlet of Sungai Bayan Lepas with 43 NTUs for both ebbing and flooding conditions. This coincides with the suspended solids concentration recorded with 42 and 54 mg/L during ebbing and flooding respectively. The second and third highest readings recorded for turbidity and SS are WQ3 and WQ13. During flooding for both stations, the turbidity values were very low but the SS readings were the opposite. This specifies that the SS value signifies the coarser solids, which are normally measured as higher SS but low turbidity.

6.2.8 Sediment Quality

13 sediment quality stations were chosen to obtain baseline sediment samples as shown in F6.35. The coordinates of the sampling stations are tabulated in T6.14.



F6.35 Sediment quality sampling stations

T6.14 Coordinates of the sediment quality sampling stations

Station	Coordinates	Description
SQ1	5°14'19.01"N, 100°11'0.34"E	North of Pulau Kendi
SQ2	5°16'22.154"N, 100°9'13.46"E	About 3 km to the west of Tanjung Gertak Sanggul
SQ3	5°16'59.78"N, 100°11'53.75"E	River mouth of Sungai Gertak Sanggul
SQ4	5°16'59.7"N, 100°12'33.5"E	River mouth of Sungai Gemuruh
SQ5	5°16'54.96"N, 100°13'36.24"E	The proposed flushing channel between Tanjung Bongkok and the proposed Island B
SQ6	5°16'40.04"N, 100°15'3.19"E	The proposed flushing channel between Tanjung Chut and the proposed Island A
SQ7	5°16'56.26"N, 100°15'27.6"E	River mouth of Sungai Bayan Lepas
SQ8	5°16'10.062"N, 100°17'37.68"E	About 1.5 km to the east of Kampung Teluk Tempoyak
SQ9	5°15'7.52"N, 100°16'24.54"E	North of Pulau Rimau
SQ10	5°14'5.429"N, 100°17'59.24"E	About 3 km to the south east of Pulau Rimau
SQ11	5°12'56.51"N, 100°14'49.159"E	About 3 km to the south of the proposed Island A
SQ12	5°14'12.098"N, 100°13'2.447"E	About 2 km to the south of the proposed Island B
SQ13	5°17'16.7"N, 100°13'31.4"E	River mouth of Sungai Teluk Kumbar

6.2.8.1 Methodology

The sediment samples were obtained using a Van Veer Grab. The grab was lowered vertically into the river or seabed. The closure of the grab bucket was then triggered when it touched the bottom. The grab was pulled up and the sediment samples were then kept in a labelled plastic container before being sent to the laboratory for analysis.

Chemical analyses were conducted in accordance to the relevant standards which are based on the US EPA Standard (T6.15). F6.36 shows the sediment quality sampling activities.

Parameter	Unit	US EPA Standard		
		Non-Polluted	Moderately Polluted	Heavily Polluted
Zinc (Zn)	mg/kg	<90	90 – 200	>200
Nickel (Ni)	mg/kg	<20	20 – 50	>50
Lead (Pb)	mg/kg	<40	40 – 60	>60
Arsenic (As)	mg/kg	<3	3 – 8	>8
Cadmium (Cd)	mg/kg	-	-	>6
Copper (Cu)	mg/kg	<25	25 – 50	>50
Chromium (Cr)	mg/kg	<25	25 – 75	>75
Nitrate	mg/kg	N/A	N/A	N/A
Total Phosphorus	mg/kg	N/A	N/A	N/A
Oil & Grease	mg/kg	<1,000	1,000-2,000	>2,000

T6.15
US EPA Standard for sediment quality

F6.36
Sediment quality sampling activities

6.2.8.2 Results

The baseline sediment quality results are tabulated in T6.16.

T6.16 Baseline sediment quality results

Parameters	Unit	Stations						
		SQ1	SQ2	SQ3	SQ4	SQ5	SQ6	SQ7
Nitrate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Phosphorus	mg/kg	598	528	820	33	648	353	594
Oil & Grease	mg/kg	<10	<10	<10	<10	<10	<10	<10
Sulphide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Organic Matter	%	32.6	28.8	4.0	2.0	43.8	3.9	5.2
Total Organic Carbon	%	1.6	2.6	1.2	0.6	2.8	1.2	1.2
Nickel	mg/kg	10	8	4	<1	11	3	5
Copper	mg/kg	9	5	55	<1	21	6	14
Chromium	mg/kg	18	16	8	<1	20	5	9
Lead	mg/kg	14	12	10	1	15	6	16
Arsenic	mg/kg	3	5	2	<1	6	3	5
Cadmium	mg/kg	<1	<1	<1	<1	<1	<1	<1
Zinc	mg/kg	41	33	128	4	53	24	58
Manganese	mg/kg	319	327	74	13	294	144	123
Iron	mg/kg	21,700	23,000	12,200	1,030	29,000	12,100	19,100

		SQ8	SQ9	SQ10	SQ11	SQ12	SQ13
Nitrate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Phosphorus	mg/kg	740	444	669	620	648	625
Oil & Grease	mg/kg	<10	<10	<10	<10	<10	<10
Sulphide	mg/kg	<0.1	0.5	<0.1	<0.1	<0.1	<0.1
Organic Matter	%	48.9	3.1	33.5	34.0	27.4	4.0
Total Organic Carbon	%	2.3	1.3	0.9	1.7	1.4	1.8
Nickel	mg/kg	11	1	10	10	9	2
Copper	mg/kg	33	3	8	9	10	34
Chromium	mg/kg	20	2	19	18	17	5
Lead	mg/kg	16	3	16	15	14	13
Arsenic	mg/kg	7	3	7	5	6	1
Cadmium	mg/kg	<1	<1	<1	<1	<1	<1
Zinc	mg/kg	52	10	46	42	41	47
Manganese	mg/kg	406	184	362	303	361	40
Iron	mg/kg	27,900	4,820	28,500	22,400	24,400	5,350

6.2.8.3 Discussions

The results as tabulated in T6.16 show significantly high values of copper (Cu) in the sediment at station SQ3 (Sungai Gertak Sanggul) at 55 mg/kg, making it fall under the "Heavily Polluted" category. The high levels of Cu in the sediment are probably due to the accumulation of heavy metals coming from the upstream human activities of Sungai Gertak Sanggul. Zinc (Zn) concentration falls under "Moderately Polluted" for station SQ3. The same station also shows the highest values for Total Phosphorus with 820 mg/kg, indicating high level of nutrients in the sediment. The concentration of chromium (Cr) is quite high at some stations with the highest at stations SQ5 and SQ8 but still falling under "Non-Polluted". Arsenic (As) concentration too is high and falls under "Moderately Polluted" with high values at stations SQ5, SQ8 and SQ10. Organic matters are also detected at significant levels for almost all stations. It can be concluded that the sediment quality within the Project area is categorised as "Moderately Polluted" and probably caused by anthropogenic activities.

6.2.9 Noise

Ambient noise measurements were carried out to establish the existing background noise levels near the sensitive receptors. This information will be used in the noise impact assessment and/or for compliance verification during the construction stage of the Project based on the Planning Guidelines for Environmental Noise Limits Control, Second Edition (2007) published by DOE.

6.2.9.1 Methodology

The measurements were performed according to the International Electro-technical Commission (IEC) specifications. The sound level meter was placed at a height of about 1.2 m above the ground on a tripod. The guidelines specified that the monitoring time should be "continuous day-night sampling". The sound-level meter was calibrated onsite each day before the first measurement was taken and after the final measurement was completed.

The noise parameters measured were L_{eq}, L_{min}, L_{max}, L_{10} and L_{90}. The definition of the noise descriptors are indicated as follows:

a) L_{eq}: the equivalent continuous noise level in dBA, which has the same energy as the original fluctuating noise for the same given period of time;
b) L_{min}: the noise level in dBA, which is the lowest level measured for the same a) period;
c) L_{max}: the noise level in dBA, which is the highest level measured for the same period;
d) L_{10}: the noise level in dBA, which exceeds 10% of the time; and
e) L_{90}: the noise level in dBA, which exceeds 90% of the time.

Three locations were identified as the noise sampling stations as tabulated in T6.17 and also illustrated in F6.37. The baseline results were compared to the following construction noise criteria given in DOE's The Planning Guidelines for Environmental Noise Limits and Control, as summarised in T6.18.

T6.17 Locations of noise sampling stations

Station	Description	Coordinates
N1	Sekolah Jenis Kebangsaan Cina Poi Eng	5° 16' 56.24" N, 100° 11' 45.44" E
N2	Sekolah Kebangsaan Teluk Kumbar	5° 17' 26.32" N, 100° 13' 58.69" E
N3	Perkarangan Masjid Al Qahhar	5° 16' 28.95" N, 100° 15' 59.58" E

Receiving Land Use Category	Day-time (0700 - 2200)	Night-time (2200 - 0700)
Noise Sensitive Areas, Low Density Residential, Institutional (School, Hospital), Worship Areas	50 dBA	40 dBA
Suburban Residential (Medium Density) Areas, Public Spaces, Parks, Recreational Areas	55 dBA	45 dBA
Urban Residential (High Density) Areas, Designated Mixed Development Areas (Residential - Commercial)	60 dBA	50 dBA
Commercial Business Zones	65 dBA	55 dBA
Designated Industrial Zones	70 dBA	60 dBA

T6.18 Maximum Permissible Sound Levels (L_{Aeq}) by Receiving Land Use for Planning and New Development (Schedule 1)

6.2.9.2 Results

The baseline noise results are tabulated in T6.19.

Station	Time Period	Noise Level (dBA)				
		L_{Aeq}	L_{min}	L_{max}	L_{10}	L_{90}
N1	Day-time (0700 – 2200)	54.2	48.6	68.2	60.3	53.7
	Night-time (2200 – 0700)	49.7	46.9	57.0	52.9	49.2
N2	Day-time (0700 – 2200)	53.1	47.4	60.2	57.9	52.2
	Night-time (2200 – 0700)	49.6	46.2	54.7	51.2	48.5
N3	Day-time (0700 – 2200)	48.3	45.5	60.3	50.2	48.0
	Night-time (2200 – 0700)	46.7	43.4	59.6	49.7	45.9

T6.19 Baseline noise results

6.2.9.3 Discussions

The results recorded were compared with the Suburban Residential Areas land use category. The results show that noise during day time is below the maximum permissible limit while for night time is slightly higher. The noise was mainly generated from human activities from the school areas and vehicles' movement on the road. Sounds from animals also added to the ambient noise recorded at the stations.

6.2.10 Air Quality

The ambient air quality sampling was conducted to determine the existing environmental air quality around the Project area. It was done from the 16th to 18th February 2016. The parameters observed were Total Suspended Particulates (TSP), Particulate Matter ($PM_{2.5}$), Sulphur Dioxide (SO_2), Carbon Monoxide (CO), Nitrogen Dioxide (NO_2) and Ozone (O_3).

6.2.10.1 Methodology

Three stations were selected for the study namely AQ1, AQ2 and AQ3. The locations of the stations are described in T6.20 and also depicted in F6.37. The ambient air is absorbed from the surrounding area using a pre-calibrated portable pump stationed at fixed points. For the TSP parameter, the High Volume sampler method was used to collect the samples. These were tested at the laboratory for the concentrations of relevant parameters. The results were then compared with the New Malaysia Ambient Air Quality Standard (DOE, 2014) (T6.21). Only TSP is compared with the Recommended Malaysian Air Quality Guidelines (RMAQG).

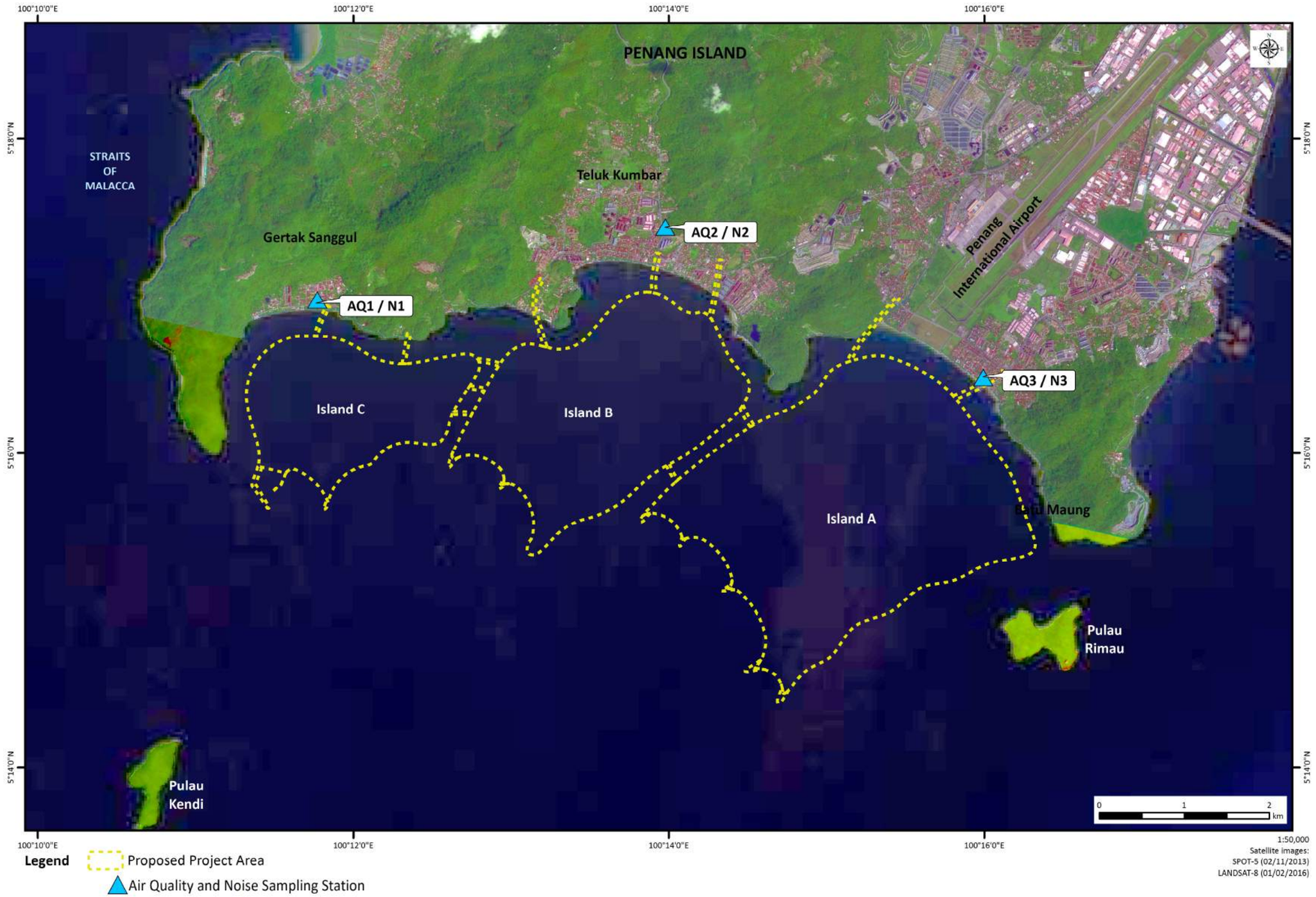
T6.20 Locations of the air quality sampling stations

Station	Description	Coordinates
AQ1	Sekolah Jenis Kebangsaan Cina Poi Eng	5° 16’ 56.24” N, 100° 11’ 45.44” E
AQ2	Sekolah Kebangsaan Teluk Kumbar	5° 17’ 26.32” N, 100° 13’ 58.69” E
AQ3	Perkarangan Masjid Al Qahhar	5° 16’ 28.95” N, 100° 15’ 59.58” E

T6.21 New Malaysia Ambient Air Quality Standard

Pollutants	Averaging Time	New Malaysia Ambient Air Quality Standard		
		Interim Target 1 in 2015 (IT-1) (µg/m^3)	Interim Target 2 in 2018 (IT-2) (µg/m^3)	Standard 2020 (µg/m^3)
PM_{10}	1 year	50	45	40
	24 hours	150	120	100
$PM_{2.5}$	1 year	35	25	15
	24 hours	75	50	35
SO_2	1 hour	350	300	250
	24 hours	105	90	80
NO_2	1 hour	320	300	280
	24 hours	75	75	70
O_3	1 hour	200	200	180
	8 hour	120	120	100
CO*	1 hour	35	35	30
	8 hour	10	10	10

Note: *mg/m^3
Source: DOE, 2014



F6.37 Air quality and noise sampling stations

6.2.10.2 Results

The air quality baseline results are shown in T6.22.

T6.22 Baseline air quality results

Parameters	Duration	Results			RMAQG/Malaysia Ambient Air Quality Standard
		AQ1	AQ2	AQ3	
TSP (µg/m^3)	24 hours	42	14	111	260
$PM_{2.5}$ (µg/m^3)	24 hours	28	<1	69	75
SO_2 (µg/m^3)	1 hour	167	167	167	350
NO_2 (µg/m^3)	1 hour	<42	<42	<42	320
CO (mg/m^3)	1 hour	<0.1	<0.1	<0.1	35
O_3 (µg/m^3)	1 hour	<20	<20	<20	200

6.2.10.3 Discussion

The TSP level at station AQ3 is quite high compared to stations AQ1 and AQ2. However, the results for all parameters are below the standard. Therefore, it can be concluded that the existing air quality within the Project area is good.

6.2.11 Marine Traffic and Navigation

This section will address the environmental issues associated with the proposed development and impacts on marine traffic and navigation within the Project area. The assessment has been made based on the information received and from research specifically done on the subject matter, and has taken into account various factors regarding:

a) existing marine facilities and utilisation;
b) existing condition of local climate; and
c) existing marine traffic procedures and safety rules.

A Marine Traffic Risk Assessment (MTRA) will be carried out to assess marine traffic risks caused by the Project, both during and post construction, and to develop Standard Operating Procedure to ensure safety of all boats and vessels, including fishing boats

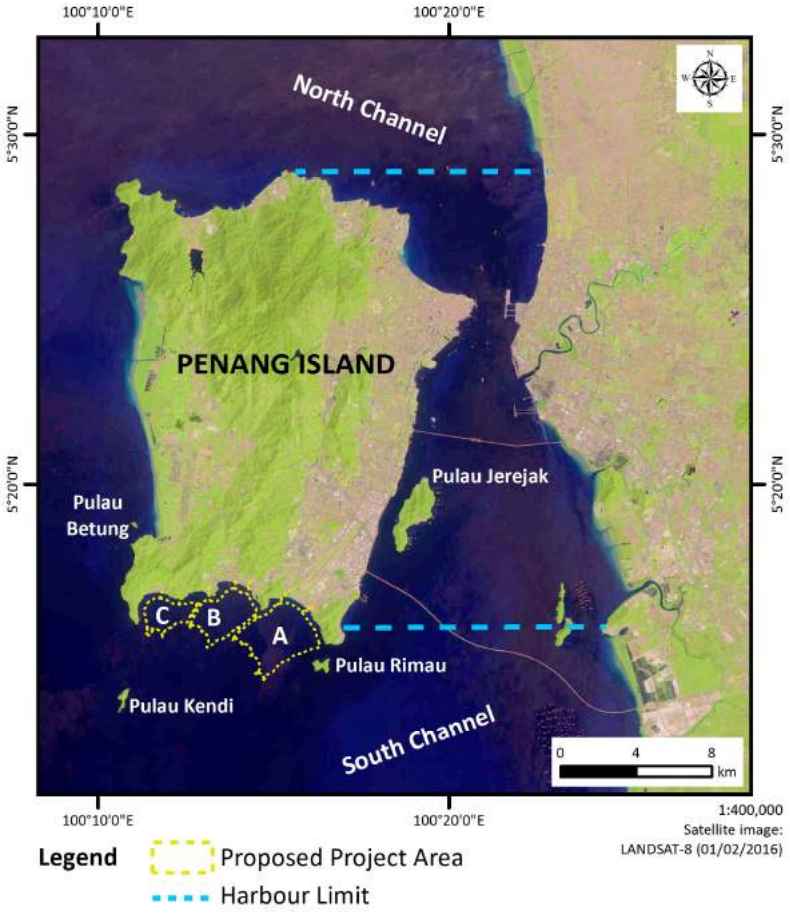
6.2.11.1 Methodology

The assessment was done using qualitative and quantitative methods including local knowledge, experience, data available from the Project Proponent, adjacent port-operating companies, government authorities and agencies, as well as interviews with the fishermen, their associations and local communities.

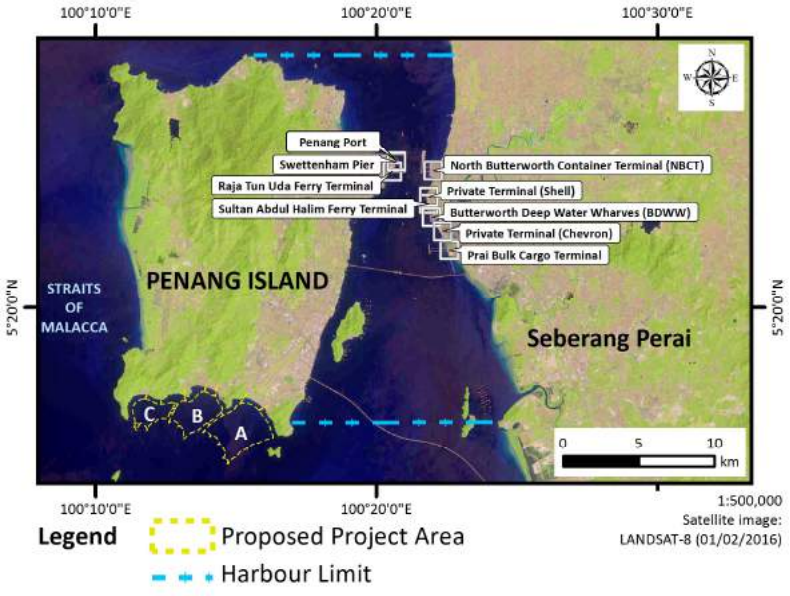
6.2.11.2 Existing Marine Facilities and Utilisation

Penang Port is the oldest and longest established port in Malaysia. It is administrated by Penang Port Commission while Penang Port Sdn. Bhd. is licensed to act as its operator. Equipped with facilities to handle nearly all types of containerised and non-containerised cargo, Penang Port provides important access for shippers in the northern states of Peninsular Malaysia and also the southern provinces of Thailand.

The proposed Project site is located on the southern bay of Penang Island which is outside of the boundary of the Penang Port Limit. One of the accesses to Penang Port, called South Channel, is located adjacent to the Project site as illustrated in F6.38. F6.39 shows the main existing marine facilities located in Penang.



F6.38
North and South Channels



F6.39
Main marine facilities in Penang

a) Marine Facilities

Several marine facilities can be found within the Penang Port Limit which are as follows:

i) *Swettenham Pier* - Passenger traffic for leisure cruises is handled at the Swettenham Pier Cruise Terminal located on the island of Penang.
ii) North Butterworth Container Terminal (NBCT) - NBCT is equipped with six berths (N1 to N6) that are 1.5 km in total length together with 13 Quay Gantry Cranes (QGCs). Out of these cranes, seven are post Panamax QGCs capable of handling vessels with 18 rows of container across. Berth capacity is currently at 2 million Twenty-foot Equivalent Units (TEU) per annum.
iii) *Ferry Terminal* - Penang Port provides ferry services from 5:30 am to 1:00 am linking Georgetown (Raja Tun Uda Terminal) on the island with Butterworth (Sultan Abdul Halim Terminal) on the mainland. It operates a fleet of eight ferries, namely *Pulau Pinang, Pulau Payar, Pulau Angsa, Pulau Kapas, Pulau Undan, Pulau Rawa, Pulau Talang-Talang* and *Pulau Rimau*.
iv) *Butterworth Deep Water Wharves (BDWW)* - Break-bulk handling is primarily undertaken at BDWW, a terminal completed in 1969. Located on the mainland, BDWW is capable of handling 2.5 million tonnes of cargo per annum. It offers a linear berth with a length of 1.05 km.
v) *Prai Bulk Cargo Terminal* - This dedicated bulk cargo terminal was built to handle both dry and liquid bulk cargoes. The terminal is situated south of Perai Power Station and to the north of the Penang Bridge. It has 5 berths and measures 632 m in length. This terminal is capable of handling 3.9 million tonnes of cargo per annum whereby 500 m of berth is utilised for normal dry-bulk cargo while the remaining 132 m of berth is used for handling Dangerous Goods (DG) in either liquid or gaseous state. An inner berth measuring 154 m in length allows for the handling of both dry and liquid bulk cargo.
vi) *Private Terminals* - Oil storage depots found in Butterworth were first set up more than 100 years ago. They are very near to the sea ports, industrial estate and busy shipping lane of Penang Straits. In 2013 about 2.7 million tonnes were handled at private terminals operated by companies such as Chevron, Petron and Shell who together with Petronas are the biggest players in the liquid bulk market.

T6.23 shows the number of vessel calls at Penang Port for the past few years encompassing various types of vessels.

T6.23 Number of vessel calls at Penang Port

Year	Type of Vessel							Total
	Ferry	Container	Tanker	Bulk Carrier	General Cargo	Others	Cruise Vessel	
2013	762	1,557	1,140	210	711	407	1,331	6,118
2014	1,000	1,557	1,058	193	627	428	1,201	6,064
2015	1,180	1,529	1,098	238	610	444	1,128	6,227

Source: Penang Port Sdn. Bhd.

b) Bridges

Apart from the marine facilities, it should be noted that both of the bridges connecting Penang Island and the mainland are situated within the Penang Port Limit. The bridges are:

i) *Penang Bridge* - The bridge is 13.5 km long with a span of 8.4 km over water that connects Prai on the mainland with Gelugor on the island. The iconic centre span has a height limitation of 28 m for vessels passing underneath it.
ii) *Sultan Abdul Halim Muadzam Shah Bridge* - Conversationally known as "The Second Bridge", it connects Bandar Cassia (Batu Kawan) in Seberang Perai with Batu Maung on Penang Island. The total length of the bridge is 24 km with length over water at 16.9 km. It too has a height limitation of 28 m for vessels passing underneath it.

c) Fishing Vessels

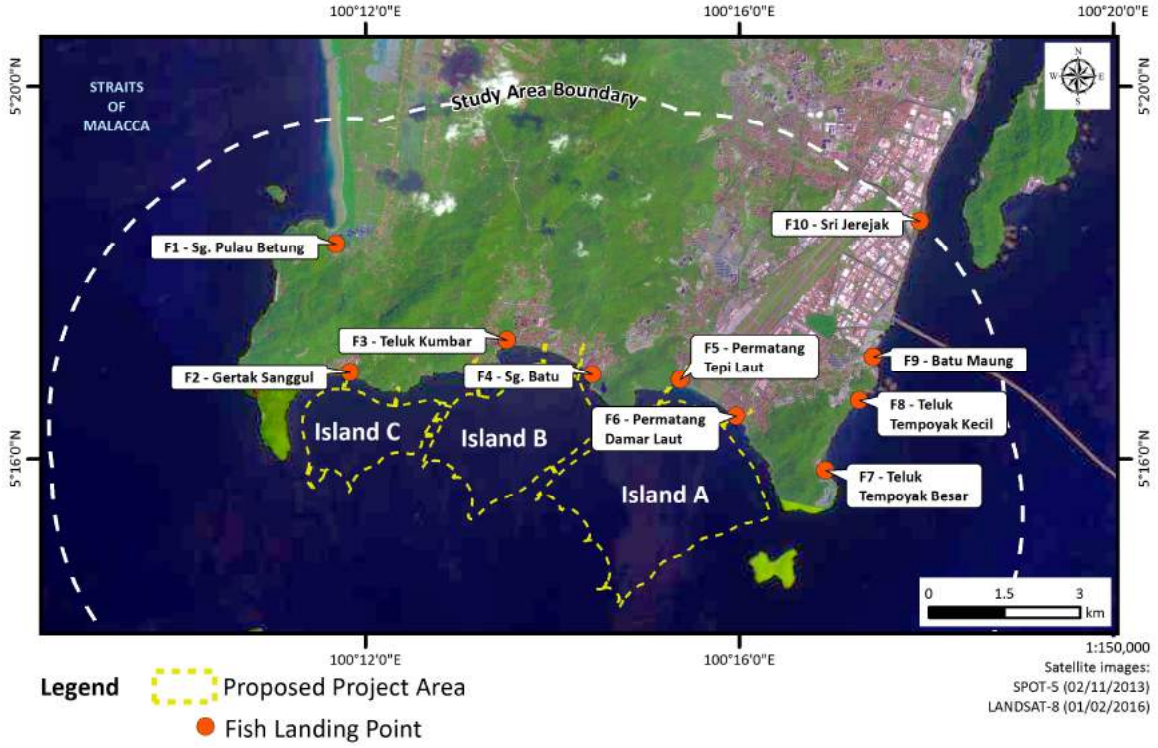
Based on the location of the proposed Project site, it is expected that most of the fishermen affected are from the Southwest District of Penang. The total number of fishermen in the SW District is approximately 2,757 while the number of licensed fishing boats is about 733 boats, as shown in T6.24.

T6.24 Fish landing points and the numbers of registered fishermen and licensed boats

Fish Landing Points	No. of Fishermen	No. of Boats		
		Outboard Engine	Inboard Engine	Total
Permatang Damar Laut	185	91	1	92
Sungai Batu	180	90	0	90
Teluk Kumbar	220	129	1	130
Gertak Sanggul	106	56	4	60
Sri Jerjak	92	50	0	50
Batu Maung	1,591	40*	77	117*
Teluk Tempoyak	157	85	0	85
Pulau Betung	226	109	0	109
Total	**2,757**	**650**	**83**	**733**

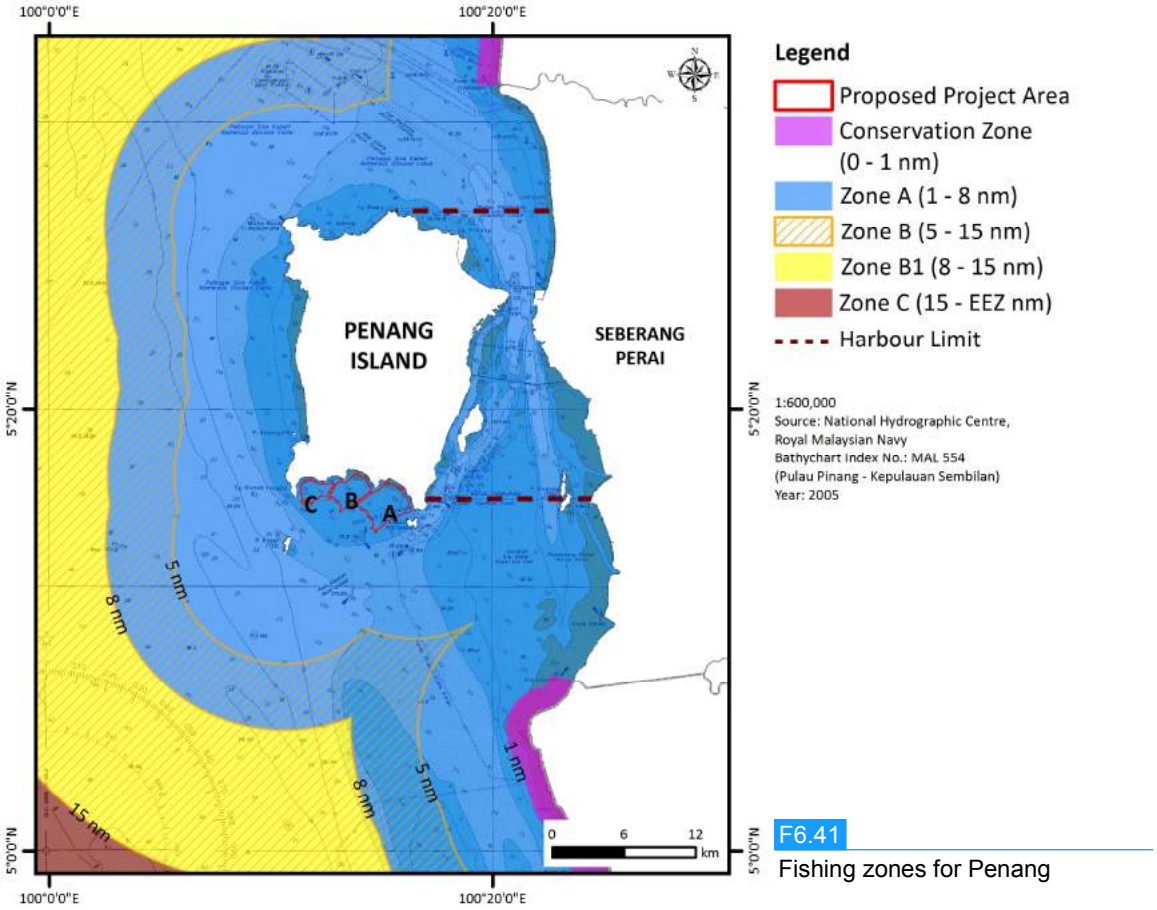
Source: Department of Fisheries, Penang (2016) - unpublished
Note: *Estimated

Focusing on the southern bay of Penang Island, there are a few fishing villages located along the shoreline adjacent to the Project site. The identified fish-landing points are shown in F6.40. Meanwhile, T6.24 listed each of the fish-landing points together with the respective numbers of registered fishermen and licensed boats.

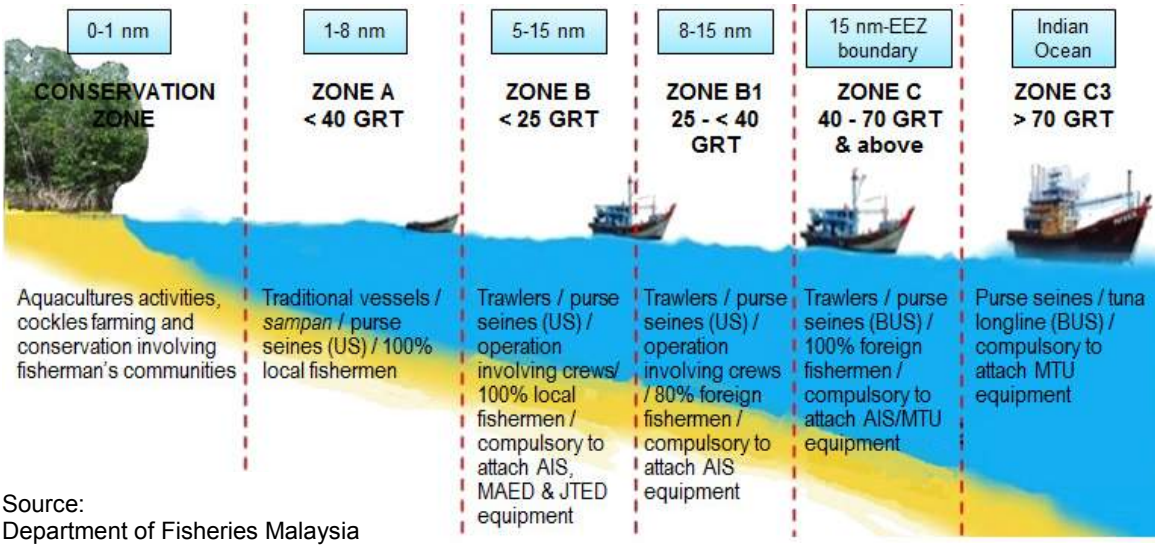


F6.40 Fish landing points

Fishing activities are carried out within the straits between the island and mainland and as far out to the Straits of Malacca. According to the prevailing regulation, no fishing is allowed within one nautical mile from the coastline as it is considered as conservation zone. However, Penang has been exempted from having a conservation zone as per the letter by the Department of Fisheries (DOF) [Ref No: Prk.ML.08/35-22(71)]. This exemption is due to complaints from local fishermen through *Persatuan Nelayan Pulau Pinang* of the shrinking fishing area caused by the presence of the conservation zone. The fishing zones are illustrated in F6.41. Details of the fishing zones are shown in F6.42. Artisanal fishing is allowed within Zone A while boats equipped with commercial fishing gears are required to operate within Zone B and beyond. Fishing boats do criss-cross the navigational channels when sailing to and from their fishing grounds.



F6.41 Fishing zones for Penang



Source:
Department of Fisheries Malaysia

F6.42 Details of each fish zone

6.2.11.3 Existing Marine Traffic Procedures and Safety Rules

a) Penang Port Control

Penang Port Control monitors and regulates marine traffic in the Port Area and the respective navigable waters within the Port Limit. The movement of all vessels within the Port Limit must obtain prior permission from the Penang Port Control.

Pilotage is mandatory for the movement of ships of 600 Gross Register Tonnage (GRT) and above within the pilotage compulsory area, as well as ships of 200 GRT and above berthing or unberthing at private jetties or the port's wharves.

b) Existing navigation

Penang Port can be approached using the North or South Channel:

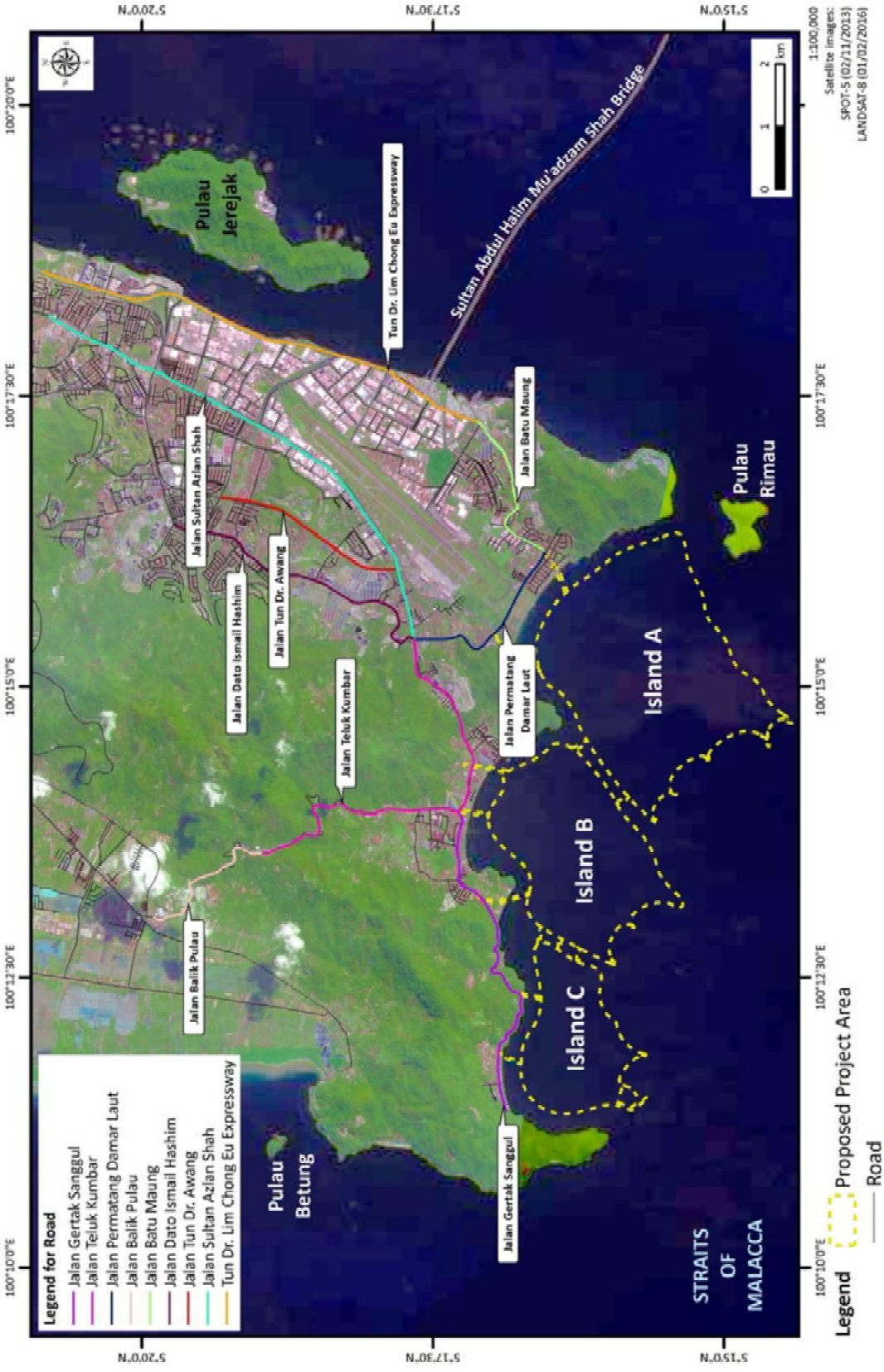
i) *North Channel* - The North Channel is the primary approach to Penang Port and it is used by most vessels. The main ship channel is 10 miles in length, has a width of 183 m and a depth of at least 10.2 m. North Channel can be approached via the North Channel Light Float (5°35.9' N, 100°12.45' E). Vessels awaiting pilot can anchor in the pilot waiting area. Approaches to the port area are well marked by navigational aids.
ii) *South Channel* - For entry through the South Channel, a pilot will be taken on board near the Rimau Wreck Buoy located 1.6 km south of Pulau Rimau Lighthouse. The approach via this channel is restricted to vessels with water draft and air draft of 6 and 28 m respectively. The number of vessels using South Channel is very small in comparison with the total vessel calls at Penang Port.

6.2.12 Land Traffic

The study area is illustrated in F6.43. The area consists of all major road corridors and junctions likely to be affected by the traffic volumes generated by the proposed PSR development, including all site access points to Islands A, B and C, major junctions and roadway sections in proximity of the PSR development.

6.2.12.1 Methodology

Traffic counts were undertaken at major junctions during the AM and PM periods to capture typical traffic conditions during a commuter weekday. These junctions were selected due to their close proximity to the PSR islands. Vehicles entering and leaving each survey station are recorded in 15-minute intervals and classified as motorcycles, cars, light trucks, heavy trucks or buses. Video cameras were set up at the selected sites to capture the vehicle flows and turning movements. The counts are then enumerated manually for the nominated AM and PM peak hours.



F6.43 Traffic study area

6.2.12.2 Passenger Car Unit (PCU) Conversion Factors

For the purpose of assessing the capacity of the road network, each vehicle classification is converted into PCUs to reflect the amount of road capacity they use in relation to a standard car. The conversion unit from vehicles to PCUs for the observed classes of vehicles is based on the values provided by Trip Generation Manual (HPU Malaysia), 2010 as summarised below in T6.25.

Vehicle Classification	PCU Conversion Factor
Car/Van/4WD/MPV	1.00
Motorcycles	0.33
Light lorry	1.75
Lorry/truck/heavy vehicles	2.25
Buses/coaches	2.25

T6.25
PCU conversion factors

Source: Trip Generation Manual (HPU Malaysia), 2010

6.2.12.3 Definition of the Peak Periods

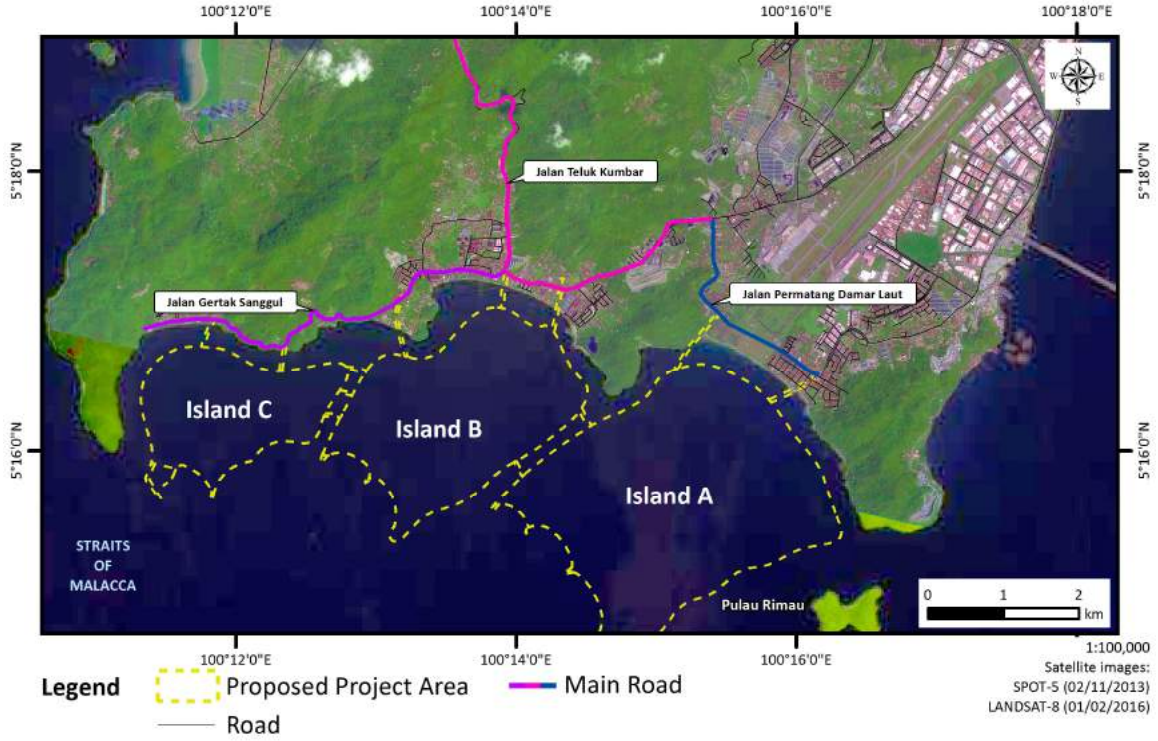
The peak hour periods were determined by analysing the hourly traffic flows at all junctions within the study area. Based on analysis of the traffic flow data collected, the peak hours are found to occur during the following periods:

a) AM peak: 0730 – 0830 hours; and
b) PM peak: 1730 – 1830 hours.

6.2.12.4 Existing Major Roads

The major roads that are included in the study area in close proximity to the proposed PSR development are (F6.44):

a) *Jalan Permatang Damar Laut* - F6.45 shows the configuration of Jalan Permatang Damar Laut which is 2-lane 2-way road. Jalan Permatang Damar Laut is a major state road (P10) functioning as a collector road from Batu Maung to Teluk Kumbar area.
b) *Jalan Teluk Kumbar* - This is one of the major federal roads with the 2-lane 2-way type road that connects Jalan Permatang Damar Laut and Jalan Balik Pulau. The road condition is shown in F6.46.
c) *Jalan Gertak Sanggul* - Jalan Gertak Sanggul is a 2-lane 2-way road which is categorised as a state road that is divided into two which are P226, from Jalan Teluk Kumbar to Jalan Kampung Masjid and P224, the state road from Jalan Kampung Masjid to the Gertak Sanggul area. This road functions as the main collector road for Gertak Sanggul area as shown in F6.47.



F6.44 Existing major roads nearest to proposed PSR

F6.45 Jalan Permatang Damar Laut (towards Batu Maung)

F6.46 Jalan Teluk Kumbar (from Jalan Permatang Damar Laut)

F6.47 Jalan Gertak Sanggul (from Teluk Kumbar)

6.2.12.5 Existing Traffic Volumes

The operational conditions of the roadways are based on the "Level of Service" (LoS) concept to classify the varying conditions of traffic flow. Levels of service are designated from "A" through "F", from best to worst, covering the entire range of traffic operating conditions. LoS "A" through "E" generally represents conditions where traffic volumes are at less than the facilities capacity, while LoS "F" represents conditions where capacity is exceeded and/or forced conditions exist. For both signalised and non-signalised junctions, the Level of Service (LoS) relates to the delay experienced by traffic at the junctions. T6.26 shows the relationship between delay and the LoS. The current junction performance for the AM and PM peak periods is tabulated in T6.27 and also illustrated in F6.48 and F6.49.

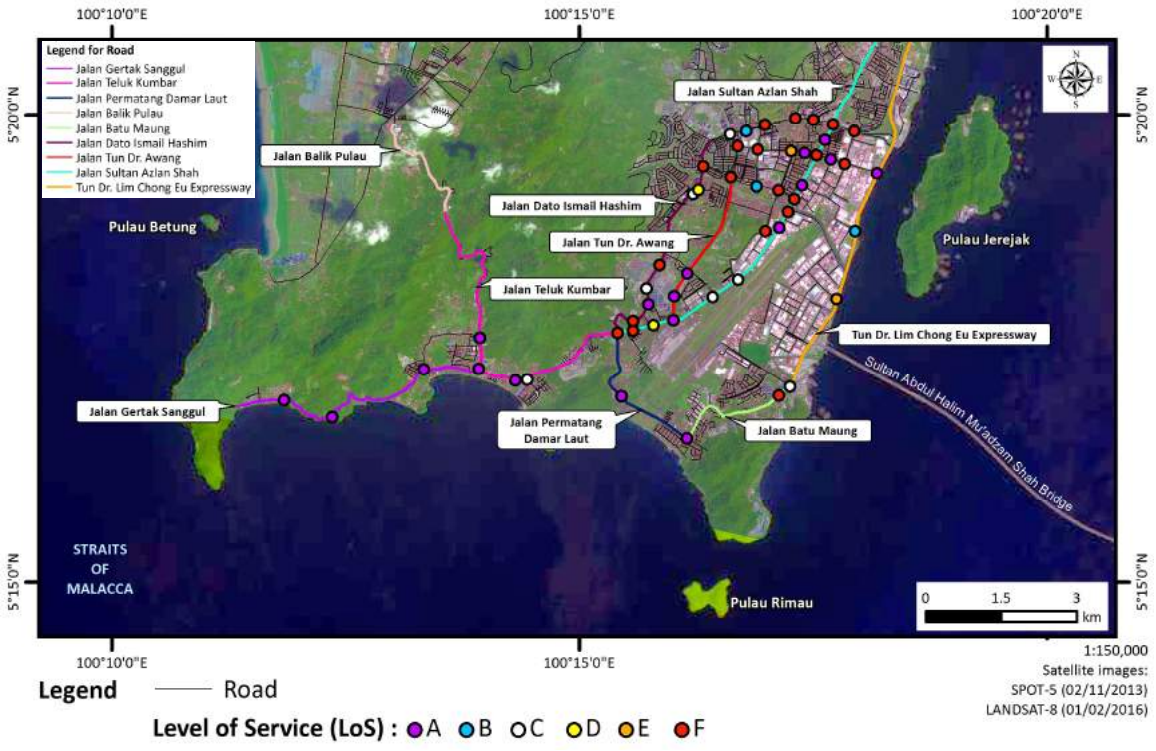
Level of Service	Controlled Delays in Seconds	
	Priority Junctions	Signalised Junctions
A	=< 10 seconds	=< 10 seconds
B	>10 -15 seconds	>10 - 20 seconds
C	>15 - 25 seconds	>20 - 35 seconds
D	>25 - 35 seconds	>35 - 55 seconds
E	>35 - 50 seconds	>55 - 80 seconds
F	> 50 seconds	> 80 seconds

T6.26 LoS for signalised and priority junctions

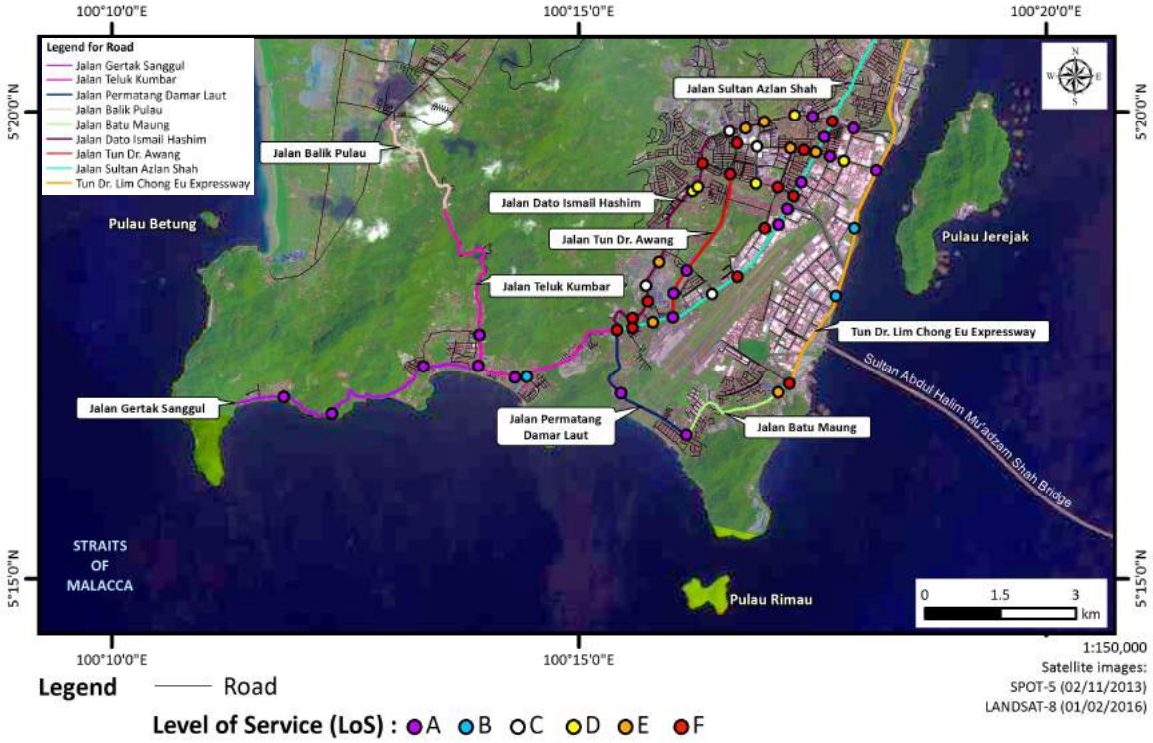
Source: REAM, 2002

Level of Service		A	B	C	D	E	F
Number of junctions	AM	18	3	7	2	2	20
	PM	19	3	4	5	7	14

T6.27 Existing number of junctions for each LoS (2015) (AM and PM) junction performance



F6.48 Existing AM peak hour junction performance



F6.49 Existing PM peak hour junction performance

6.3 Existing Biological Environment

This section presents the findings from terrestrial and marine biology study at the Project site within the study area.

6.3.1 Terrestrial Biology

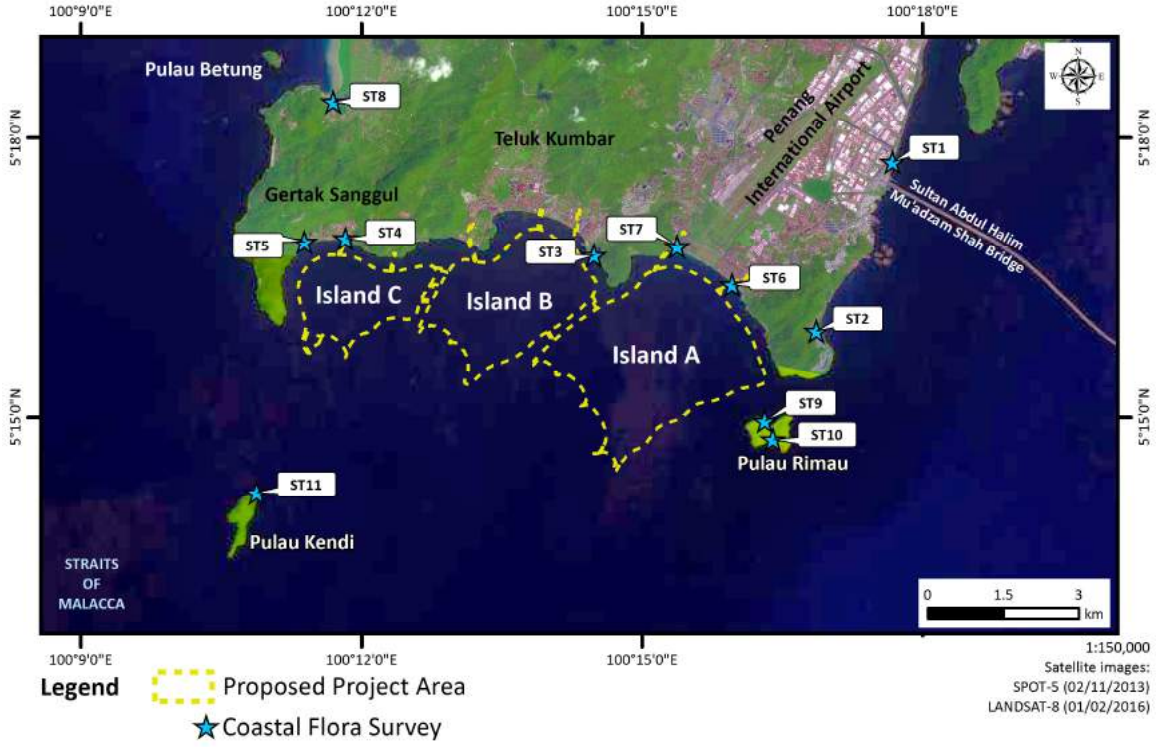
The terrestrial biology study covers the flora and fauna components as explained in the next sections.

6.3.1.1 Coastal Flora

The coastal flora surveys will involve identifying the plant species and mangrove current condition. The plant species identified are then listed. Pilot surveys have been done to familiarise with the sites and routes. Pictures of plants and sites are taken for reference.

6.3.1.1.1 Methodology

The survey on coastal flora of South Penang was undertaken from 2nd to 5th February 2016. General surveys of the coastal vegetation had covered from the Batu Maung area in the east of Penang along the south Penang coastline up to Sungai Pulau Betung in the Balik Pulau area (F6.50). A total of eight sampling stations were marked along the south Penang coastline plus three more at Pulau Rimau and Pulau Kendi (T6.28).



F6.50 Coastal flora survey locations

Station	Location	Coordinates
ST1	Batu Maung	5° 17.739' N,100° 17.685' E
ST2	Teluk Tempoyak	5° 15.929' N, 100° 16.867' E
ST3	Permatang Damar Laut	5° 16.424' N, 100° 15.966' E
ST4	Permatang Tepi Laut	5° 16.835' N, 100° 15.379' E
ST5	Sungai Batu	5° 16.740' N, 100° 14.490' E
ST6	Gertak Sanggul	5° 16.924' N, 100° 11.834' E
ST7	End survey Gertak Sanggul	5° 16.886' N, 100° 11.391' E
ST8	Sungai Pulau Betung	5° 18.392' N, 100° 11.700' E
ST9	Pulau Kendi	5° 14.195' N, 100° 10.880' E
ST10	Pulau Rimau	5° 14.767' N, 100° 16.402' E
ST11	Pulau Rimau	5° 14.963' N, 100° 16.317' E

T6.28 Coordinates of the coastal flora survey locations

For this study, three plots of 100 m x 20 m (10 subplots of 20 m x 10 m) and one plot of 30 m x 20 m (three subplots of 20 m x 10 m) are established. All trees with diameter at breast height (DBH) of 5 cm and above are measured and identified. Samples of leaves, flowers and fruits of various plants species identified on-site are collected and pressed. All trees with diameter at breast height (DBH) of 5 cm and above are recorded. The species abundance parameters i.e. frequency, density, basal area, importance value index and diversity indices are calculated following Brower *et al.* (1997), whereas the biomass is estimated using regression equation as suggested by Clough & Scott (1989). Species of conservation interest or rare are highlighted based on the IUCN Red List Categories and Criteria for mangrove species (Polidoro *et al.*, 2012).

All plants were recorded and classified into three categories based on Japar (1994). "Exclusives" are plants that can live only in the mangrove area, inundated by the tides and are very important to the mangrove or coastal ecosystem. The non-exclusive species are plants that do not play such an important role compared to the exclusive species in the mangrove area and these plants are also not necessarily found only in the mangrove habitat. Most coastal plant species are in this category. "Associates" are plants which can occur anywhere and these plants are not limited to mangrove forests only (Japar, 1994). In addition, plants habits were also noted during the surveys.

6.3.1.1.2 Results

In general, a total 121 plant species from 61 families was recorded from the surveys (T6.29). Almost 75% of the total plants are from non-exclusive category, which is not unexpected since the survey area is of sandy coastal habitat. Some 22 exclusive species of mangrove plants were found mostly at the riverine and lagoon areas of the survey sites. All recorded plant species are commonly found in many other coastal and riverine mangrove areas. No species of conservation interest or rare based on the IUCN Red List Categories and Criteria for mangrove species (Polidoro *et al.*, 2010) were found in the study area.

The sampling sites can be divided into three types of habitat, which are sandy coastal area, riverine and rocky island. Sandy coastal habitat where the coastal plants were found includes areas from Permatang Damar Laut to Permatang Tepi Laut and Gertak Sanggul. Riverine plants, mainly of the mangrove species, were mostly found at Teluk Tempoyak and Sungai Pulau Betung and a few mangrove species at Sungai Batu, Sungai Gemuruh and Sungai Teluk Kumbar. The two small islands, Pulau Kendi and Pulau Rimau have rocky coasts, especially Pulau Kendi. Pulau Rimau is still accessible via its sandy pockets area. Pulau Kendi is unique for its abundance of huge trees of the well known herbal plant *Eurycoma longifolia*, or locally known as the *Tongkat Ali* tree. The rocky shores of Pulau Kendi most probably deters the locals from harvesting the *Tongkat Ali*.

Richness-wise, Pulau Rimau has the highest plant species richness with 57 species, followed by Sungai Batu coastline up to Gertak Sanggul with 41 species, Teluk Tempoyak with 39 species and Sungai Pulau Betung with 33 species. Sungai Gemuruh and Sungai Gertak Sanggul have the least number of species with three and seven species respectively. Examples of the flora found are shown in F6.51.

6.3.1.2 Mangrove

The health and status of the mangroves found at and within the Project site was determined using line-transect sampling and through ground observations (where line-transect is inappropriate to be applied). A total of six transects (T1 to T6) were involved. Transects T1 and T2 were located at Teluk Tempoyak Kecil, T3 and T4 at Teluk Tempoyak Besar while T5 and T6 at Sungai Bayan Lepas. Mangrove ground observations were carried out at four locations i.e. O1 at Bayan Lepas Main Drain, O2 at Sungai Batu, O3 at Teluk Kumbar and O4 at Gertak Sanggul. The survey was conducted on 4th March 2016, 31st May 2016 and 1st June 2016. The location and description of the assessment areas are provided in T6.30 and F6.52.

T6.29 List of coastal flora species recorded at the Project area

Species		Local Name	Plant Type	Exclusive/ Non Exclusive/ Associate	Batu Maung	Sungai Batu	Teluk Tempoyak	Permatang Damar Laut	Permatang Tepi Laut	Sungai Pulau Betung	Pulau Rimau	Pulau Kendi	Sungai Gertak Sanggul	Sungai Gemuruh	Sungai Teluk Kumbar
Acanthaceae	*Asystasia gangetica* (L.) T. Anderson ssp. *micrantha* (Nees) Ensermu.	Rumput Israeil	Herb	Non-exclusive		/	/		/				/		
	Acanthus ebracteatus Vahl.	Jeruju Putih	Herb	Exclusive			/			/					
Anacardiaceae	*Anacardium occidentale* L.	Gajus	Tree	Non-exclusive		/									
	Buchanania arborescens (Blume) Blume	Otak Udang Tumpul	Tree	Non-exclusive							/				
Apocynaceae	*Cerbera manghas* L.	Pong-pong	Tree	Non-exclusive							/				
Araliaceae	*Schefflera elliptica* (Blume) Harms	Jari Lima	Epiphy	Non-exclusive							/	/			
Asclepiadaceae	*Hoya coronaria* Blume	Akar Setebal	Climber	Non-exclusive							/				
Aspleniaceae	*Aspelnium nidus* L.	Paku Sarang Burung	Fern	Associate					/						
Asteraceae	*Chromolaena odorata* (L.) R.M. King & H. Rob.	Kapal Terbang	Shrub	Non-exclusive	/	/	/				/				
	Pluchea indica (L.) Less	Beluntas	Herb	Non-exclusive			/								/
	Wollastonia biflora (L.) DC	Serunai laut	Herb	Non-exclusive	/	/	/	/		/	/				/
Avicenniaceae	*Avicennia alba* Blume.	Api-api Putih	Tree	Exclusive		/	/		/	/					/
	Avicennia officinalis L.	Api-api Ludat	Tree	Exclusive		/	/			/			/		/
	Avicennia marina (Forssk.) Vierh	Api-api Jambu	Tree	Exclusive	/		/		/	/	/				/
Aizoaceae	*Sesuvium portulacastrum* (L.) L.	Gelang Pasir	Herb	Exclusive	/	/	/	/							
Bignoniaceae	*Dolichandrone spathacea* (L. f.) K. Schum	Tui	Tree	Exclusive						/					
	Oroxylum indicum (L.) Benth. ex Kurz	Kacang Pedang	Tree	Non-exclusive							/				
Blechnaceae	*Stenochlaena palustris* (Burm. f.) Bedd	Pucuk Miding	Fern	Non-exclusive											/
Boraginaceae	*Cordia subcordata* Lam.	Sea Trumpet	Tree	Non-exclusive	/	/	/				/				
Calophyllaceae	*Calophyllum inophyllum* L.	Bintangor laut	Tree	Non-exclusive								/			
Casuarinaceae	*Casuarina equisertfolia* J.R. Forst. & G. Forst.	Rhu	Tree	Non-exclusive		/			/						
Combretaceae	*Terminalia catappa* L.	Ketapang	Tree	Non-exclusive	/	/	/	/	/	/	/	/		/	/
Convolvulaceae	*Ipomoea cairica* (L.) Sweet	Railway Creeper	Climber	Non-exclusive											/
	Ipomoea pes-caprae (L.) R.Br. ssp. *brasiliensis*	Seri Pagi	Herb	Non-exclusive	/	/		/		/					
Cycadaceae	*Cycas rumphii* Miq	Paku Sikas	Tree	Non-exclusive							/				
Davalliaceae	*Davallia denticulata* (Burm.f.) Mett.	Paku Tertutup	Fern	Associate							/				
Dilleniaceae	*Tetracera indica* (Christm. & Panz.) Merr.	Mempelas Licin	Climber	Non-exclusive							/				
	Tetracera scandens (L.) Merr	Mempelas Kesat	Climber	Non-exclusive							/				
Cyperaceae	*Cyperus compactus* Retz.	Sedge	Herb	Non-exclusive		/				/					
	Cyperus stoloniferus Retz.	Sedge	Herb	Non-exclusive		/									
	Fimbristylis cymosa R.Br.	Sedge	Herb	Non-exclusive						/					
Ebenaceae	*Diospyros ferrea* (Willd.) Bakh	Buey	Tree	Non-exclusive								/			
Elaeocarpaceae	*Elaeocarpus macrocerus* (Turcz.) Merr	Mendong	Tree	Non-exclusive							/				
Euphorbiaceae	*Excoecaria agallocha* L.	Buta-buta	Tree	Exclusive			/			/					/
	Jatropha gossypifolia L.	Jarak	Shrub	Non-exclusive	/										
	Macaranga tanarius (L.) Müll.Arg.	Mahang	Tree	Non-exclusive			/								
Erythroxyllaceae	*Erythroxylum cuneatum* (Miq.) Kurz.	Cinta mula	Tree	Non-exclusive		/					/	/			
Fabaceae	*Acacia auriculiformis* A. Cunn. *ex* Benth	Akasia Kuning	Tree	Non-exclusive	/	/	/	/	/						
	Albizia lebbeck (L.) Benth	Batai Laut	Tree	Non-exclusive							/				

Exclusive = 22 species; Non-exclusive = 90 species; Associate = 9 species

T6.29 List of coastal flora species recorded at the Project area (cont'd)

Species		Local Name	Plant Type	Exclusive/ Non Exclusive/ Associate	Batu Maung	Sungai Batu	Teluk Tempoyak	Permatang Damar Laut	Permatang Tepi Laut	Sungai Pulau Betung	Pulau Rimau	Pulau Kendi	Sungai Gertak Sanggul	Sungai Gemuruh	Sungai Teluk Kumbar
Fabaceae	*Albizia saman*	Pokok Hujan	Tree	Non-exclusive		/			/						
	Caesalpinia crista L.	Kuku Tupai	Climber	Non-exclusive	/										/
	Caesalpinia bonduc (L.) Roxb	Kuku Tupai Besar	Climber	Non-exclusive						/					
	Callerya atropurpurea (Wall.) Schot	Tulang Daeng	Tree	Non-exclusive							/				
	Canavalia rosea (Sw.) DC	Kacang Laut	Climber	Non-exclusive						/	/				
	Dendrolobium umbellatum (L.) Benth	Petai Laut	S/tree	Non-exclusive		/									
	Derris trifoliata Lour	Ketui	Climber	Exclusive			/		/	/					
	Leucaena leucocephala (Lam.) de Wit.	Petai Belalang	Tree	Non-exclusive	/	/		/	/	/					/
	Mimosa pigra L.	Semalu Besar	Shrub	Non-exclusive											/
	Pongamia pinnata (L.) Pierre var. Pinnata	Mempari	Tree	Non-exclusive	/	/		/	/		/	/			
	Pterocarpus indicus Willd	Angsana	Tree	Non-exclusive							/				
	Peltophorum pterocarpum (DC.) K. Heyne	Jemerlang	Tree	Non-exclusive	/	/					/				
	Tamarindus indica	Asam Jawa	Tree	Non-exclusive		/	/	/	/						
Flagellariaceae	*Falgellaria indica* L.	Rotan Dini	Climber	Exclusive											/
Goodeniaceae	*Scaevola taccada* (Gaertn.) Roxb	Pelampong	Shrub	Non-exclusive		/		/			/	/			
Lectythidaceae	*Barringtonia asiatica* (L.) Kurz	Putat Laut	Tree	Non-exclusive								/			
Loganiaceae	*Fagraea fragrans* Roxb	Tembusu	Tree	Non-exclusive							/				
Lythraceae	*Lawsonia inermis* L.	Inai	S/tree	Non-exclusive				/							
Malvaceae	*Hibiscus tiliaceus* L.	Baru-baru	Tree	Non-exclusive	/	/	/	/		/	/	/	/		/
	Thespesia populnea (L.) Sol. ex Corrêa	Bebaru	Tree	Non-exclusive		/	/			/	/	/	/		/
Moringaceae	*Moringa oleifera* Lam	Merunggai	Tree	Non-exclusive		/									
Melastomataceae	*Melastoma malabathricum* L.	Senduduk	Shrub	Non-exclusive							/				
	Memecylon edule Roxb. var. *ovatum*	Delek Air	Tree	Non-exclusive							/	/			
	Memecylon caeruleum Jack	Delek	S/tree	Non-exclusive							/				
Meliaceae	*Chukrasia tabularis* A. Juss	Surian Batu	Tree	Non-exclusive								/			
	Xylocarpus granatum J. König	Nyireh Bunga	Tree	Exclusive			/			/	/	/			/
	Xylocarpus moluccensis (Lam.) M. Roem.	Nyireh Batu	Tree	Exclusive			/			/					/
Moraceae	*Ficus superba* (Miq.) Miq	Ara Laut	Tree	Non-exclusive	/	/		/			/	/			
	Ficus microcarpa L.*f.*	Ara Beringin	Tree	Non-exclusive		/		/	/	/		/			/
Myrsinaceae	*Aegiceras corniculatum* (L.) Blanco	Kuku Lang	S/tree	Exclusive							/				
Olacaceae	*Ximenia americana* L.	Bidara Laut	S/tree	Non-exclusive			/								
Oleandraceae	*Nephrolepis auriculata* (L.) Trimen	Giant Swordfern									/	/			
Orchidaceae	*Cymbidium finlaysonianum* Lindl.	Okid	Epiphy	Associate							/	/			
Ochnaceae	*Campylospermum serratum* (Gaertn.)	Mata Ketam	Tree	Non-exclusive							/				
Palmae	*Caryota mitis* Lour.	Fish-tail	Palma	Non-exclusive			/				/				
	Cocos nucifera L.	Kelapa	Palma	Non-exclusive		/									
	Licuala spinosa Wurmb	Palas	Palma	Non-exclusive								/			
	Nypa fruticans Wurmb.	Nipah	Palma	Exclusive			/		/	/					/
	Oncosperma tigillarium (Jack) Ridl.	Nibong	Palma	Non-exclusive							/	/			
Pandanaceae	*Pandanus odoratissimus* L.f	Pandan Laut	Pandan	Non-exclusive							/	/			
Passifloraceae	*Passiflora foetida* L	Ulat Bulu	Climber	Non-exclusive	/	/									
	Passiflora laurifolia L	Markisa	Climber	Non-exclusive								/			

Exclusive = 22 species; Non-exclusive = 90 species; Associate = 9 species

T6.29 List of coastal flora species recorded at the Project area (cont'd)

Species		Local Name	Plant Type	Exclusive/ Non Exclusive/ Associate	Batu Maung	Sungai Batu	Teluk Tempoyak	Permatang Damar Laut	Permatang Tepi Laut	Sungai Pulau Betung	Pulau Rimau	Pulau Kendi	Sungai Gertak Sanggul	Sungai Gemuruh	Sungai Teluk Kumbar
Poaceae	*Chloris barbata* Sw		Herb	Associate						/					
	Imperata cylindrical (L.) P.Beauv	Lalang	Herb	Associate							/				
	Ischaemum muticum L.	Centipede Grass	Herb	Associate		/	/				/			/	/
	Panicum maximum Jacq.	Guinea Grass	Herb	Associate		/	/								/
	Pennisetum polystachion (L.) Schult	Panic Grass	Herb	Associate											/
	Saccharum officinarum	Tebu	Herb	Associate									/		
	Urochloa mutica (Forssk.) T. Q. Nguyen	Buffalo Grass	Herb	Associate											/
Polypodiaceae	*Drynaria sparsisora* (Desv.) T. Moore	Paku Sakat Tupai	Fern	Associate					/	/	/				
	Pyrrosia piloselloides (L.) M.G. Price	Paku Duit-duit	Fern	Non-exclusive							/				
Phyllanthaceae	*Breynia vitis-idaea* (Burm.f.) C.E.C. Fisch	Hujan Panas	Shrub	Non-exclusive	/										
Pteridaceae	*Acrostichum aureum* L.	Piai Raya	Fern	Exclusive		/	/			/				/	/
Rubiaceae	*Guettarda speciosa* L.	Selar Malam	Tree	Non-exclusive							/				
	Morinda citrifolia L.	Mengkudu Besar	Tree	Non-exclusive							/				
	Uncaria acida (W. Hunt.) Roxb.	Akar Kait	Climber	Non-exclusive											/
	Prismatomeris tetrandra (Roxb.)	Haji Samat	S/tree	Non-exclusive							/				
	Morinda elliptica (Hook.f.) Ridl.	Mengkudu Kecil	Tree	Non-exclusive			/				/				
	Scyphiphora hydrophyllacea C.F. Gaertn	Chengam	S/tree	Exclusive		/									
Rhizophoraceae	*Bruguiera cylindrica* (L.) Blume	Berus-berus	Tree	Exclusive			/		/	/			/		/
	Bruguiera gymnorhiza (L.) Lam.	Tumu Merah	Tree	Exclusive			/			/					
	Bruguiera parviflora (Roxb.) Wight & Arn	Lengadai	Tree	Exclusive			/			/					
	Ceriops tagal (Pers.) C.B. Rob	Tengar	Tree	Exclusive			/								
	Rhizophora apiculata Blume	Bakau Minyak	Tree	Exclusive		/	/		/	/			/		/
	Rhizophora mucronata Lam	Bakau Kurap	Tree	Exclusive		/	/		/						/
Rhamnaceae	*Colubrina asiatica* L. *ex* Brongn.	Peria Laut	Shrub	Non-exclusive	/		/	/		/	/				
Rutaceae	*Glycosmis mauritiana* (Lam.) Tanaka	Lelimau	Tree	Non-exclusive		/									
	Micromelum minutum (G. Forst.) Wight & Arn	Cemamak	Tree	Non-exclusive							/				
Sapindaceae	*Lepisanthes rubiginosa* (Roxb.) Leenh	Mertajam	Tree	Non-exclusive							/				
	Mischocarpus sundaicus Blume		S/tree	Non-exclusive		/									
Sapotaceae	*Palaquium obovatum* (Griff.) Engl.	Taban Putih	Tree	Non-exclusive							/	/			
	Pouteria obovata (R.Br.) Baehni	Nenasi	Tree	Non-exclusive		/	/				/	/			
Simaroubaceae	*Eurycoma longifolia* Jack	Tongkat Ali	Tree	Non-exclusive								/			
Sonneratiaceae	*Sonneratia alba* J.J.Sm.	Perepat	Tree	Exclusive			/		/	/	/				
Sterculiaceae	*Heritiera littoralis* Dryand	Dungun	Tree	Non-exclusive								/			
	Sterculia foetida L.	Kelumpang	Tree	Non-exclusive							/				
Tiliaceae	*Microcos tomentosa* Sm.	Kenidai	Tree	Non-exclusive		/					/				
Turneraceae	*Turnera ulmifolia* L.	Yellow Alder	Shrub	Non-exclusive				/							
Ulmaceae	*Trema orientalis* (L.) Blume.	Tampang Besi	Tree	Non-exclusive		/									
Verbenaceae	*Clerodendrum inerme* (L.) Gaertn	Lampin Budak	Shrub	Non-exclusive		/	/			/	/				
	Lantana camara L.	Tahi Ayam	Shrub	Non-exclusive			/								
	Premna serratifolia L	Bebuas	S/tree	Non-exclusive	/				/			/			
	Stachytarpheta indica (L.) Vahl	Selasih Dendi	Herb	Non-exclusive						/					
	Vitex pinnata L.	Levan	Tree	Non-exclusive							/				
Vitaceae	*Cayratia trifolia* (L.) Domin	Lakum	Climber	Non-exclusive			/		/	/	/				/
Total					**19**	**41**	**39**	**15**	**21**	**33**	**57**	**26**	**7**	**3**	**29**

Exclusive = 22 species; Non-exclusive = 90 species; Associate = 9 species


Cordia subcordata


Colubrina asiatica


Ipomoea cairica


Eurycoma longifolia

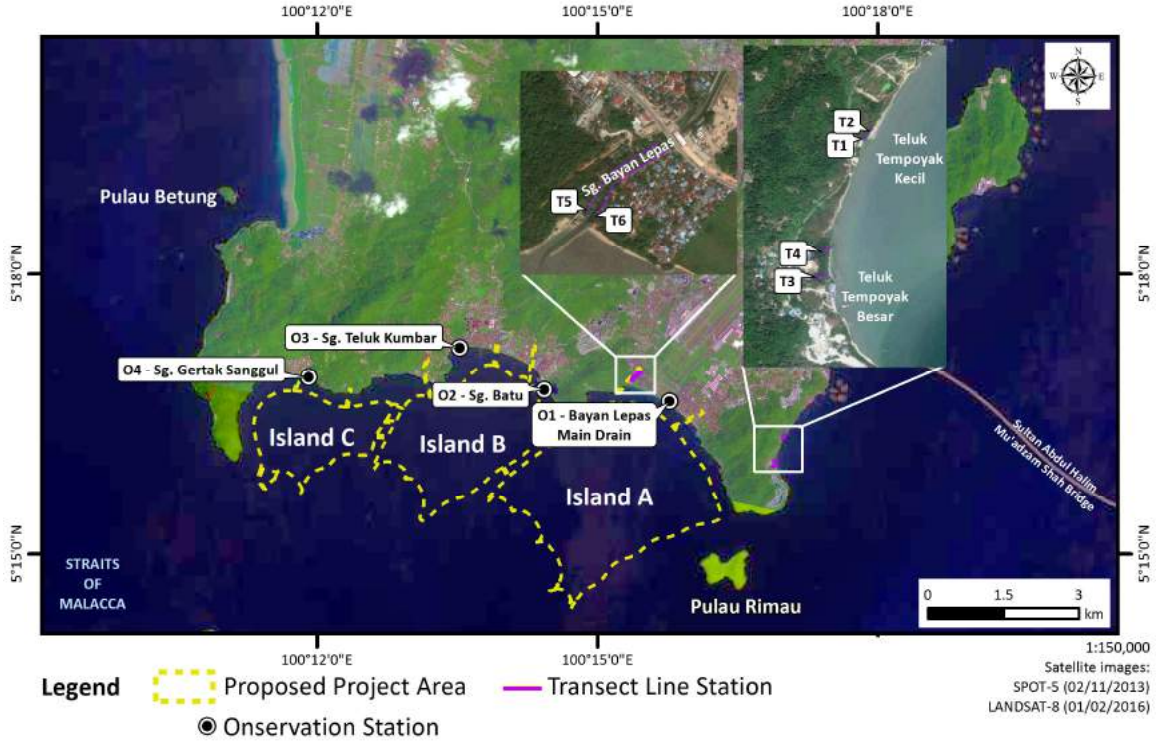

Guettarda spesiosa


Bruguiera gymnorrhiza

F6.51 Floras found during the survey

T6.30 Description of mangrove assessment at the study area

Station	Coordinates		Description				
	Start	End	Date	Time (hours)	Transect Line (m)	Quadrate	Location
Transect Line							
T1	5°16'51.3"N 100°15'21.6"E	5°16'56.7"N 100°15'27.3"E	4/3/16	0800	20	2	Teluk Tempoyak Kecil
T2	5°16'51.3"N 100°15'22.2"E	5°16'56.2"N 100°15'28.1"E		0930	30	3	Teluk Tempoyak Kecil
T3	5°15'56.8"N 100°16'54.4"E	5°15'56.4"N 100°16'52.5"E		1000	50	5	Teluk Tempoyak Besar
T4	5°16'00.3"N 100°16'54.9"E	5°15'59.8"N 100°16'53.3"E	31/5/16	0900	60	6	Teluk Tempoyak Besar
T5	5°16'14.5"N 100°16'59.0"E	5°16'14.8"N 100°16'59.5"E	4/3/16	1100	250	25	Sungai Bayan Lepas (Permatang Tepi Laut)
T6	5°16'15.7"N 100°17'00.4"E	5°16'15.4"N 100°16'59.6"E	1/6/16	0900	250	25	Sungai Bayan Lepas (Kampung Binjai)
Observation							
O1	5°16'55.7"N 100°11'53.7"E	5°16'54.6"N 100°11'53.8"E	1/6/16	1200	Observation	-	Bayan Lepas Main Drain
O2	5°17'15.4"N 100°13'31.3"E	5°17'14.1"N 100°13'26.1"E		1300		-	Sungai Batu
O3	5°16'44.6"N 100°14'25.7"E	5°16'44.9"N 100°14'25.9"E		1100		-	Teluk Kumbar
O4	5°16'42.8"N 100°15'46.5"E	5°16'45.3"N 100°15'47.8"E		1000		-	Gertak Sanggul



F6.52 Location of transect/observation locations for mangrove assessment

6.3.1.2.1 Methodology

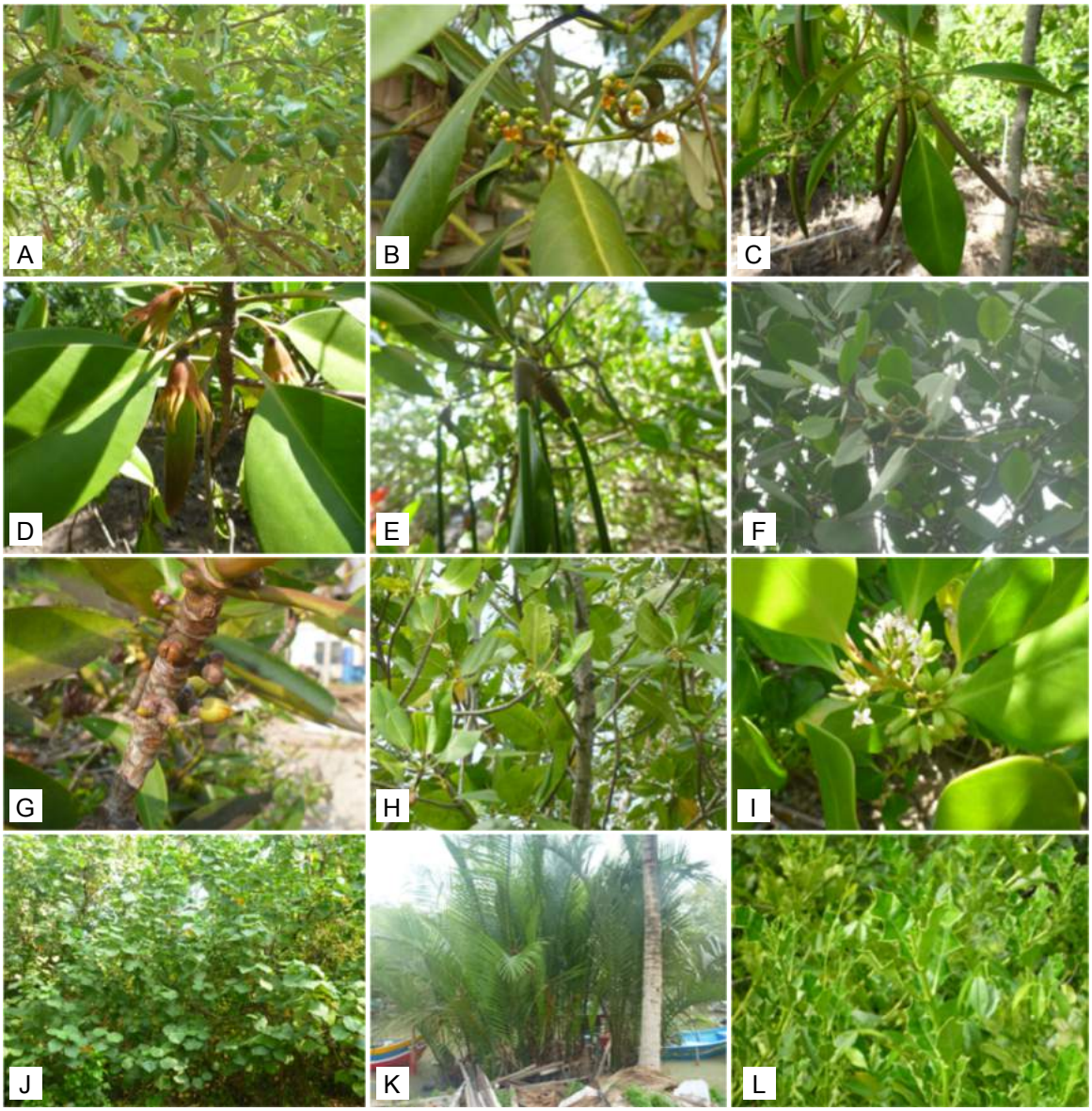
For line-transect sampling, at each transect line, a pole starting at the edge of a mangrove forest marked the first point. It is important to ensure that the transect line is long enough to cover the habitat, particularly the succession line. The transect tape was laid until it reached the other end of the mangrove forest in a straight line, and the end point was also marked by a pole (F6.53A). Quadrates (10 m x 10 m) were marked off against the transect line (F6.53B). Both surveys (line-transect sampling and ground observations) recorded major characteristics such as sediment type, number of trees, mangrove speciation, girth sizes and height (F6.53C and F6.53D).

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 several reference books, such as by Primavera *et al.* (2004) and Rusila Noor *et al.* (1999).

F6.53 Mangrove assessment. A: Employed 50 m line transect, B: Marked 10.0 m x 10.0 m quadrate against the transect line, C-D: Girth size measurement

6.3.1.2.2 Results

11 species of mangroves belonging to four families were recorded. The most dominant group at the study area was family Rhizophoraceae, represented by six species, followed by families Acanthaceae and Sonneratiaceae with two species each and family Rubiaceae with one species (F6.54 and T6.31). Rhizophoraceae has a widespread distribution worldwide, since its members are able to adapt to extreme environments. This is related to the ability of their propagules to survive prolonged submersion in seawater (Tomlinson, 1986). The Diameter Breast Height (DBH) and heights of mangrove trees ranged from 4 to 250 cm and 4.5 to 35 m, respectively. As for mangrove saplings, the DBH ranged from 2 to 25 cm with heights from 0.5 to 4 m (T6.32).



F6.54 Mangroves found at the study area. A: Api – Api Putih (*Avicennia alba*), B: Api-api Ludat (*Avicennia officinalis*), C: Bakau Berus (*Bruguiera cylindrica*), D: Tumu Merah (*Bruguiera gymnorrhiza*), E: Tengar (*Ceriops tagal*), F: Perepat (*Sonneratia alba*), G: Bakau Minyak (*Rhizophora apiculata*), H: Bakau Kurap (*Rhizophora mucronata*), I: Chengam (*Scyphiphora hydrophyllacea*), J: Bebaru (*Hibiscus tiliaceus*), K: Nipah (*Nypa fruticans*), L: Jeruju Hitam (*Acanthus illicifolius*)

T6.31 Mangrove species found at the study area

Family	Scientific Name	Local Name	Life Form	Abundance
True Mangrove				
Rhizophoraceae	*Bruguiera cylindrica*	Bakau Berus	Tree	Common
	Bruguiera gymnorrhiza	Tumu Merah	Tree	Common
	Bruguiera parviflora	Lenggadai	Tree	Rare
	Ceriops tagal	Tengar	Tree	Common
	Rhizophora apiculata	Bakau Minyak	Tree	Common
	Rhizophora mucronata	Bakau Kurap	Tree	Rare
Acanthaceae	*Avicennia alba*	Api-api Putih	Tree	Common
	Avicennia officinalis	Api-api Ludat	Tree	Common
Sonneratiaceae	*Sonneratia alba*	Perepat	Tree	Rare
	Sonneratia caseolaris	Berembang	Tree	Rare
Rubiaceae	*Scyphiphora hydrophyllacea*	Chengam	Tree	Rare
Mangrove Associate				
Malvaceae	*Hibiscus tiliaceus*	Bebaru	Shrub	Commonh
Arecaceae	*Nypa fruticans*	Nipah	Tree	Rare
Acanthaceae	*Acanthus illicifolius*	Jeruju Hitam	Shrub	Rare

T6.32 Mangrove transects at the study area

Location	Transect/ Observation	Species	Type	Number of Trees	DBH (cm)	Height (m)
Line-Transect Sampling						
Teluk Tempoyak Kechil (T1) Start: 05°16.261' N, 100°17.007' E End: 05°16.257' N, 100°16.994' E	T1Q1	*Rhizophora apiculata*	Trees	8	10-12	4.5-5
	T1Q2		Saplings	5	5-14	2.5-4
Teluk Tempoyak Kechil (T2) Start: 05°16.242' N, 100°16.983' E End: 05°16.247' N, 100°16.992' E	T2Q1	*Avicennia alba*	Trees	4	59-89	7-11
		Rhizophora apiculata	Trees	1	60	6.5
			Saplings	1	30	3.5
	T2Q2	*Rhizophora apiculata*	Trees	1	41	5.5
		Sonneratia sp.	Trees	1	69	14.5
	T2Q3	*Avicennia officinalis*	Trees	1	29	5
		Rhizophora apiculata	Trees	2	70-90	8-9.5
Teluk Tempoyak Besar (T3) End (05°15.996' N, 100°16.889' E) Start (05°16.005' N, 100°16.915' E)	T3Q1	*Avicennia officinalis*	Trees	1	18	4.5
			Saplings	1	11	2.5
		Bruguiera cylindrica	Trees	12	12-64	5-10.5
			Saplings	50	2.3-11	1.4-4
		Ceriops tagal	Trees	3	16-170	5-12
			Saplings	21	5-11	2.5-4
	T3Q2	*Avicennia officinalis*	Trees	1	85	8
			Saplings	1	5	2

T6.32 Mangrove transects at the study area (cont'd)

Location	Transect/ Observation	Species	Type	Number of Trees	DBH (cm)	Height (m)
Line-Transect Sampling						
Teluk Tempoyak Besar (T3) End (05°15.996' N, 100°16.889' E) Start (05°16.005' N, 100°16.915' E)	T3Q2	*Bruguiera cylindrica*	Trees	6	16-64	7-15
			Saplings	41	5-11	3-2.5
		Bruguiera gymnorrhiza	Trees	1	43	10
			Saplings	6	5-6	2-3
		Ceriops tagal	Trees	2	14-22	5.5
			Saplings	7	5-9	2.3-2.5
		Rhizophora apiculata	Saplings	1	11	4
	T3Q3	*Avicennia alba*	Trees	2	230-250	15-16
		Bruguiera cylindrica	Trees	5	13-18	5.5-8
			Saplings	26	5-25	1.8-4
		Ceriops tagal	Trees	1	14	5.5
		Rhizophora apiculata	Trees	3	15-18	6.5
			Saplings	2	6-7	3
	T3Q4	*Bruguiera cylindrica*	Trees	3	13-24	5.5-12
		Bruguiera gymnorrhiza	Trees	1	31	8
			Saplings	1	7	2
		Rhizophora apiculata	Trees	1	21	5.5
		Rhizophora mucronata	Trees	2	30-200	5.5-35
			Saplings	2	9-15	3-4
	T3Q5	*Bruguiera cylindrica*	Trees	4	32-70	9.5-12
		Ceriops tagal	Trees	9	11-78	4.5-20
Teluk Tempoyak Besar (T4) Start (05°15.947' N, 100°16.907' E) End (05°15.940' N, 100°16.875' E)	T4Q1	*Avicennia officinalis*	Trees	2	101-170	18-20
			Saplings	2	5-18	2.2-4
		Bruguiera cylindrica	Trees	5	10-60	5-12
			Saplings	36	3-10	1.8-4
		Ceriops tagal	Trees	5	12-22	5-7
			Saplings	32	4-12	1.4-4
		Bruguiera gymnorrhiza	Saplings	26	4-5	2
	T4Q2	*Avicennia officinalis*	Trees	1	70	8
		Bruguiera cylindrica	Trees	1	30	12
			Saplings	36	3-10	0.5-4
		Bruguiera gymnorrhiza	Trees	1	41	10
			Saplings	19	2-8	0.5-4
		Ceriops tagal	Saplings	12	4-10	2-4
	T4Q3	*Avicennia officinalis*	Trees	1	280	20
			Saplings	3	6	4
		Bruguiera cylindrica	Trees	19	6-60	5-10
			Saplings	15	4-8	2-4

T6.32 Mangrove transects at the study area (cont'd)

Location	Transect/ Observation	Species	Type	Number of Trees	DBH (cm)	Height (m)
Line-Transect Sampling						
Teluk Tempoyak Besar (T4) Start (05°15.947' N, 100°16.907' E) End (05°15.940' N, 100°16.875' E)	T4Q3	*Bruguiera gymnorrhiza*	Trees	1	4	5
			Saplings	4	2-8	0.5-3
		Rhizophora apiculata	Trees	2	15-46	6-10
		Ceriops tagal	Saplings	2	8	4
	T4Q4	*Avicennia officinalis*	Trees	3	40-50	7-8
		Bruguiera cylindrica	Trees	3	10-40	7-8
		Bruguiera gymnorrhiza	Trees	1	12	5
		Rhizophora apiculata	Trees	7	20-70	7-12
	T4Q5	*Bruguiera cylindrica*	Trees	14	6-50	5-12
		Bruguiera parviflora	Trees	6	6-50	5-8
		Ceriops tagal	Trees	3	12-16	5-7
		Rhizophora apiculata	Trees	9	6-60	5-12
		Bruguiera gymnorrhiza	Saplings	1	12	4
		Rhizophora apiculata	Saplings	1	10	4
	T4Q6	*Bruguiera cylindrica*	Trees	33	6-70	5-10
			Saplings	5	4-5	2
		Bruguiera parviflora	Trees	1	12	8
		Rhizophora apiculata	Trees	19	8-40	6-10
Sungai Bayan Lepas-Permatang Tepi Laut (T5) Start (05°16.855' N, 100°15.370' E) End (05°16.936' N, 100°15.469' E)	T5Q1	*Avicennia alba*	Trees	6	15-46	4.5-10
	T5Q2	No mangrove recorded				
	T5Q3					
	T5Q4					
	T5Q5	*Avicennia alba*	Trees	1	35	8
			Saplings	1	7	2
	T5Q6	*Avicennia alba*	Trees	2	58-67	14-15
		Sonneratia caseolaris	Trees	1	70	8
	T5Q7	*Avicennia alba*	Trees	4	30-70	7-15
		Sonneratia sp.	Trees	2	45-48	10
	T5Q8	No mangrove recorded				
	T5Q9	*Avicennia alba*	Trees	2	60-70	15
		Avicennia officinalis	Trees	1	40	7
		Avicennia sp.	Trees	1	50	8

T6.32 Mangrove transects at the study area (cont'd)

Location	Transect/ Observation	Species	Type	Number of Trees	DBH (cm)	Height (m)
Line-Transect Sampling						
Sungai Bayan Lepas-Permatang Tepi Laut (T5) Start (05°16.855' N, 100°15.370' E) End (05°16.936' N, 100°15.469' E)	T5Q9	*Rhizophora apiculata*	Trees	1	30	7
		Sonneratia sp.	Trees	1	70	8
	T5Q10	*Avicennia officinalis*	Trees	1	50	8
		Rhizophora apiculata	Trees	1	25	10
	T5Q11	No mangrove recorded				
	T5Q12					
	T5Q13					
	T5Q14	*Avicennia alba*	Trees	1	70	12
	T5Q15	No mangrove recorded				
	T5Q16					
	T5Q17					
	T5Q18					
	T5Q19					
	T5Q20					
	T5Q21	*Avicennia alba*	Trees	3	30-60	10-14
	T5Q22	*Avicennia alba*	Trees	3	70-120	12-15
	T5Q23	No mangrove recorded				
	T5Q24					
	T5Q25	*Avicennia alba*	Trees	2	40-60	15
		Sonneratia alba	Trees	1	70	15
Sungai Bayan Lepas-Kampung Binjai (T6) Start: 05°16.856' N, 100°15.360' E End: 05°16.945'N, 100°15.455' E	T6Q1	*Avicennia alba*	Trees	2	60-70	15
		Rhizophora apiculata	Trees	1	25	6
		Sonneratia alba	Trees	2	25-35	6-7
			Saplings	1	8	2
	T6Q2	No mangrove recorded				
	T6Q3					
	T6Q4	*Avicennia alba*	Trees	3	25-40	6-7
			Trees	5	30-60	6-10
		Avicennia officinalis	Trees	1	20	7
			Trees	2	40-70	7-10
		Sonneratia alba	Trees	3	30-50	6-10
	T6Q5	No mangrove recorded				
	T6Q6					
	T6Q7	*Rhizophora mucronata*	Trees	1	30	10
	T6Q8	No mangrove recorded				
	T6Q9	*Avicennia alba*	Trees	1	40	10
		Avicennia officinalis	Trees	4	20-70	7-10
		Rhizophora apiculata	Trees	1	30	10

T6.32 Mangrove transects at the study area (cont'd)

Location	Transect/ Observation	Species	Type	Number of Trees	DBH (cm)	Height (m)
Line-Transect Sampling						
Sungai Bayan Lepas-Kampung Binjai (T6) Start: 05°16.856' N, 100°15.360' E End: 05°16.945'N, 100°15.455' E	T6Q10	*Avicennia alba*	Trees	2	12-140	4.5-20
			Saplings	25	5	2
		Rhizophora sp.	Saplings	3	4	1
	T6Q11	*Avicennia officinalis*	Trees	5	20-55	5-10
			Saplings	3	15	2
		Bruguiera cylindrica	Trees	3	10-35	5-10
			Saplings	3	3	1
		Sonneratia alba	Trees	3	35-55	10
			Saplings	4	4-10	2-4
	T6Q12	*Avicennia officinalis*	Trees	8	30-75	8-10
		Bruguiera gymnorrhiza	Trees	1	40	10
		Rhizophora apiculata	Trees	3	10-20	7-10
		Sonneratia alba	Trees	5	50-70	10
	T6Q13	No mangrove recorded				
	T6Q14	*Avicennia alba*	Trees	2	120-130	12
		Avicennia officinalis	Trees	7	40-50	10
		Rhizophora apiculata	Trees	4	10-15	6-7
			Saplings	5	3-4	2
		Sonneratia alba	Trees	5	55-70	10-12
	T6Q15	No mangrove recorded				
	T6Q16	*Avicennia alba*	Trees	18	10-110	5-12
		Avicennia officinalis	Trees	6	45-90	8-12
		Rhizophora apiculata	Trees	6	45-90	10-12
			Saplings	24	3-4	0.5-1
		Sonneratia alba	Trees	1	60	12
		Bruguiera cylindrica	Saplings	1	8	3
	T6Q17	No mangrove recorded				
	T6Q18	*Avicennia alba*	Trees	4	50-170	10-12
			Saplings	25	3-4	0.5-1
		Avicennia officinalis	Trees	8	20-60	7-10
		Bruguiera gymnorrhiza	Trees	1	45	12
		Avicennia sp.	Saplings	20	2-3	0.5
	T6Q19	No mangrove recorded				
	T6Q20	*Avicennia officinalis*	Trees	8	30-70	7-12
			Saplings	2	10	3-4
		Bruguiera cylindrica	Trees	2	20-40	5-10
			Saplings	2	10-15	3-4

T6.32 Mangrove transects at the study area (cont'd)

Location	Transect/ Observation	Species	Type	Number of Trees	DBH (cm)	Height (m)
Line-Transect Sampling						
Sungai Bayan Lepas -Kampung Binjai (T6) Start: 05°16.856' N, 100°15.360' E End: 05°16.945'N, 100°15.455' E	T6Q20	*Sonneratia alba*	Trees	1	70	12
	T6Q21	*Avicennia alba*	Trees	6	35-70	8-12
		Avicennia officinalis	Trees	7	20-70	6-12
		Bruguiera cylindrica	Trees	5	15	6
		Rhizophora apiculata	Trees	4	15-50	7-10
		Rhizophora mucronata	Trees	1	40	10
		Sonneratia alba	Trees	3	50-90	10-12
		Avicennia sp.	Saplings	20	2-3	0.5
	T6Q22	No mangrove recorded				
	T6Q23					
	T6Q24					
	T6Q25	*Avicennia alba*	Trees	5	50-100	10-12
		Avicennia officinalis	Trees	5	40-60	8-10
Ground Observation						
Bayan Lepas Main Drain (O1) Start: 05°16.714' N, 100°15.775' E End: 05° 16.755'N, 100° 15.797'E	O1	*Sonneratia* sp.	Trees	32	12-15	5-6
			Saplings	9	8-12	2-4
Sungai Batu (O2) Start: 05° 16.743' N, 100° 14.428' E End: 05° 16.749'N, 100° 14.432' E	O2	*Scyphiphora hydrophyllacea*	Trees	2	50-60	5
			Saplings	1	50	4
Teluk Kumbar (O3) Start: 05° 17.256' N, 100° 13.522' E End: 05° 17.235' N, 100° 13.435'E	O3	*Avicennia* sp.	Trees	7	32-150	8-12
		Rhizophora sp.	Trees	3	22-25	6-7
Gertak Sanggul (O4) Start: 05°16.928' N, 100°11.895' E End: 05° 16.910' N, 100° 11.897' E	Q4	*Avicennia* sp.	Trees	1	40	5
			Saplings	2	6-8	3

At Teluk Tempoyak Kecil, the major species recorded was Bakau Minyak (*Rhizophora apiculata*). *Rhizophora apiculata* has been known as a salt-resistant species that commonly prefers deep soft mud, but it is also capable of growing in sandy soil and coral ramparts. Moreover, this species is also easily propagated by propagules (Qifeng *et al*., 2009; Selvam, 2007). There were also saplings of Bakau Minyak (*Rhizophora apiculata*) recorded at these areas, indicating a capability for natural regeneration. Other mangrove species found included Api-api Putih (*Avicennia alba*), Api-api Ludat (*Avicennia officinalis*) and *Sonneratia* sp.. *Rhizophora* strands were easily distinguished by their distinctive stilt roots and bark patterns, while pencil-like pneumatophores and thick cone-shaped pneumatophores characterised *Avicennia* and *Sonneratia* respectively (Primavera *et al*., 2004).

Mangroves at Teluk Tempoyak Besar formed a slightly dense forest and the distribution pattern was found to be fairly uniform. Species such as Bakau Berus (*Bruguiera cylindrica*), Tumu Merah (*Bruguiera gymnorrhiza*) and Tengar (*Ceriops tagal*) were recorded from the seaward to the landward zones, where the most abundant was Bakau Berus (*Bruguiera cylindrica*).

Bruguiera cylindrica is a type of facultative mangrove that has no morphological structures to secrete salt, however, it can adapt to salinity conditions through physiological processes (Anukriti *et al*., 2009; Hanagata *et al*., 1999). Both *Bruguiera* and *Ceriops* could be recognised through the knee roots. However, *Bruguiera* possesses flowers in a cup-shaped calyx, while *Ceriops* flowers are in a ball-shaped calyx (Primavera *et al*., 2004).

Other species such as Api-api Ludat (*Avicennia officinalis*) were only recorded at the seaward zone, while Api-api Putih (*Avicennia alba*), Lenggadai (*Bruguiera parviflora*), Bakau Minyak (*Rhizophora apiculata*) and Bakau Kurap (*Rhizophora mucronata*) were mostly found towards the inland. Many previous studies had reported that species zonation patterns in mangroves were influenced by the geomorphological processes, differential dispersal of propagules by tidal action, differential predation of propagules, physiological specialisation and interspecific competition (Mckee, 1993; Smith, 1987; Ball, 1980; Rabinowitz, 1978; Thom, 1967). Mangrove saplings were also found, where the most dominant species was Bakau Berus (*Bruguiera cylindrica*) (F6.55).

F6.55 Mangrove saplings at Teluk Tempoyak Besar

Additionally, species of mangrove associates i.e. Bebaru (*Hibiscus tiliaceus*) were recorded in Teluk Tempoyak Besar. The mangrove associated species (or “non exclusive” species) are 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 associates behave differently from true mangroves. Moreover, they do not show higher salt tolerance and mostly grew best in freshwater environment (Youssef, 2007).

At Permatang Tepi Laut, the mangroves recorded were less dense with the most dominant species being Api-api Putih (*Avicennia alba*). *Avicennia alba* is a true halophyte and salt excreting species; hence, can tolerate high salinity levels (Chowdury, 2015; Harekrishna *et al*., 2014). A study by Nur Arina *et al*. (2010) reported that this species was highly tolerant on excess sedimentation in their natural habitat. Other mangrove species such as Api-api Ludat (*Avicennia officinalis*), Bakau Minyak (*Rhizophora apiculata*), Perepat (*Sonneratia alba*) and Berembang (*Sonneratia caseolaris*) were also recorded. Saplings of Api-api Putih (*Avicennia*

alba) were also found during the current study. Additionally, two species of mangrove associates were recorded at this area, namely Nipah (*Nypa fruticans*) and Jeruju Hitam (*Acanthus illicifolius*).

A uniform distribution of mangroves were recorded in Kampung Binjai. Major species such as Api-api Putih (*Avicennia alba*), Api-api Ludat (*Avicennia officinalis*), Bakau Minyak (*Rhizophora apiculata*) and Perepat (*Sonneratia alba*) were scattered along the river banks of Sungai Bayan Lepas. Inland species recorded include Bakau Berus (*Bruguiera cylindrica*), Tumu Merah (*Bruguiera gymnorrhiza*) and Bakau Kurap (*Rhizophora mucronata*), though with low density. Saplings of *Sonneratia alba, Avicennia alba, Avicennia officinalis, Bruguiera cylindrica* and *Rhizophora apiculata* also occupied this area. As with Permatang Tepi Sungai, mangrove associates such as Nipah (*Nypa fruticans*) and Jeruju Hitam (*Acanthus illicifolius*) were also recorded at this area.

Patches of mangroves were also recorded at Bayan Lepas Main Drain, Sungai Batu, Teluk Kumbar and Gertak Sanggul. The mangroves at these sites consisted of three major genera i.e. *Avicennia*, *Rhizophora* and *Sonneratia* and single species i.e. Chengam (*Scyphiphora hydrophyllacea*). The occurrence of *Avicennia*, *Rhizophora* and *Sonneratia* in the other areas of Penang have also been reported in previous studies (Asyraf *et al*., 2015; Wan Nur Fasihah Zarifah and Asyraf, 2012; Siti Nurfazilah *et al*., 2010). *S. hydrophyllacea* is an uncommon species of mangroves in the Southeast Asian countries (Solomon Raju and Rajesh, 2014). This species generally inhabits the muddy, sandy and rocky substrates at the inland area. Previous studies have reported that *S. hydrophyllacea* is intolerant of lengthy periods of freshwater inundation and commonly occupies areas with frequent tidal inundation (Wim *et al*., 2006).

6.3.1.3 Fauna

The study of fauna within the Project area was only focused on avifauna i.e. birds. Other types of terrestrial fauna were considered insignificant for this Project.

Davison and Chew (1995) recorded a total of 639 bird species in Peninsular Malaysia. Wells (1999) reported approximately 380 species of birds that depend on the forest or forest fringe in Peninsular Malaysia, and these form over 60% of the recorded birds. Migratory species are only recorded during the migratory season which is from mid October until May. Therefore, any visit falling within this period will see more migratory species than local species. Some migratory species compete for similar resources with the local species and might temporarily displace them from the area, resulting in a decline of their population (Sekercioglu, 2012). Species tolerant to habitat change, the survivor groups, are less likely to decline (Harris and Pimm, 2004). The totally dependent species have a low tolerance for habitat change. The factors responsible for this low tolerance include relative inability of these species to colonise required habitat or to adapt to new habitat, as well as changes in dietary guilds (Lim and Sodhi, 2004).

Nowadays, urbanisation is known as one of the serious events that occur worldwide involving significant changes to the natural environment and affecting the ecological components of forests (Fontana *et al.*, 2011). It also has the greatest local effect on wildlife because of its persistence on the landscape and its dissimilarity to natural land cover (Marzluff and Ewing, 2001).

The protection of wildlife in Peninsular Malaysia is governed by the Wildlife Conservation Act 2010 which provides for the protection and conservation of wildlife and for matters connected therewith. Under this Wildlife Act, there are two categories of birds. Schedule 1 consists of protected wildlife (16 bird species) and other protected wildlife (240 bird species), Schedule II

consists of totally protected wildlife (more than 700 bird species). Wildlife means any species of wild animal or wild bird, whether totally protected or protected, vertebrate or invertebrate, live or dead, mature or immature and whether or not may be tamed or bred in captivity.

6.3.1.3.1 Methodology

The objective of the survey was to obtain an inventory of the avifauna of the study area, by using visual and audio identification methods besides photography. Surveys were done from 2nd to 6th February 2016 at Teluk Kumbar, Batu Maung, Permatang Damar Laut, Permatang Tepi Laut, Pulau Rimau, Pulau Kendi, Gertak Sanggul, Kampung Nelayan, Sungai Betung and Balik Pulau.

At each study site, three persons were involved in observations along the river, islands namely Pulau Rimau and Pulau Kendi, and roadside. Bird observations were made early in the morning at 08:00 am until 11:00 am and between 17:00 pm to 18:00 pm. Each bird observed was photographed whenever possible using Nikon D3X mounted with Nikkor 600 mm f/4 lens and Nikon D500 mounted with Nikkor 200-500 mm f/4 lens + 2x TC.

6.3.1.3.2 Results

T6.33 tabulates the list of avifauna found within the study area and its status based on IUCN Red List of Threatened Species, 2007 in which all of the avifauna recorded are categorised under the status Least Concerned (LC). F6.56 shows some of the avifauna observed at the study area.

T6.33 List of avifauna found at the study area

Location	English Name of Species	Species Name	Sighting	Status
Teluk Kumbar and Batu Maung	Black-naped Oriole	*Oriolus chinensis*	✓	LC
	Brahminy Kite	*Haliastur Indus*	✓	LC
	Blue-throated Bee-eater	*Merops viridis*	✓	LC
	Common Myna	*Acridotheres tristis*	✓	LC
	Common Tailorbird	*Orthotomus sutorius*	✓	LC
	Eurasian Tree Sparrow	*Passer montanus*	✓	LC
	House Crow	*Corvus splendens*	✓	LC
	Little Egret	*Egretta garzetta*	✓	LC
	Little Heron	*Butorides striata*	✓	LC
	Pacific Swallow	*Hirundo tahitica*	✓	LC
	Peaceful Dove	*Geopelia placida*	✓	LC
	Philippine Glossy Starling	*Aplonis panayensis*	✓	LC
	Pied Triller	*Lalage nigra*	✓	LC
	Red-eyed Bulbul	*Pycnonotus brunneus*	✓	LC
	Stork-billed Kingfisher	*Pelargopsis capensis*	✓	LC
	White-breasted Waterhen	*Amaurornis phoenicurus*	✓	LC
	White-throated Kingfisher	*Halcyon smyrnensis*	✓	LC
	Yellow-vented Bulbul	*Pycnonotus goiavier*	✓	LC

T6.33 List of avifauna found at the study area

Location	English Name of Species	Species Name	Sighting	Status
Kampung Nelayan and Pulau Betung	Black-naped Oriole	*Oriolus chinensis*	✓	LC
	Brown-throated Sunbird	*Anthreptes malacensis*	✓	LC
	Asian Koel	*Eudynamys scolopaceus*	✓	LC
	Common Sandpiper	*Actitis hypoleucos*	✓	LC
	House Crow	*Corvus splendens*	✓	LC
	Little Heron	*Butorides striata*	✓	LC
	Philippine Glossy Starling	*Aplonis panayensis*	✓	LC
	Malaysian Pied Fantail	*Rhipidura javanica*	✓	LC
	Stork-billed Kingfisher	*Pelargopsis capensis*	✓	LC
	White-bellied Sea Eagle	*Haliaeetus leucogaster*	✓	LC
	White-throated Kingfisher	*Halcyon smyrnensis*	✓	LC
Gertak Sanggul	Black-naped Oriole	*Oriolus chinensis*	✓	LC
	Brown-throated Sunbird	*Anthreptes malacensis*	✓	LC
	Common Sandpiper	*Actitis hypoleucos*	✓	LC
	Eurasian Tree Sparrow	*Passer montanus*	✓	LC
	House Crow	*Corvus splendens*	✓	LC
	Little Heron	*Butorides striata*	✓	LC
	Yellow-vented Bulbul	*Pycnonotus goiavier*	✓	LC
Permatang Damar Laut and Permatang Tepi Laut	Black-naped Oriole	*Oriolus chinensis*	✓	LC
	Blue-tailed Bee-eater	*Merops philippinus*	✓	LC
	Common Iora	*Aegithina tiphia*	✓	LC
	Asian Koel	*Eudynamys scolopaceus*	✓	LC
	Common Myna	*Acridotheres tristis*	✓	LC
	Common Sandpiper	*Actitis hypoleucos*	✓	LC
	Eurasian Tree Sparrow	*Passer montanus*	✓	LC
	House Crow	*Corvus splendens*	✓	LC
	Javan Myna	*Acridotheres javanicus*	✓	LC
	Little Egret	*Egretta garzetta*	✓	LC
	Little Heron	*Butorides striata*	✓	LC
	Orange-bellied Flowerpecker	*Dicaeum trigonostigma*	✓	LC
	Pacific Swallow	*Hirundo tahitica*	✓	LC
	Purple-naped Sunbird	*Hypogramma hypogrammicum*	✓	LC
	Yellow-vented Bulbul	*Pycnonotus goiavier*	✓	LC
Pulau Rimau and Pulau Kendi	Brahminy Kite	*Haliastur Indus*	✓	LC
	Common Sandpiper	*Actitis hypoleucos*	✓	LC
	Common Tern	*Sterna hirundo*	✓	LC
	Little Heron	*Butorides striata*	✓	LC
	Red-eyed Bulbul	*Pycnonotus brunneus*	✓	LC
	Stork-billed Kingfisher	*Pelargopsis capensis*	✓	LC
	White-bellied Sea Eagle	*Haliaeetus leucogaster*	✓	LC
	White-throated Kingfisher	*Halcyon smyrnensis*	✓	LC


Black-naped Oriole


Blue-throated Bee-eater


White-throated Kingfisher


Yellow-vented Bulbul


Philippine Glossy Starling


Peaceful Dove


Brahminy Kite


Pacific Swallow


House Crow


Asian Koel


Little Heron


Eurasian Tree Sparrow


Stork-billed Kingfisher


Common Sandpiper


Malaysian Pied Fantail


White-breasted Waterhen


Common Myna


Brown-throated Sunbird

F6.56 Avifauna found at the study area

6.3.2 Marine Biology

The environmental baseline study involved the collection of primary data for the following:

a) biological productivity (phytoplankton, zooplankton and macrobenthos);
b) coral reefs;
c) turtles; and
d) fish.

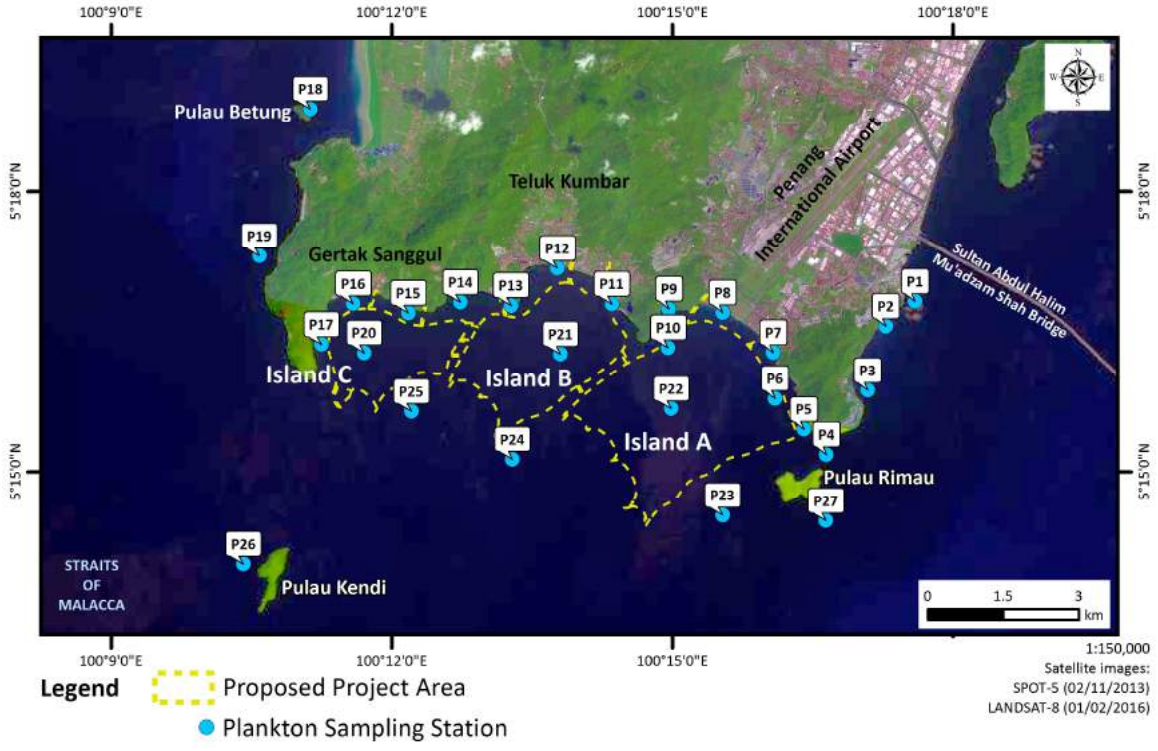
6.3.2.1 Biological Productivity

The primary data collection for biological productivity was based on a stratified sampling method, which involved allocation of sampling points at designated location within and outside the reclamation footprint based on a sampling grid of 1 km x 1 km. Details of the sampling and analytical regimes are provided below.

6.3.2.1.1 Phytoplankton and Zooplankton

a) Methodology

A total of 27 sampling stations were involved i.e. 19 stations along the foreshore area, three within the reclamation area/footprint, three offshore area (outside the reclamation footprint) and one each off Pulau Kendi and Pulau Rimau (F6.57 and T6.34).



F6.57 Location of the sampling stations for Plankton assessment (P1-P27)

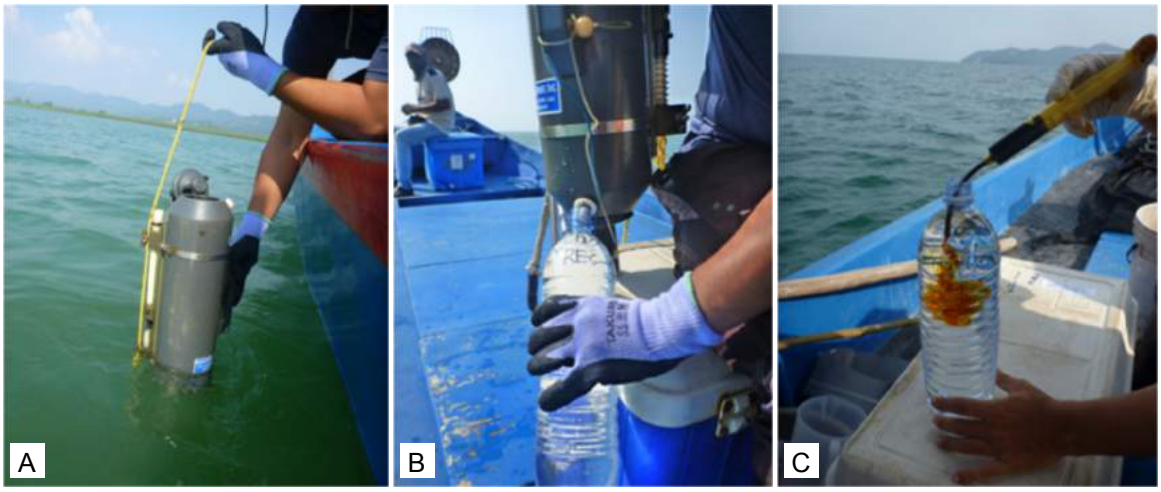
T6.34 Description of the sampling stations for Plankton (Phytoplankton and Zooplankton) assessment

Station	Coordinates		Description			
	Latitude	Longitude	Date	Time	Tide	Weather
Foreshore Area						
P1	05°16.800'N	100°17.628'E	3/3/16	1250	Low neap tide	Sunny
P2	05°16.494'N	100°17.430'E		1255	Low neap tide	Sunny
P3	05°15.883'N	100°17.092'E		1245	Low neap tide	Sunny
P4	05°15.180'N	100°16.649'E		1235	Low neap tide	Sunny
P5	05°15.459'N	100°16.419'E		1300	Low neap tide	Sunny
P6	05°15.827'N	100°16.203'E		1305	Low neap tide	Sunny
P7	05°16.217'N	100°16.025'E		1310	Low neap tide	Sunny
P8	05°16.614'N	100°15.501'E		1330	Low neap tide	Sunny
P9	05°16.701'N	100°14.945'E		1325	Low neap tide	Sunny
P10	05°16.403'N	100°14.895'E		1315	Low neap tide	Sunny
P11	05°16.784'N	100°14.355'E		1205	Low neap tide	Sunny
P12	05°17.139'N	100°13.775'E		1155	Low neap tide	Sunny
P13	05°16.773'N	100°13.274'E		1145	Low neap tide	Sunny
P14	05°16.813'N	100°12.738'E		1140	Low neap tide	Sunny
P15	05°16.698'N	100°12.171'E		1130	Low neap tide	Sunny
P16	05°16.795'N	100°11.590'E		1120	Low neap tide	Sunny
P17	05°16.365'N	100°11.248'E		1110	Low neap tide	Sunny
P18	05°18.890'N	100°11.144'E	4/3/16	1620	Low neap tide	Sunny
P19	05°17.308'N	100°10.586'E		1700	Low neap tide	Sunny
Reclamation Area (Within Reclamation Footprint)						
P20	05°16.275'N	100°11.702'E	3/3/16	1105	Low neap tide	Sunny
P21	05°16.263'N	100°13.811'E		1210	Low neap tide	Sunny
P22	05°15.670'N	100°14.988'E		1220	Low neap tide	Sunny
Offshore Area (Outside Reclamation Footprint)						
P23	05°14.541'N	100°15.531'E	3/3/16	1225	Low neap tide	Sunny
P24	05°15.143'N	100°13.293'E		1045	Low neap tide	Sunny
P25	05°15.653'N	100°12.218'E		1055	Low neap tide	Sunny
Off Pulau Kendi						
P26	05°14.009'N	100°10.415'E	3/3/16	1000	Low neap tide	Sunny
Off Pulau Rimau						
P27	05°14.523'N	100°16.636'E	3/3/16	1240	Low neap tide	Sunny

■ Phytoplankton

The phytoplankton assessment involved the collection of water samples at the designated sampling points. At each sampling station the following standard procedures were employed:

i) water samples were collected using Niskin Water Sampler (F6.58A).
ii) 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 (F6.58B).
iii) 15 mL of Lugol's iodine solution was added as preservatives (F6.58C).



F6.58 Phytoplankton assessment. A: Sample collected using Niskin water sampler, B: Mixture of surface, middle and bottom water of the water column transferred in the PET plastic bottle, C: Samples preserved with 15 mL Lugol's iodine solution

At the laboratory:

i) phytoplankton composition and diversity was determined by firstly concentrating, and then followed with sub-sampling and counting using an inverted microscope.
ii) plankton samples were identified at family and genus/species using a high compound microscope. Phytoplankton density was calculated in terms of number of cells per millilitres (cells/mL).
iii) plankton diversity was assessed based on the Shannon-Weiner Diversity Index (H'), which provides information about rarity and commonness of species in a community. A high 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 formula:

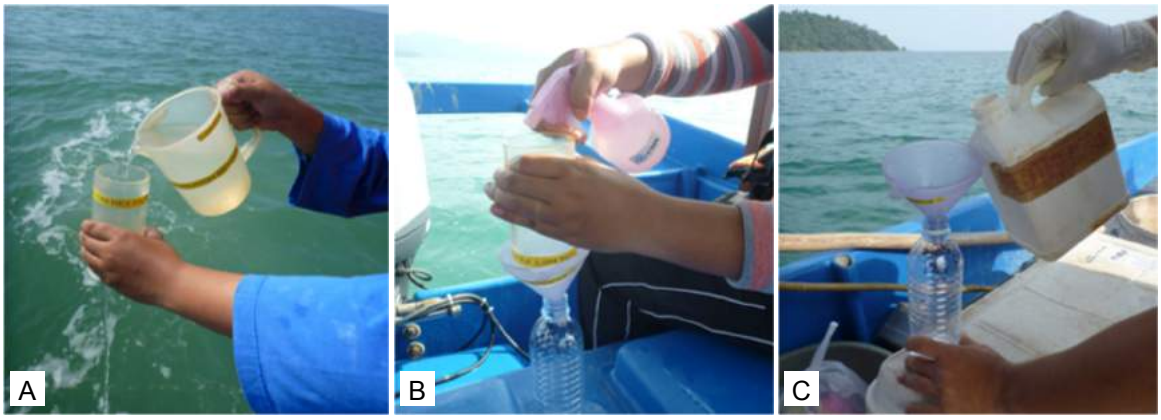
$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

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

■ Zooplankton

For the zooplankton assessment, sampling stations also coincided with the phytoplankton sampling stations. At each sampling station:

i) 20 litres of a mixture of surface, middle and bottom water of the water column was collected and filtered through 140 mm plankton net (F6.59A).
ii) zooplankton samples retained on the plankton net were washed into a 500 mL bottle and labelled (F6.59B).
iii) 10% formaldehyde was added as preservatives (F6.59C).



F6.59 Zooplankton assessment. A: Water filtered through a 140 mm plankton net, B: Retained plankton samples washed into a PET plastic bottle, C: Samples preserved with 10% seawater buffered formalin solution

At the laboratory:

i) zooplankton composition and diversity were determined by firstly concentrating, and followed with sub-sampling and counting using a stereomicroscope.
ii) samples were identified at family and genus/species using a high compound microscope. Zooplankton density was calculated in terms of individual per litre (ind./L).
iii) species diversity was also assessed based on the Shannon-Weiner Diversity Index (H').

b) Results

■ Phytoplankton

The assessment of phytoplankton at the study area recorded three different phyla i.e. Bacillariophyta, Dinoflagellata and Cyanophyta (T6.35). Bacillariophyta was the most abundant group in terms of species as well as densities at all sampling stations representing 86.1% of the total population of phytoplankton, while 13.4% was Dinoflagellata and 0.5% was Cyanophyta (F6.60). The highest density of phytoplankton was recorded at P13 (foreshore area) (204.58 cells/mL), followed by P11 (foreshore area) (201.32 cells/mL) and P12 (foreshore area) (199.68 cells/mL), while the lowest was recorded at P25 (offshore area - outside reclamation footprint) (18.11 cells/mL) (F6.61).

Phytoplankton population were dominated by Bacillariophyta (also known as diatoms) with a mean density of 88.63±62.98 (11.77-194.70) cells/mL. Bacillariophyta are one of the most species-rich 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 to 1,783 different planktonic diatom 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 (Ganjian, 2007; Carter *et al*., 2005; Ganjian, *et al*., 2004; Zubaidah *et al.,* 2001; Mann, 1999). The study by Mann (1999), estimated that diatoms provided 20 to 25% of globally fixed carbon and atmospheric oxygen, thus influencing biogeochemical cycles worldwide.

T6.35 Phytoplankton density (cells/mL) and diversity (H') at the study area

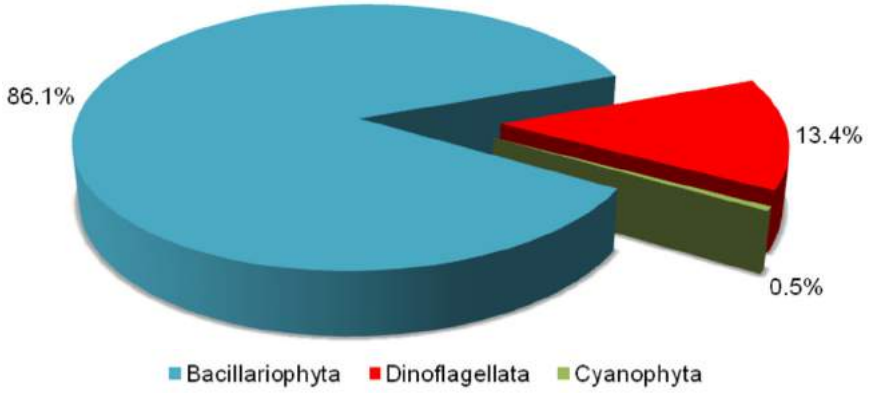
Taxa	Station								
	Foreshore Area								
	P1	P2	P3	P4	P5	P6	P7	P8	P9
Phylum: Bacillariophyta									
Amphora	1.57	-	-	-	-	-	4.27	0.74	-
Asteriolampra	-	10.51	6.51	0.74	6.02	2.16	-	5.17	5.58
Bacteriastrum	-	-	-	-	-	-	-	-	-
Bacillaria	-	-	2.17	-	-	-	1.07	5.17	6.97
Ballerochea	-	15.02	2.17	-	9.46	-	61.94	31.04	20.21
Chaetoceros	7.84	5.26	11.93	-	5.16	25.94	5.34	5.17	69.70
Cocconeis	1.57	-	-	-	0.86	-	-	1.48	-
Coscinodiscus	14.11	10.51	27.13	0.74	-	-	27.77	14.78	6.27
Ditylum	-	-	-	-	-	-	-	-	-
Eucampia	-	1.50	-	-	-	-	-	2.22	-
Guinardia	5.49	2.25	10.85	1.47	0.86	6.49	7.48	8.13	6.27
Hemiaulus	-	-	1.09	-	-	-	-	-	2.79
Lauderia	-	2.25	3.26	1.47	0.86	-	1.07	-	2.09
Licmophora	3.14	-	-	-	-	-	-	-	-
Navicula	-	0.75	-	-	-	-	1.07	-	0.70
Nitzschia	43.90	40.98	24.96	-	26.66	4.32	21.36	22.17	6.97
Odontella	-	-	1.09	-	-	-	9.61	9.61	1.39
Pleurosigma	5.49	9.01	4.34	2.94	22.36	9.73	6.41	15.52	6.97
Rhizosolenia	3.92	3.76	7.60	4.41	8.60	6.49	12.82	16.99	18.82
Stauroneis	-	-	8.68	-	-	1.08	-	-	-
Surirella	-	0.75	3.26	-	-	-	-	1.48	-
Thalassiosira	3.92	9.01	14.11	-	6.88	3.24	7.48	14.04	8.36
Thalassionema	-	-	-	-	-	-	-	-	-
Triceratium	-	-	-	-	-	-	1.07	-	-
Other diatom	10.98	6.76	13.02	-	13.76	-	8.74	15.52	8.36
Subtotal (cells/mL)	**101.93**	**118.32**	**142.17**	**11.77**	**101.48**	**59.45**	**177.50**	**169.23**	**171.45**
Phylum: Dinoflagellata									
Ceratium	0.78	-	-	1.47	-	1.08	2.14	1.48	0.70
Gymnodinium	1.57	-	-	-	-	6.49	-	-	-
Peridinium	10.98	66.09	49.91	3.68	24.94	22.70	6.41	0.74	8.36
Protoperidinium	1.57	-	-	2.21	0.86	1.08	4.27	2.22	0.70
Subtotal (cells/mL)	**14.90**	**66.09**	**49.91**	**7.36**	**25.80**	**31.35**	**12.82**	**4.44**	**9.76**
Phylum: Cyanophyta									
Trichodesmium	0.78	-	-	-	1.72	-	-	-	-
Subtotal (cells/mL)	**0.78**	**0.00**	**0.00**	**0.00**	**1.72**	**0.00**	**0.00**	**0.00**	**0.00**
Density (cells/mL)	**117.61**	**184.41**	**192.08**	**19.13**	**129.00**	**90.80**	**190.32**	**173.67**	**181.21**
Diversity Index (H')	**2.15**	**2.07**	**2.37**	**2.04**	**2.18**	**2.02**	**2.29**	**2.54**	**2.21**

T6.35 Phytoplankton density (cells/mL) and diversity (H') at the study area (cont'd)

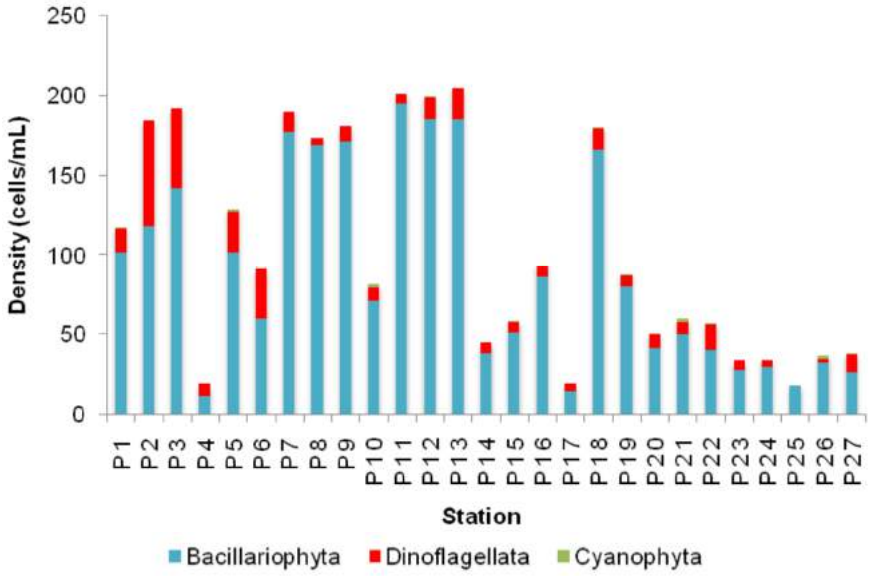
Taxa	Station									
	Foreshore Area									
	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19
Phylum: Bacillariophyta										
Amphora	-	-	-	3.18	-	1.43	0.55	0.39	-	0.59
Asteriolampra	0.82	-	3.43	1.06	1.24	0.72	6.56	0.78	0.88	2.24
Bacteriastrum	0.82	-	-	-	-	-	-	-	-	-
Bacillaria	-	-	1.71	-	-	-	-	-	-	-
Ballerochea	3.27	3.78	11.14	6.36	-	-	-	-	0.44	0.11
Chaetoceros	25.33	126.63	85.70	71.02	13.04	5.74	3.28	0.78	2.21	3.00
Cocconeis	-	-	1.71	-	-	-	1.09	-	-	0.27
Coscinodiscus	0.82	15.12	7.71	21.20	1.24	2.15	19.69	1.55	20.29	10.92
Ditylum	-	-	-	-	-	-	-	-	-	-
Eucampia	-	-	-	-	-	-	-	-	-	-
Guinardia	3.27	2.84	9.43	7.42	1.86	4.30	8.75	1.94	-	3.75
Hemiaulus	-	-	0.86	-	-	-	0.55	-	-	0.14
Lauderia	-	-	-	-	0.62	-	-	-	-	-
Licmophora	-	-	-	-	-	-	-	-	-	-
Navicula	0.82	0.95	-	2.12	0.62	-	-	0.39	0.88	0.32
Nitzschia	12.26	11.34	35.14	43.46	12.42	22.23	28.44	4.27	5.29	15.06
Odontella	-	-	0.86	1.06	-	-	0.55	-	-	0.14
Pleurosigma	4.09	6.62	5.14	8.48	3.11	5.74	1.09	2.33	1.32	2.62
Rhizosolenia	6.54	14.18	7.71	8.48	2.48	0.72	12.03	1.55	0.44	3.69
Stauroneis	-	-	-	-	-	-	0.55	-	-	0.14
Surirella	-	-	-	-	-	0.72	-	-	0.88	0.40
Thalassiosira	8.17	3.78	4.29	2.12	1.24	4.30	1.64	0.39	132.00	34.58
Thalassionema	-	2.84	-	1.06	-	-	-	-	-	-
Triceratium	-	-	0.86	-	-	-	-	-	-	-
Other diatom	4.90	6.62	9.43	8.48	-	3.59	1.64	0.39	1.76	1.85
Subtotal (cells/mL)	**71.11**	**194.70**	**185.12**	**185.50**	**37.87**	**51.64**	**86.41**	**14.76**	**166.39**	**79.80**
Phylum: Dinoflagellata										
Ceratium	1.63	1.89	1.71	1.06	-	-	-	-	0.88	0.22
Gymnodinium	-	-	1.71	-	1.86	-	2.74	1.16	3.53	1.86
Peridinium	6.54	3.78	8.57	18.02	4.35	5.74	1.64	3.49	7.06	4.48
Protoperidinium	-	0.95	1.71	-	1.24	-	2.19	-	1.76	0.99
Subtotal (cells/mL)	**8.17**	**6.62**	**13.70**	**19.08**	**7.45**	**5.74**	**6.57**	**4.65**	**13.23**	**7.55**
Phylum: Cyanophyta										
Trichodesmium	2.45	-	0.86	-	-	0.72	0.55	-	0.88	0.54
Subtotal (cells/mL)	**2.45**	**0.00**	**0.86**	**0.00**	**0.00**	**0.72**	**0.55**	**0.00**	**0.88**	**0.54**
Density (cells/mL)	**81.73**	**201.32**	**199.68**	**204.58**	**45.32**	**58.10**	**93.53**	**19.41**	**180.50**	**87.89**
Diversity Index (H')	**2.23**	**1.50**	**2.05**	**2.04**	**2.06**	**2.04**	**2.14**	**2.27**	**1.12**	**2.06**

T6.35 Phytoplankton density (cells/mL) and diversity (H') at the study area (cont'd)

Taxa	Station							
	Reclamation Area (Within Reclamation Footprint)			Offshore Area (Outside Reclamation Footprint)			Off Pulau Kendi and Pulau Rimau	
	P20	P21	P22	P23	P24	P25	P26	P27
Phylum: Bacillariophyta								
Amphora	1.25	-	-	-	-	-	-	-
Asteriolampra	1.25	0.89	0.58	3.59	2.41	-	0.60	0.66
Bacteriastrum	0.63	-	-	-	-	-	-	-
Bacillaria	-	-	-	-	-	-	-	-
Ballerochea	-	-	-	-	-	-	2.42	-
Chaetoceros	11.88	2.68	1.17	8.62	6.02	2.36	1.81	0.59
Cocconeis	-	-	-	-	-	-	0.60	-
Coscinodiscus	1.25	-	1.17	-	7.22	-	0.60	0.96
Ditylum	-	-	-	-	-	-	0.60	-
Eucampia	-	-	-	-	-	-	-	-
Guinardia	2.50	-	3.50	1.44	3.01	3.94	1.21	2.49
Hemiaulus	-	-	-	-	-	-	-	-
Lauderia	-	-	1.75	3.59	-	-	1.81	1.61
Licmophora	-	0.89	-	-	-	-	-	-
Navicula	-	-	-	-	-	-	1.81	-
Nitzschia	15.63	38.36	2.92	2.15	2.41	7.87	12.68	1.46
Odontella	-	-	-	-	-	-	-	-
Pleurosigma	3.75	-	22.74	1.44	6.62	-	-	12.84
Rhizosolenia	1.88	1.78	2.92	2.87	0.60	2.36	3.62	3.67
Stauroneis	-	-	0.58	-	-	-	-	0.29
Surirella	-	-	-	-	-	-	-	-
Thalassiosira	1.88	0.89	-	2.87	1.20	-	1.81	-
Thalassionema	-	-	-	-	-	-	0.60	-
Triceratium	-	-	-	-	-	-	-	-
Other diatom	-	4.46	2.92	1.44	-	1.58	2.42	1.46
Subtotal (cells/mL)	**41.90**	**49.95**	**40.25**	**28.01**	**29.49**	**18.11**	**32.59**	**26.01**
Phylum: Dinoflagellata								
Ceratium	0.63	-	1.17	-	1.81	-	0.60	1.32
Gymnodinium	1.88	1.78	7.58	-	1.20	-	1.81	3.79
Peridinium	5.00	5.35	5.25	4.31	1.81	-	-	4.47
Protoperidinium	0.63	0.89	1.75	1.44	-	-	-	1.98
Subtotal (cells/mL)	**8.14**	**8.02**	**15.75**	**5.75**	**4.82**	**0.00**	**2.41**	**11.56**
Phylum: Cyanophyta								
Trichodesmium	0.63	1.78	1.17	-	-	-	1.81	0.59
Subtotal (cells/mL)	**0.63**	**1.78**	**1.17**	**0.00**	**0.00**	**0.00**	**1.81**	**0.59**
Density (cells/mL)	**50.67**	**59.75**	**57.17**	**33.76**	**34.31**	**18.11**	**36.81**	**38.15**
Diversity Index (H')	**2.13**	**1.40**	**2.11**	**2.22**	**2.15**	**1.44**	**2.36**	**2.23**



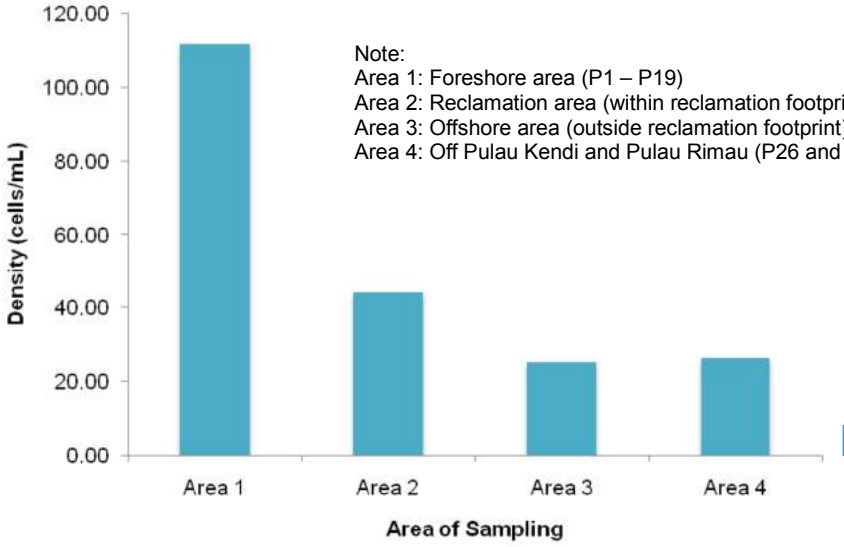
F6.60
Composition of the Phytoplankton at the study area



F6.61
Phytoplankton density (cells/mL) at the study area

A total of 25 taxa of Bacillariophyta was recorded at the study area. The highest number recorded was at the foreshore area (24 taxa), 15 taxa off Pulau Kendi/Pulau Rimau, 14 taxa within the reclamation footprint and 10 taxa offshore area (outside the reclamation footprint). In terms of speciation, a significantly high abundance of *Chaetoceros* and *Nitzschia* was recorded at the study area, accounting for 21.2 and 19.4% of the total Bacillariophyta density respectively. These taxa were found at all survey area, with the mean density for *Chaetoceros* ranging from 3.06±1.77 (1.81-4.31) to 24.90±36.02 (0-126.63) cells/mL, while for *Nitzschia* ranged from 4.14±3.23 (2.15-7.87) to 20.06±13.82 (0-43.90) cells/mL. Previous studies reported that *Chaetoceros* and *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, 1980; Chua and Chong, 1975). Other taxa recorded mean density ranging from 0.04±0.19 (0-0.82) to 8.83±12.19 (0-22.74) cells/mL.

On the whole, the highest mean density of Bacillariophytes was recorded at the foreshore area [111.88±61.30 (11.77-194.70) cells/mL], followed by within the reclamation footprint (44.03±5.19 (40.25-49.95) cells/mL), off Pulau Kendi/Pulau Rimau [26.24±8.98 (19.89-32.59) cells/mL] and offshore area (outside the reclamation footprint) [25.20±6.19 (18.11-29.49) cells/mL] (F6.62).



F6.62
Mean density (cells/mL) of Phylum Bacillariophyta at the study area

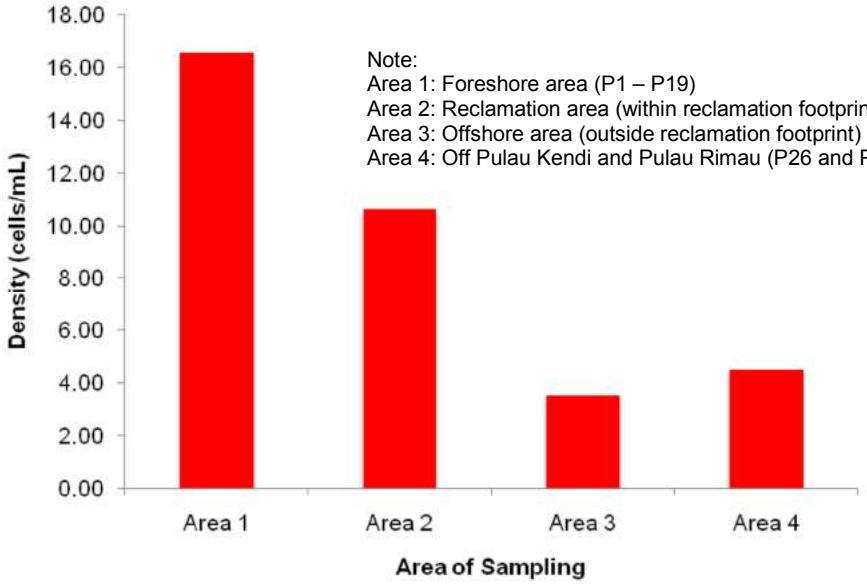
Dinoflagellata was represented by *Ceratium*, *Gymnodinium*, *Peridinium* and *Protoperidinium*, with mean density of 13.76±14.64 (0-66.09) cells/mL. The most dominant taxa was *Peridinium* that covered 76.3% of the total density of dinoflagellates, followed by *Gymnodinium* (10.5%), *Protoperidinium* (7.7%) and *Ceratium* (5.5%). *Peridinium* was found at all survey areas, where mean density ranged from 2.00±2.82 (0-4.00) to 13.55±17.23 (0.74-66.09) cells/mL. According to Ismael and Maria Del Socorro (2008), *Peridinium* was a large genus of small-to-medium-sized dinoflagellates in the marine ecosystem. Other taxa such as *Ceratium*, *Gymnodinium* and *Protoperidinium* only had low mean density, ranged from 0.40±0.69 (0-1.20) to 3.75±3.32 (1.78-7.58) cells/mL.

Where HAB (Harmful Algal Blooms) are concerned, the study by Cembella (2003) reported that about 75 to 80% of toxic phytoplankton species were 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 (Smayda, 1997).

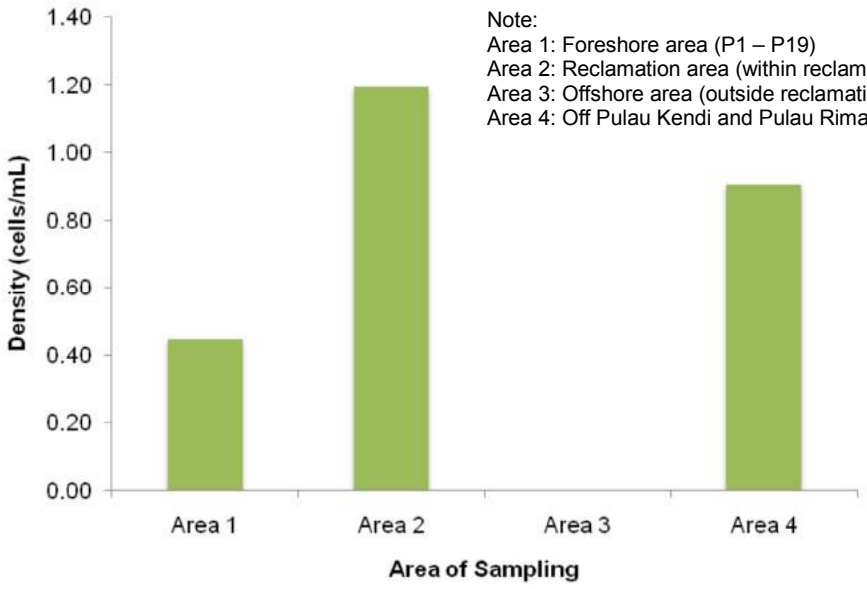
For instance, blooms of *Peridinium quinquecorne* reported in lagoon of La Ensenada de La Paz, Gulf of California with an abundance ranged from 3,400 to 6,400 cells/mL (Ismael and Maria Del Socorro, 2008). This density is far higher than that recorded during the current study, indicating that the waters 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 is obviously of concern and needs to be monitored.

On the whole, the foreshore area recorded highest mean density of dinoflagellate, with value of 16.59±16.47 (4.44-66.09) cells/mL, followed by the area within the reclamation footprint [10.64±4.43 (8.02-15.75) cells/mL], the offshore area (outside the reclamation footprint) (3.52±3.09 (0-5.75) cells/mL) and the area off Pulau Kendi/Pulau Rimau [4.48±2.93 (2.41-6.56) cells/mL] (F6.63).

As for Cyanophyta, it was represented by *Trichodesmium*. The highest mean density of *Trichodesmium* was recorded within the reclamation footprint [1.19±0.58 (0.63-1.78) cells/mL], followed by off Pulau Kendi/Pulau Rimau [0.91±1.28 (0-1.81) cells/mL] and the foreshore area [0.45±0.68 (0-2.45) cells/mL] (F6.64). *Trichodesmium* is known as the predominant diazotrophs in most ocean waters (Chen *et al*., 2008; Chen *et al*., 2003). This species is important in the nitrogen cycle since they account for 25 to 50% of nitrogen fixation in the world's oceans (Mahaffey *et al*., 2005; Karl *et al*., 2002).

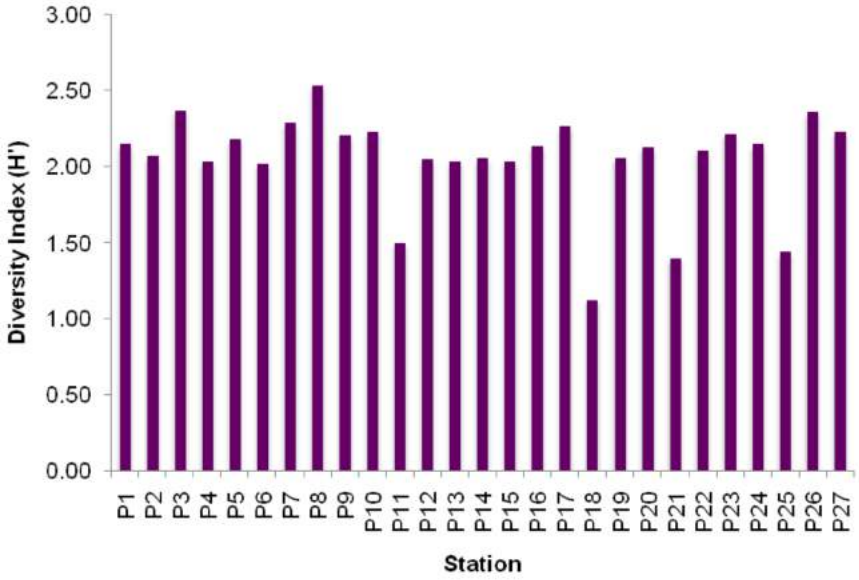


F6.63 Mean density (cells/mL) of Phylum Dinoflagellata at the study area



F6.64 Mean density (cells/mL) of Phylum Cyanophyta at the study area

Overall, the mean phytoplankton density at the study area was 102.93±68.45 (18.11-204.58) cells/mL. Species diversity is an important aspect of biological monitoring and a reliable parameter to determine how healthy an environment is (Ogbeibu and Edutie, 2002). The mean Shannon Weiner Diversity Index (H') recorded at 2.05±0.32 (1.12-2.54), where most of the stations found to be highly diverse (F6.65). The highest value recorded at P8 (2.54) and the lowest value at P18 (1.12), with both stations being located at the foreshore area.



F6.65
Phytoplankton diversity index (H') at the study area

- 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 (Ayodele and Adeniyi, 2005; Santhanam and Srivinasan, 1994; Robertson and Duke, 1987; Grindley, 1984). 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 (Uriarte and Villate, 2005; Hoff and Snell, 1987). Moreover, they also respond to a wide variety of disturbances including nutrient loading (Dodson, 1992; Pace, 1986), acidification (Keller and Yan, 1991; Brett, 1989), contaminants (Yan *et al.,* 1996), forage fish (Carpenter and Kitchell, 1993) and sediment inputs (Cuker, 1997).

The zooplankton distribution in the study area is shown in T6.36. There was a total of six phyla recorded i.e. Arthropoda (Crustacea), Chordata, Mollusca, Chaetognatha, Cnidaria and Annelida. Arthropoda, which contributed 79.0% of the total zooplankton density, was the major group in this area, followed by Chordata (7.9%) and Mollusca (6.5%) (F6.66). Other phyla contributed less than 3.0%. The highest zooplankton density was recorded at P7 (foreshore area) (45.15 ind./L), followed by P10 (foreshore area) (41.40 ind./L) and P16 (foreshore area) (35.73 ind./L), while others recorded lower than 24 ind./L (F6.67).

Zooplankton populations were dominated by Arthropoda (crustacean) with mean density of 8.58±10.64 (0.25-39.75) ind./L. The most dominant group was Copepoda (98.4% of the total Arthropod density), followed by Decapoda (0.9%) and Diplostraca (0.7%). Previous studies have showed that copepods are distributed widely in seawater and account for 55 to 60% of the zooplankton populations in the Straits of Malacca (Rezai *et al.* 2011; Zannatul and Muktadir, 2009; Rezai 2002; Lee, 1999). 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 harsher environmental conditions since they have the tough physical structures and versatile feeding habits (carnivorous and omnivorous) of all zooplankton (Ferdous and Muktadir, 2009).

T6.36 Zooplankton density (cells/mL) and diversity (H') at the study area

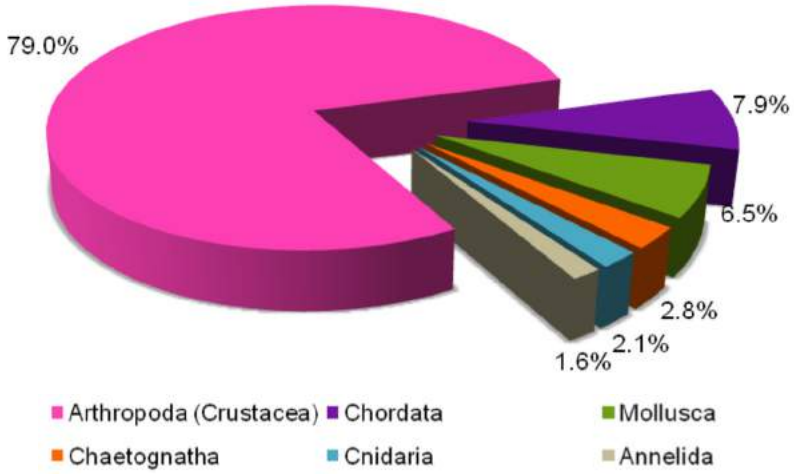
Taxa	Station									
	Foreshore Area									
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Phylum: Arthropoda (Crustacea)										
Copepods										
Nauplii	1.10	0.35	0.85	0.30	0.60	0.50	7.35	4.65	1.05	18.20
Copepodids	0.25	0.05	0.45	0.15	0.15	-	2.85	1.20	0.25	1.10
Calanoids										
Acartia	0.15	0.05	0.20	0.25	0.30	-	0.45	0.60	0.25	0.70
Calanus	0.05	0.05	-	0.10	-	-	-	-	-	-
Eucalanus	0.80	0.25	3.10	0.20	0.35	-	16.65	7.05	2.30	15.00
Labidocera	-	-	-	-	-	-	-	-	-	-
Paracalanus	-	-	0.15	-	-	-	1.20	0.30	0.10	0.60
Cyclopoids								-	-	-
Oithona	0.10	-	0.15	-	0.05	-	2.25	0.30	0.10	0.50
Harpacticoid										
Microsetella	9.55	0.20	0.20	-	2.10	-	5.40	-	-	-
Macrosetella	-	-	-	-	-	-	-	-	-	-
Euterpina	0.30	-	0.25	0.05	0.35	0.05	1.95	1.35	0.20	1.20
Poecilostomatoid										
Corycaeus	0.20	0.95	0.75	0.50	0.60	0.10	1.05	0.15	0.50	0.40
Oncaea	0.10	0.05	-	0.05	-	-	-	-	-	0.10
Decapod										
Decapod larvae	-	-	0.10	-	0.05	0.10	0.45	-	-	0.10
Diplostraca										
Evadne	-	-	-	-	0.05	0.10	0.15	-	0.05	-
Subtotal (ind./L)	**12.60**	**1.95**	**6.20**	**1.60**	**4.60**	**0.85**	**39.75**	**15.60**	**4.80**	**37.90**
Phylum: Chordata										
Oikopluera	0.05	0.15	0.85	0.15	-	0.30	1.35	0.75	3.50	2.40
Subtotal (ind./L)	**0.05**	**0.15**	**0.85**	**0.15**	**0.00**	**0.30**	**1.35**	**0.75**	**3.50**	**2.40**
Phylum: Mollusca										
Bivalve larvae	0.25	0.05	0.15	0.25	0.05	0.10	1.05	0.15	0.60	0.10
Gastropod larvae	-	-	-	-	0.10	-	0.15	-	-	0.10
Subtotal (ind./L)	**0.25**	**0.05**	**0.15**	**0.25**	**0.15**	**0.10**	**1.20**	**0.15**	**0.60**	**0.20**
Phylum: Chaetognatha										
Sagitta	0.05	0.05	0.25	-	0.05	0.20	1.35	0.45	0.30	0.50
Subtotal (ind./L)	**0.05**	**0.05**	**0.25**	**0.00**	**0.05**	**0.20**	**1.35**	**0.45**	**0.30**	**0.50**
Phylum: Cnidaria										
Unidentified salp	-	-	-	-		0.05	0.15	-	-	-
Unidentified jelly fish	-	-	-	-	0.10	-	0.15	0.15	0.30	0.10
Subtotal (ind./L)	**0.00**	**0.00**	**0.00**	**0.00**	**0.10**	**0.05**	**0.30**	**0.15**	**0.30**	**0.10**
Phylum: Annelida										
Polychaete larvae	-	-	-	-	0.05	-	1.20	-	0.15	0.30
Subtotal (ind./L)	**0.00**	**0.00**	**0.00**	**0.00**	**0.05**	**0.00**	**1.20**	**0.00**	**0.15**	**0.30**
Density (ind./L)	**12.95**	**2.20**	**7.45**	**2.00**	**4.95**	**1.50**	**45.15**	**17.10**	**9.65**	**41.40**
Diversity Index (H')	**1.10**	**1.82**	**1.98**	**2.10**	**1.96**	**1.91**	**2.12**	**1.72**	**1.95**	**1.48**

T6.36 Zooplankton density (cells/mL) and diversity (H') at the study area (cont'd)

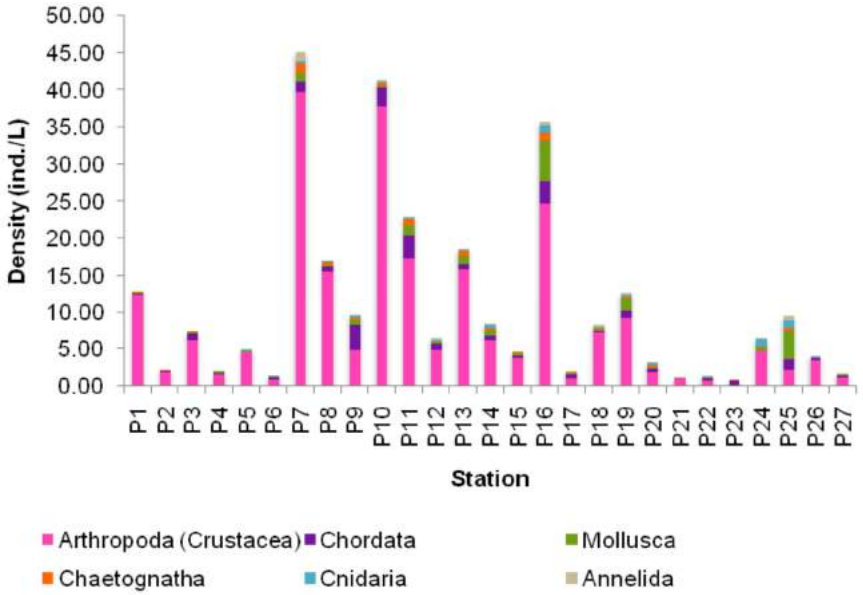
Taxa	Station								
	Foreshore Area								
	P11	P12	P13	P14	P15	P16	P17	P18	P19
Phylum: Arthropoda (Crustacea)									
Copepods									
Nauplii	2.40	1.65	0.90	2.35	1.15	3.25	0.10	1.60	1.53
Copepodids	0.40	0.25	0.55	0.45	0.40	1.63	0.05	0.90	0.75
Calanoids									
Acartia	0.70	0.20	0.05	0.20	-	0.75	0.20	0.05	0.25
Calanus	-	-	-	-	-	-	-	-	-
Eucalanus	8.50	2.10	9.10	0.85	1.35	15.00	0.05	2.80	4.80
Labidocera	0.60	-	0.20	0.05	-	0.38	-	-	0.10
Paracalanus	0.50	-	-	0.20	0.45	1.38	-	0.60	0.61
Cyclopoids									
Oithona	0.50	0.25	0.10	0.45	0.15	-	-	0.15	0.08
Harpacticoid									
Microsetella	1.90	0.10	3.50	0.15	-	0.50	-	0.35	0.21
Macrosetella	-	-	-	-	-	-	-	-	-
Euterpina	1.00	0.10	0.90	0.35	0.10	1.13	0.40	0.55	0.55
Poecilostomatoid									
Corycaeus	0.30	-	0.10	0.95	0.05	0.38	0.15	0.20	0.20
Oncaea	-	0.05	-	0.10	-	0.33	-	0.05	0.10
Decapod									
Decapod larvae	0.40	0.05	0.40	-	-	-	0.05	-	0.01
Diplostraca									
Evadne	0.10	0.05	0.10	0.15	0.15	-	-	-	0.04
Subtotal (ind./L)	**17.30**	**4.80**	**15.90**	**6.25**	**3.80**	**24.73**	**1.00**	**7.25**	**9.20**
Phylum: Chordata									
Oikopluera	3.10	0.90	0.65	0.60	0.35	3.00	0.55	0.20	1.03
Subtotal (ind./L)	**3.10**	**0.90**	**0.65**	**0.60**	**0.35**	**3.00**	**0.55**	**0.20**	**1.03**
Phylum: Mollusca									
Bivalve larvae	1.40	0.25	1.05	0.70	0.20	5.00	0.25	0.40	1.46
Gastropod larvae	-	0.10	-	-	0.05	0.50	-	-	0.14
Subtotal (ind./L)	**1.40**	**0.35**	**1.05**	**0.70**	**0.25**	**5.50**	**0.25**	**0.40**	**1.60**
Phylum: Chaetognatha									
Sagitta	0.90	0.15	0.80	0.30	0.20	1.00	0.15	0.05	0.35
Subtotal (ind./L)	**0.90**	**0.15**	**0.80**	**0.30**	**0.20**	**1.00**	**0.15**	**0.05**	**0.35**
Phylum: Cnidaria									
Unidentified salp	-	-	-	-	0.05	-	-	-	0.01
Unidentified jelly fish	0.10	0.05	0.20	0.45	0.05	1.00	0.10	0.10	0.31
Subtotal (ind./L)	**0.10**	**0.05**	**0.20**	**0.45**	**0.10**	**1.00**	**0.10**	**0.10**	**0.33**
Phylum: Annelida									
Polychaete larvae	0.20	0.25	0.05	0.15	0.05	0.50	0.05	0.35	0.24
Subtotal (ind./L)	**0.20**	**0.25**	**0.05**	**0.15**	**0.05**	**0.50**	**0.05**	**0.35**	**0.24**
Density (ind./L)	**23.00**	**6.50**	**18.65**	**8.45**	**4.75**	**35.73**	**2.10**	**8.35**	**12.73**
Diversity Index (H')	**2.17**	**2.03**	**1.77**	**2.42**	**2.13**	**2.04**	**2.17**	**2.10**	**2.18**

T6.36 Zooplankton density (cells/mL) and diversity (H') at the study area (cont'd)

Taxa	Station							
	Reclamation Area (Within Reclamation Footprint)			Offshore Area (Outside Reclamation Footprint)			Off Pulau Kendi & Pulau Rimau	
	P20	P21	P22	P23	P24	P25	P26	P27
Phylum: Arthropoda (Crustacea)								
Copepods								
Nauplii	0.05	0.15	0.10	0.05	0.35	-	0.30	0.20
Copepodids	0.10	0.20	-	-	0.35	-	0.15	0.08
Calanoids								
Acartia	0.30	0.05	-	0.05	0.05	0.30	-	0.13
Calanus	0.05	-	-	-	-	-	-	0.05
Eucalanus	0.15	0.25	0.25	0.05	2.30	1.30	1.60	0.23
Labidocera	0.15	-	-	-	-	-		-
Paracalanus	0.05	-	-	-	-	-	0.10	-
Cyclopoids								
Oithona	0.15	-	-	-	0.85	0.10	0.55	-
Harpacticoid								
Microsetella	0.10	0.05	-	-	0.10	-	-	-
Macrosetella	-	0.15	-	-	-	-	0.05	-
Euterpina	0.15	-	-	0.05	0.05	0.05	0.45	0.03
Poecilostomatoid								
Corycaeus	0.50	0.15	0.15	-	0.25	0.45	0.25	0.33
Oncaea	-	-	-	-	-	0.05	-	0.03
Decapod								
Decapod larvae	0.10	0.05	0.05	-	0.15	-	0.10	0.03
Diplostraca								
Evadne	-	0.05	0.15	0.05	0.30	-	-	0.08
Subtotal (ind./L)	**1.85**	**1.10**	**0.70**	**0.25**	**4.75**	**2.25**	**3.55**	**1.15**
Phylum: Chordata								
Oikopluera	0.45	-	0.40	0.45	-	1.50	0.30	0.28
Subtotal (ind./L)	**0.45**	**0.00**	**0.40**	**0.45**	**0.00**	**1.50**	**0.30**	**0.28**
Phylum: Mollusca								
Bivalve larvae	0.05	0.05	0.05	-	0.25	0.35	-	0.15
Gastropod larvae	0.15	-	0.05	-	0.10	3.36	-	0.03
Subtotal (ind./L)	**0.20**	**0.05**	**0.10**	**0.00**	**0.35**	**3.71**	**0.00**	**0.18**
Phylum: Chaetognatha								
Sagitta	0.25	-	-	0.20	0.20	0.35	0.15	-
Subtotal (ind./L)	**0.25**	**0.00**	**0.00**	**0.20**	**0.20**	**0.35**	**0.15**	**0.00**
Phylum: Cnidaria								
Unidentified salp	-	-	-	-	0.10	0.30	-	-
Unidentified jelly fish	0.35	-	0.25	-	0.90	0.70	0.05	0.13
Subtotal (ind./L)	**0.35**	**0.00**	**0.25**	**0.00**	**1.00**	**1.00**	**0.05**	**0.13**
Phylum: Annelida								
Polychaete larvae	0.10	-	0.05	-	0.25	0.65	0.05	0.03
Subtotal (ind./L)	**0.10**	**0.00**	**0.05**	**0.00**	**0.25**	**0.65**	**0.05**	**0.03**
Density (ind./L)	**3.20**	**1.15**	**1.50**	**0.90**	**6.55**	**9.46**	**4.10**	**1.75**
Diversity Index (H')	**2.64**	**2.12**	**2.04**	**1.48**	**2.19**	**2.02**	**2.02**	**2.38**



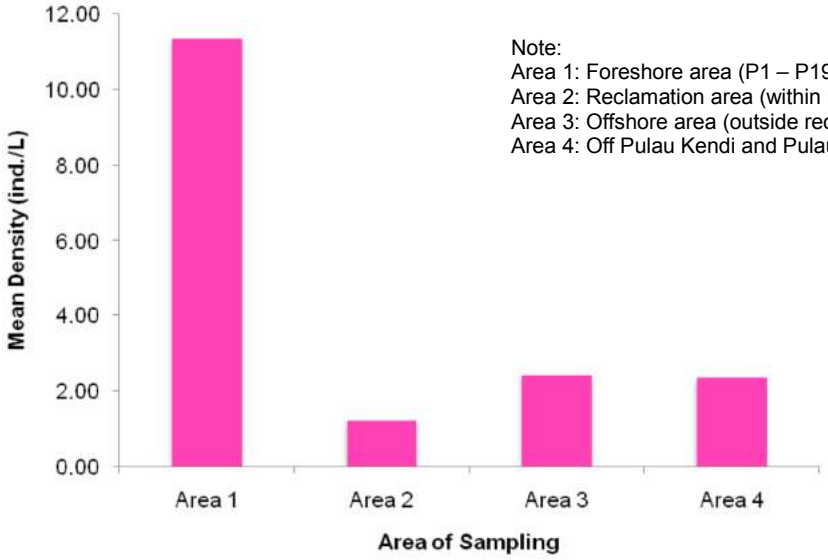
F6.66
Composition of the Zooplankton at the study area



F6.67
Zooplankton density (ind./L) at the study area

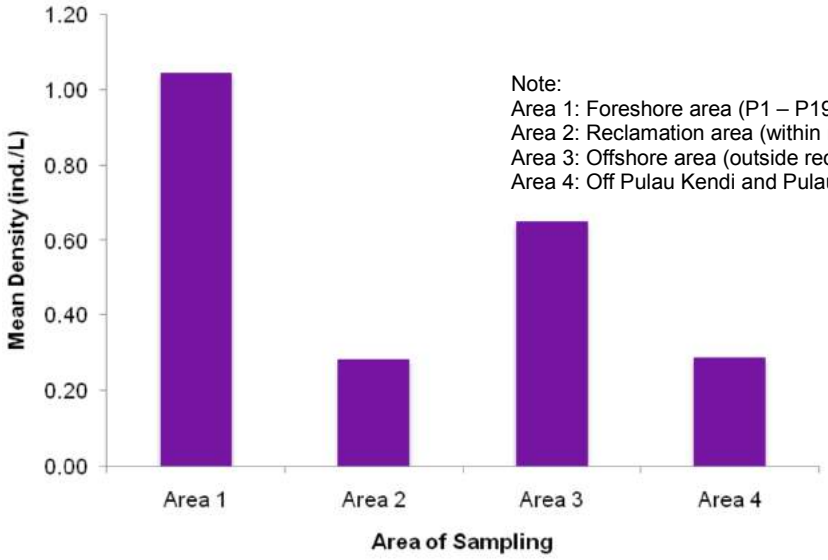
A total of 15 taxa from Phylum Arthropoda was recorded at the study area. The highest number of taxa (15 taxa) was recorded within the reclamation footprint, with 14 taxa recorded at the foreshore area and 13 taxa recorded each for the offshore area (outside reclamation footprint) and off Pulau Kendi/Pulau Rimau. *Eucalanus* (Copepoda) was the most abundant taxa, constituting 41.6% of the total Arthropod density. The mean density of *Eucalanus* ranged from 0.22±0.06 (0.15-0.25) to 4.75±5.56 (0.05-16.65) ind./L. Studies showed that *Eucalanus* was a common genus reported in the 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 was recorded at the foreshore area [11.37±11.62 (0.85-39.75] cells/mL), followed by the offshore area (outside the reclamation footprint) [2.42±2.25 (0.25-4.75) cells/mL], area off Pulau Kendi/Pulau Rimau [2.35±1.70 (1.15-3.55) cells/mL] and area within the reclamation footprint [1.22±0.58 (0.70-1.85) cells/mL] (F6.68).



F6.68
Mean density (ind./L) of Phylum Arthropoda at the study area

The second most abundant phylum was Chordata, which was represented by *Oikopluera*. The highest mean density of *Oikopluera* was recorded at the foreshore area [1.05±1.11 (0-3.50) ind./L], followed by area offshore area (outside the reclamation footprint) [0.65±0.77 (0-1.50) ind./L], off Pulau Kendi/Pulau Rimau [0.29±0.02 (0.28-0.30) ind./L] and area within the reclamation footprint [0.28±0.25 (0-0.45) ind./L] (F6.69). According to Lakkis (1994), *Oikopleura* was abundant in most parts of the marine ecosystem due to its high tolerance of polluted water. Moreover, they are able to feed on nanoplankton, picoplankton and even submicron colloids (Acuña *et al.,* 1996; Bedo *et al*., 1993; Flood *et al.*, 1992; Urban *et al.*, 1992; King *et al*., 1980).



F6.69
Mean density (ind./L) of Phylum Chordata at the study area

Mollusca was the third most abundant phylum with mean density of 0.71±1.23 (0-5.50) ind./L. Mollusca comprises of gastropod and bivalve larvae, where bivalve larvae (74.9% of the total molluscs density) were more abundant as compared to gastropod larvae (25.1%).