AEC Limited

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Benthic Survey Report

of

Tai Po waters

Wet and Dry Seasons

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NEANTHES
eco-consultant

neanthes@gmail.com

www.neanthes.com

T: 2422-4001

Workshop J 6/F Wing Hong Factory Building

18-26 Kwai Fung Crescent Kwai Chung N.T. Hong Kong

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1. SUMMARY

The aim of present survey is to obtain ecological benthic baseline of the Tai Po waters under the project 'Ecological Survey for Upgrading of Tai Po Sewage Treatment Works - Investigation'. Benthic sampling was conducted at two sampling sites (B1-B2) in the survey area. Wet and dry season samplings were completed on 16th August 2020 and 6th December 2020 respectively.

According to the survey results, the benthic environment was under long-term organic enrichment at moderate level. The benthic communities were very low in biodiversity and abundance in both seasons of sampling. Neither dominant nor abundant taxon could be determined. There was no species of conservation importance. The ecological value of the benthic communities was graded 'Very Low'.

Nelson W.Y. Lam

Environmental Consultant

2. INTRODUCTION

The aim of present survey is to obtain ecological benthic baseline of the Tai Po waters under the project 'Ecological Survey for Upgrading of Tai Po Sewage Treatment Works - Investigation'.

3. METHODOLOGIES

3.1 Sampling Sites

Benthos sampling was undertaken at two sampling sites (B1-B2) near the waters of Tai Po Waterfront Park (Fig. 3.1 and 3.2). The sampling sites were fixed by Global Positioning System (model: GARMIN 78s) on board (Table 3.1). The wet season sampling was conducted during ebb tide on 16th August 2020 under sunny weather. The dry season sampling was conducted during flood tide on 6th December 2020 under sunny weather. The water depths of B1 and B2 were 4.3-5.4 m and 3.3 m respectively.

3.2 Field Sampling

At every sampling site, three replicates of sediment samples were collected using a van Veen grab (0.1 m^2 sampling area × 15 cm biting depth). Collected samples were accepted when at least two-third of grab volume was filled. A photographic record of the sediment texture and colour was taken. The samples were washed with gentle seawater through a stack of plastic sieve boxes with 1.0 mm and 0.5 mm mesh sizes. Large animals that were visible from the residues were hand-picked into a small plastic vial. All remains were transferred into a plastic

container for temporary storage.

3.3 Laboratory Work

After arrival to laboratory, the samples were preserved with 70% ethanol solution followed by staining with 1% Rose Bengal solution. The samples were stored for one day to ensure sufficient preservation and staining. The fauna collected were sorted out from the sediment residues on a white tray with the aid of magnifying glass. For quality assurance, the sediment residues of one-third sorted samples were randomly rechecked. No missed fauna was found in the recheck.

The collected specimens were identified to the lowest taxonomic resolution. Examination of the morphological features of the specimens was undertaken with the aid of both stereoscopic and compound microscopes. The taxonomic classification was conducted in accordance to the following references: Arthropod: Dai and Yang (1991), Dong (1991), Ren (2012); Echinoderm: Liao (1997, 2003); Echiuran and Sipunculan: Zhou *et al*. (2007); Mollusk: Qi (2004); Polychaete: Day (1967), Gallardo (1967), Fauchald (1977), Yang and Sun (1988), Wu *et al*. (1997), Sun and Yang (2004). The number of individuals of each species was recorded by counting the anterior portions of the fauna only. Total biomass of each species was determined as preserved wet weight, after blotting the animals on filter paper for 3 minutes before weighing to the nearest 0.0001 g.

3.4 Data Analysis

Data collected from three replicate samples at every sampling site were pooled together for

data analysis. Shannon-Weaver Diversity Index (*H'*) and Pielou's Species Evenness (*J*) were calculated using the formulae below,

$H' = -\Sigma (Ni / N) \ln (Ni / N)$ (Shannon and Weaver, 1963)
$J = H' / \ln S$, (Pielou, 1966)

where S is the total number of species in the sample, N is the total number of individuals, and Ni is the number of individuals of the i^{th} species.

Table 3.1 The GPS coordinates, collection time, measured water depth and tidal state of every sampling site

Site	WGS84 datum (ITRF96 Reference Frame)		Wet season (16 Aug. 2020)			Dry season (6 Dec. 2020)		
	Latitude (N)	Longitude (E)	Collection Time (hh:mm)	Depth (m)	Tidal State	Collection Time (hh:mm)	Depth (m)	Tidal State
B1	N 22° 27.006’	E 114° 11.369'	9:25	5.4	Ebb	10:35	4.3	Flood
B2	N 22° 27.075’	E 114° 11.048'	9:45	3.3	Ebb	10:45	3.3	Flood

Drawing No. 2 - Tentative Marine Ecological Survey Plan

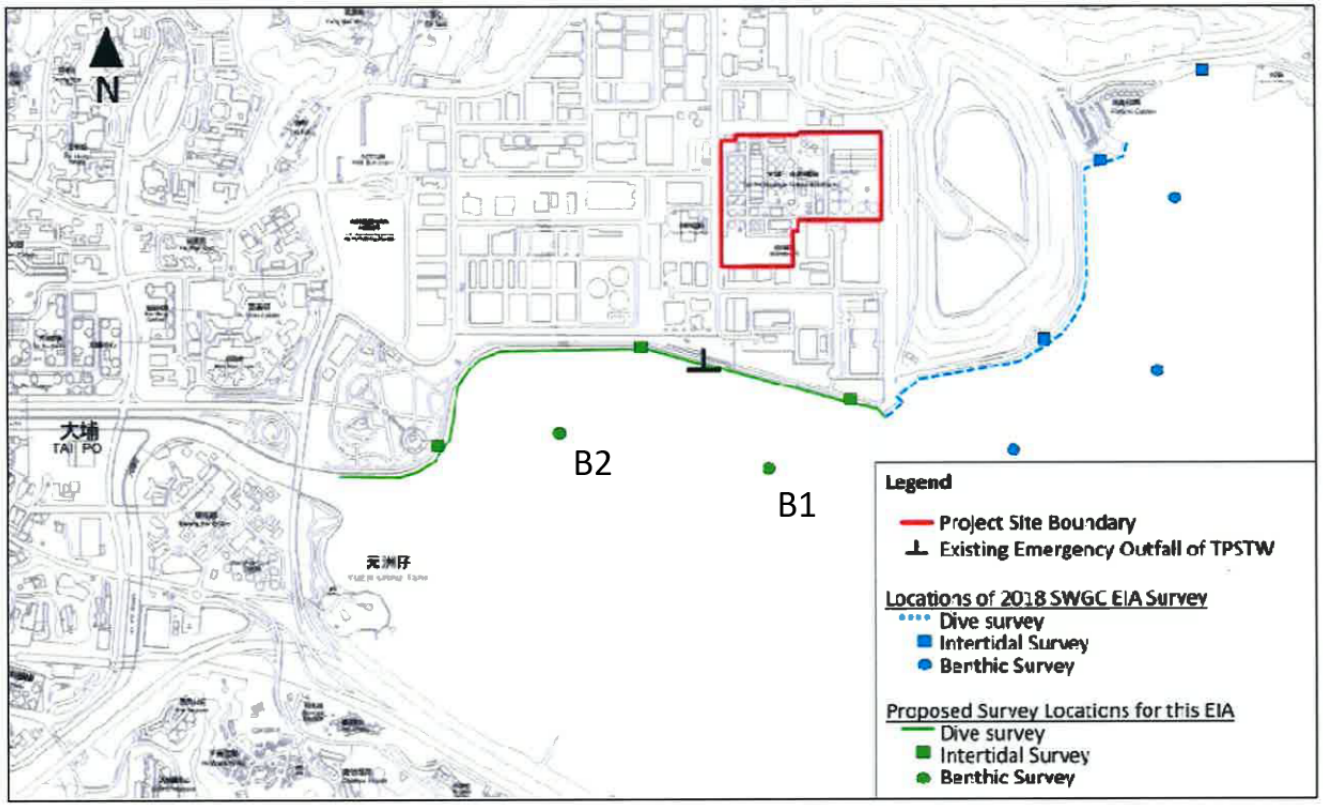

Figure 3.1 Location of sampling sites (map from AEC Limited)

B1

B2

Figure 3.2 Photographic record of the environment in the survey area (6th Dec. 2020)

4. RESULTS

4.1 Sediment Condition

Table 4.1 and figure 4.1 show the sediment condition and colour at every sampling site. Across the two seasons of sampling, the sediment texture was mainly soft mud (~95%) with little gravels (~5%) at both sampling sites. The B1 sediments were grey in colour. The B2 sediments were black in colour with mild to moderate odour of hydrogen sulphite. Rubbish and decaying leaf litters were usually found in the sediments, indicating nearby stormwater pollution.

4.2 Benthic Baseline

In general, there were only 7 taxa collected while all were identified to genus or species levels. Four of them were in phylum Mollusca while the other three were in phylum Annelida. The taxonomic resolution is provided in Appendix II.

Table 4.2 lists the total abundance and total biomass of every phylum. In the wet season sampling, 12 specimens were collected only. They were in phyla Annelida (polychaetes, 10 ind., relative abundance 83%) and Mollusca (bivalve, 2 ind., 6%). The total biomass of all specimens was 2.1933 g while it was clearly accounted by Mollusca (bivalve, 2.1778 g, 99%). In the dry season sampling, relatively more specimens (37 ind.) were collected that were in Mollusca (bivalve, 19 ind., 51%) and Annelida (polychaetes, 18 ind., 49%). But the total biomass decreased (1.1823 g) and was accounted by Mollusca (bivalve, 1.1592 g, 98%). The complete list of collected specimens is provided in Appendix III.

Table 4.3 shows the site abundance and relative abundance of each phylum at every sampling site. In the wet season sampling, the site abundances were at very low level (3-9 ind.) at the two sampling sites. Neither dominant nor abundant phylum could be found. The phyla distribution was similar between the two sampling sites. In the dry season sampling, the B1 abundance increased slightly (36 ind.) while B2 abundance remained at very low level. No dominant or abundant phylum was determined.

Table 4.4 lists the benthic fauna collected at every sampling site. In the wet season sampling, there was no dominant or abundant taxon since the site abundance was too low. Polychaete *Sigambra hanaokai* (7-20 ind. m^{-2}, relative abundance 67%) was relatively common at the two sampling sites. Other taxa were at very low densities (< 10 ind. m^{-2}). In the dry season sampling, bivalve *Meropesta nicobarica* (60 ind. m^{-2}, 50%) and polychate *Sigambra hanaokai* (50 ind. m^{-2}, 42%) were relatively common at B1. Other taxa were still at very low densities.

Table 4.5 shows the species number, community density, community biomass, Shannon-weaver Diversity Index (*H'*) and Pielou's Species Evenness (*J*) at every sampling site. Across the two seasons of sampling, the species numbers (1-4 spp. 0.3 m^{-2}), community densities (3-30 ind. m^{-2}) and biomass (0.11-6.56 g m^{-2}) were at very low levels at both sampling sites except the low to moderate community density at B1 in the dry season sampling (120 ind. m^{-2}). Because of low species number and community density, the taxa distribution was even that resulted in unrepresentatively high *J* values (0.70-0.92). Overall the *H'* values were very low (0.00-0.97).

Table 4.1 Sediment condition and colour at every sampling site

Site	Season	Major Sediment texture	Minor Sediment texture	Sediment colour	Sediment odour	Any special phenomenon
B1	Wet	~95% soft mud	~5% gravels	Grey	\	Lots of rubbish
	Dry	~95% soft mud	~5% gravels	Grey	\	\
B2	Wet	~95% soft mud	~5% gravels	Black	Moderate	Lots of rubbish
	Dry	~95% soft mud	~5% gravels	Black	Mild	Decaying leaves

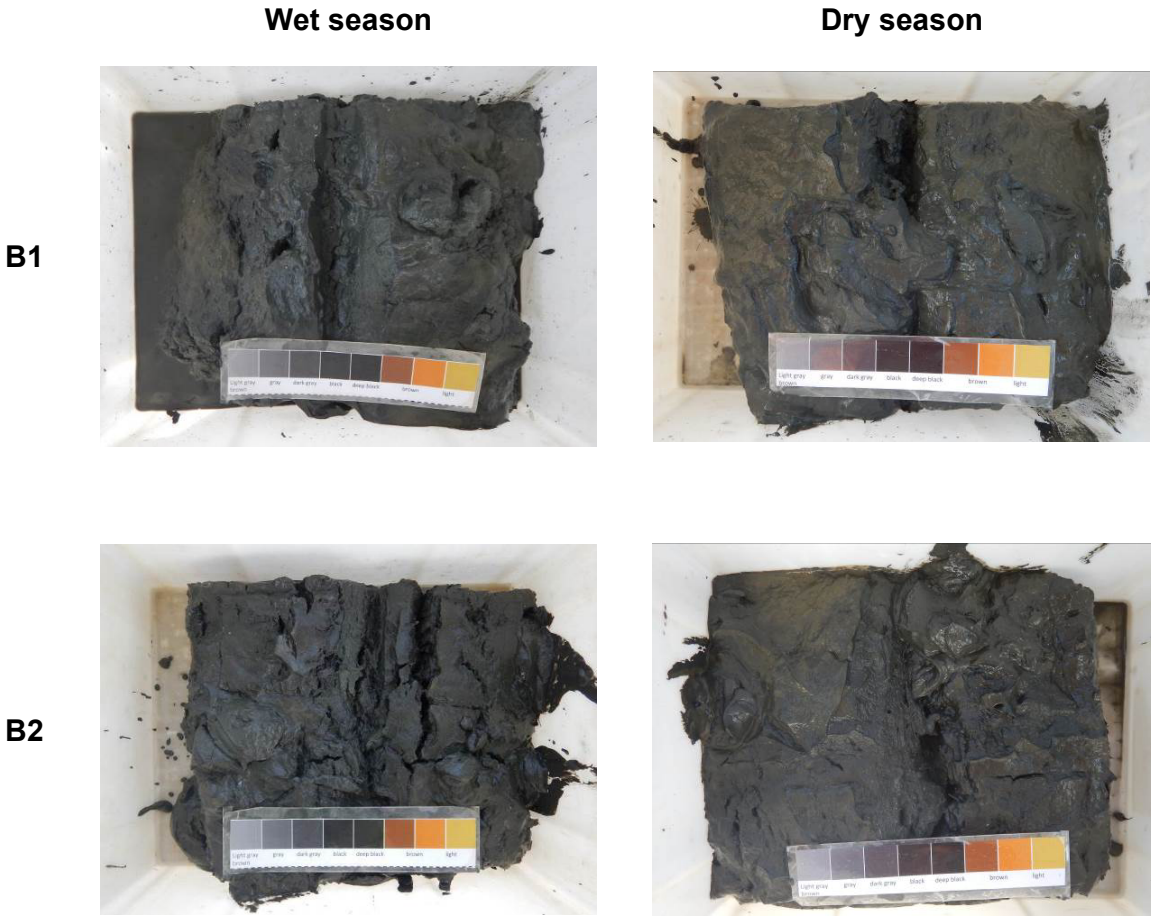

Figure 4.1 Photographic record of sediment at every sampling site

Table 4.2 Total abundance and total biomass of every phylum

Phylum	Abundance (ind.)	%	Biomass (g)	%
Wet season				
Annelida	10	83	0.0155	1
Mollusca	2	17	2.1778	99
sub-total	12		2.1933	
Dry season				
Mollusca	19	51	1.1592	98
Annelida	18	49	0.0231	2
sub-total	37		1.1823	
Total	**49**		**3.3756**	

0 %: total individual / biomass of the phylum is less than 1% of that of all specimens

Table 4.3 The site abundance (N) and relative abundance in percentage (Rel. N) of each phylum at every sampling site

Season	Wet				Dry			
Site	B1		B2		B1		B2	
Phylum	N (ind.)	Rel. N (%)	N (ind.)	Rel. N (%)	N (ind.)	Rel. N (%)	N (ind.)	Rel. N (%)
Annelida	8	89	2	67	18	50		
Mollusca	1	11	1	33	18	50	1	100
column sum	9		3		36		1	

N: Site abundance of the phylum (ind.); Rel. N: Relative abundance of the phylum per site (%)

0 %: relative abundance of the phylum is less than 1% at the sampling site

Table 4.4 The benthic fauna collected at every sampling site

Sampling site	Group	Species	Density (ind. m^{-2})	Biomass (g m^{-2})	Relative abundance (%)
		Wet season			
B1	P	*Sigambra hanaokai*	20	0.0367	67
	P	*Otopsis* sp.	7	0.0110	22
	B	*Anadara subcrenata*	3	6.5133	11
B2	P	*Sigambra hanaokai*	7	0.0040	67
	B	*Exotica cygnus*	3	0.7460	33
		Dry season			
B1	B	*Meropesta nicobarica*	60	3.7527	50
	P	*Sigambra hanaokai*	50	0.0690	42
	P	*Otopsis* sp.	7	0.0060	6
	P	*Ophiodromus angustifrons*	3	0.0020	3
B2	B	*Nitidotellina lischkei*	3	0.1113	100

B = Bivalve, P = Polychaete

wt = 0.00 g / m^2 : The specimen with total biomass less than 0.01 g / m^2

Table 4.5 Species number, community density, community biomass, Shannon-Weaver Diversity Index (*H'*) and Pielou's Species Evenness (*J*) at every sampling site

Season	Wet		Dry	
Site	B1	B2	B1	B2
Species number (spp. 0.3 m^{-2})	3	2	4	1
Community density (ind. m^{-2})	30	10	120	3
Community biomass (g m^{-2})	6.56	0.75	3.83	0.11
Shannon-Weaver Diversity Index *H'*	0.85	0.64	0.97	0.00
Pielou's Species Evenness *J*	0.77	0.92	0.70	N/A

N/A: non-applicable

5. DISCUSSION

5.1 Environmental Condition

The present survey area locates within the Tolo Harbour and Channel Water Control Zone (WCZ). The Tolo Harbour and Channel WCZ (especially the Harbor Subzone nearby Sha Tin and Tai Po) had been severely polluted and plagued with red tides in 1980s due to discharges of untreated sewage and livestock waste (EPD, 2006). Since the implementation of Tolo Harbour Action Plan in 1986 had contained the sewage and livestock problems, steady recovery of water quality was observed. There were clear decreasing trends of 5-days Biochemical Oxygen Demand (BOD_5), *E. coli* and total inorganic nitrogen, ammonia nitrogen and orthophosphate from 1986 to 2018 (details see EPD, 2019). However the overall compliance rate of water quality objective (WQO) was not satisfactory (57-79%) in the past few years (2014-2018) (details see EPD, 2019). The reason was the persistent low compliance of dissolved oxygen (DO) objective at various water quality monitoring stations (e.g. TM6, TM7 and TM8). The heavily landlocked situation and narrow exit to the open sea in Tolo Harbour leaded to weak tidal flushing and water circulation (EPD, 2006). Thermal stratification could be easily formed particularly during summer. Hence low oxygen condition was naturally resulted in bottom water especially.

In present survey area, the sediment condition was low in oxygen level. The sediments were grey or even black in colour with smell of hydrogen sulphite. It indicated mild to moderate organic loading in the sediments. The landlocked shape of harbour also minimized the sediment aeration.

5.2 Ecological Status Of Benthic Baseline

Under the adverse effects of organic enrichment and low oxygen condition, the benthic communities were characterized of very low biodiversity and abundance in the survey area. There was neither dominant taxon nor species of conservation importance. The relatively common polychaete *Sigambra hanaokai* was reported a species indifferent to organic pollution and usually present at low density (Cheung *et al*., 2008). Its abundance did not relate to the organic pollution status in sediment or other environmental stress.

5.3 Comparison Of Benthic Baseline

The benthic community was spatially divided into four location groups in Hong Kong waters (Tolo Harbour, Eastern and Southern waters, Victoria Harbour, Deep Bay) (Shin *et al*., 2004) according to a territory-wide survey conducted by CPSL (2002). Waters of 'Eastern and Southern waters' group was characterized as unpolluted while that of other location groups suffered from long-term sewage pollution (details see EPD, 2006). Table 5.1 shows the mean biodiversity index (*H'*) and species evenness (*J*) of benthic communities of the four location groups and the present survey area. Based on the results of both seasons of sampling, the mean *H'* of the present survey area (0.49-0.74) was much worse than other three polluted water groups 'Tolo Harbour', 'Victoria Harbour' and 'Deep Bay'. It reflected the presence of long-term stress on the health of benthic communities. As mentioned, the mean *J* value of the present survey area was unrepresentative, no comparison was made.

5.4 Ecological Value Of The Survey Area

Table 5.2 lists the criteria of evaluating the benthic environment of present survey area near

the Tai Po Waterfront Park according to EPD (1997). According to the survey results, the benthic environment was under long-term organic enrichment at moderate level. The benthic communities were very low in biodiversity and abundance in both seasons of sampling. Neither dominant nor abundant taxon could be determined. There was no species of conservation importance. The ecological value of the benthic communities was graded 'Very Low'.

Table 5.1 Comparison of mean *H'* and *J* of benthic communities between Tai Po waters and the four location groups of previous territory-wide survey

		Tai Po waters	Tolo Harbour	Eastern and Southern waters	Victoria Harbour	Deep Bay
	Season	Present survey	Shin *et al.*, 2004			
H'	**wet**	0.74	1.42	2.87	1.79	1.46
	dry	0.49	1.36	2.82	1.64	2.32
	mean	0.61	1.39	2.85	1.72	1.89
J	**wet**	0.85	0.73	0.82	0.47	0.53
	dry	0.70	0.83	0.81	0.44	0.73
	mean	0.77	0.78	0.82	0.46	0.63

Table 5.2 Criteria for evaluating the benthic environment of the survey area

Criteria	Remarks
Naturalness	Muddy substratum under long-term organic enrichment at moderate level.
Size	N.A.
Diversity	Very low biodiversity and abundance.
Rarity	No species of conservation importance
Re-creatability	N.A.
Fragmentation	N.A.
Ecological linkage	N.A.
Potential value	N.A.
Nursery/breeding ground	N.A.
Age	N.A.
Abundance/Richness of wildlife	N.A.
Ecological value	**Very Low**

N.A.: Non-applicable

6. REFERENCES

Cheung, S.G., Lam, N.W.Y., Wu, R.S.S., Shin, P.K.S., 2008. Spatio-temporal changes of marine macrobenthic community in sub-tropical waters upon recovery from eutrophication. II. Life-history traits and feeding guilds of polychaete community. Marine Pollution Bulletin 56, 297-307.

CPSL, 2002. Consultancy Study on Marine Benthic Communities in Hong Kong (Agreement No. CE 69/2000) submitted to Agriculture, Fisheries and Conservation Department, HKSAR Government. Centre for Coastal Pollution and Conservation, CityU Professional Services Limited (CPSL).

Dai, A.Y., Yang, S.L., 1991. Crabs of the China Seas. China Ocean Press. Beijing.

Day, J.H., 1967. A monograph on the polychaeta of South Africa. Trustees of the British Museum (Natural History). London.

Dong, Y.M., 1991. Fauna of ZheJiang Crustacea. Zhejiang Science and Technology Publishing House. ZheJiang.

EPD, 1997. Technical Memorandum on Environmental Impact Assessment Process (1st edition). Environmental Protection Department, HKSAR Government.

EPD, 2006. 20 Years of Marine Water Quality Monitoring in Hong Kong 1986-2005. In: web site of Environmental Protection Department, HKSAR Government [Latest retrieved Aug2014 from http://www.epd.gov.hk/epd/misc/marine_quality/1986-2005/index.html].

EPD, 2019. Marine Water Quality in Hong Kong in 2018. Environmental Protection Department (EPD), HKSAR Government, pp 154.

Fauchald, K., 1977. The polychaete worms. Definitions and keys to the orders, families and genera. Natural History Museum of Los Angeles County, Science Series 28. Los

Angeles, U.S.A..

Gallardo, V., 1967. Polychaeta from the Bay of Nha Trang, South Viet Nam. In: Scientific Results of Marine Investigations of the South China Sea and the Gulf of Thailand 1959-1961, Naga Report 4(3). Scripps Institution of Oceanography, University of California Press. La Jolla, California, 35-279.

Liao Y.L., 1997. Fauna Sinica, Phylum Echinodermata, Class Holothuroidea. Science Press, Beijing, pp 334.

Liao Y.L., 2003. Fauna Sinica, Invertebrata vol. 40, Echinodermata, Ophiuroidea. Science Press, Beijing, pp 505.

Pielou, E.C., 1966. Shannon's formula as a measure of species diversity: its use and misuse. American Naturalist 100, 463-465.

Qi, Z.Y., 2004. Seashells of China. China Ocean Press. Beijing, China.

Ren, X., 2012. Fauna Sinica Invertebrate Vol. 43 Crustacea Amphipoda Gammaridea (II). Science Press, Beijing.

Shannon, C.E., Weaver, W., 1963. The Mathematical Theory of Communication. Urbana: University of Illinois Press, USA.

Shin, P.K.S., Huang, Z.G., Wu, R.S.S., 2004. An updated baseline of subtropical macrobenthic communities in Hong Kong. Marine Pollution Bulletin 49, 119-141.

Sun, R.P., Yang, D.J., 2004. Fauna Sinica. Phylum Annelida. Class Polychaeta II, Order Nereidida. Science Press. Beijing.

Wu, B.L., Wu, Q.Q., Qiu, J.W., Lu, H., 1997. Fauna Sinica, Phylum Annelida, Class Polychaeta, Order Phyllodocimorpha. Science Press. Beijing.

Yang, D.J, Sun, R.P., 1988. Polychaetous annelids commonly seen from the Chinese waters (Chinese version). China Agriculture Press, China.

Zhou, H., Li, F.L., Wang, W., 2007. Fauna Sinica Invertebrate Vol. 46, Phylum Sipuncula and Phylum Echiura. Science Press. Beijing, pp 206.

Appendix I Photographic Records

■ The sediment sample was collected with 0.1 m^2 van Veen grab

■ The collected sediments were washed with gentle seawater through a sieve stack of mesh sizes 1.0 mm and 0.5 mm.

■ The preserved macrofauna in sediment residues was sorted out in laboratory

■ Taxonomic identification was undertaken with the aid of both stereoscopic and compound microscopes.

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Appendix II Taxonomic resolution of every collected species

Kingdom	Phylum	Class	Order	Family	Species
Animalia	Annelida	Polychaeta	Phyllodocida	Hesionidae	*Ophiodromus angustifrons*
Animalia	Annelida	Polychaeta	Phyllodocida	Pilargidae	*Otopsis* sp.
Animalia	Annelida	Polychaeta	Phyllodocida	Pilargidae	*Sigambra hanaokai*
Animalia	Mollusca	Bivalvia	Arcoida	Arcidae	*Anadara subcrenata*
Animalia	Mollusca	Bivalvia	Veneroida	Mactridae	*Meropesta nicobarica*
Animalia	Mollusca	Bivalvia	Veneroida	Tellinidae	*Exotica cygnus*
Animalia	Mollusca	Bivalvia	Veneroida	Tellinidae	*Nitidotellina lischkei*

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Appendix III List of collected specimens at every sampling site

Sampling site: B1			Sampling date: 16/08/2020							
No	Group	Species	1		2		3		row sum	
			ind.	wt.	ind.	wt.	ind.	wt.	ind.	wt.
1	P	*Otopsis* sp.					2	0.00	2	0.00
2	P	*Sigambra hanaokai*					6	0.01	6	0.01
3	B	*Anadara subcrenata*					1	1.95	1	1.95
		column sum	0	0.00	0	0.00	9	1.97	9	1.97

B = Bivalve, P = Polychaete

ind. = no. of individual / 0.1 m^2; wt. = wet weight, g / 0.1 m^2 (wt = 0.00 g / 0.1 m^2 : The specimen with total biomass less than 0.01 g / 0.1 m^2)

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Appendix III (Cont'd) List of collected specimens at every sampling site

Sampling site: B2		Sampling date: 16/08/2020								
No	Group	Species	1		2		3		row sum	
			ind.	wt.	ind.	wt.	ind.	wt.	ind.	wt.
1	P	*Sigambra hanaokai*					2	0.00	2	0.00
2	B	*Exotica cygnus*					1	0.22	1	0.22
		column sum	0	0.00	0	0.00	3	0.23	3	0.23

B = Bivalve, P = Polychaete

ind. = no. of individual / 0.1 m^2; wt. = wet weight, g / 0.1 m^2 (wt = 0.00 g / 0.1 m^2 : The specimen with total biomass less than 0.01 g / 0.1 m^2)

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Appendix III (Cont'd) List of collected specimens at every sampling site

Sampling site: B1		Sampling date: 06/12/2020									
No	Group	Species	1		2		3		row sum	
			ind.	wt.	ind.	wt.	ind.	wt.	ind.	wt.
1	B	*Meropesta nicobarica*	18	1.13					18	1.13
2	P	*Ophiodromus angustifrons*	1	0.00					1	0.00
3	P	*Otopsis* sp.	1	0.00	1	0.00			2	0.00
4	P	*Sigambra hanaokai*	11	0.01	4	0.01			15	0.02
		column sum	31	1.14	5	0.01	0	0.00	36	1.15

B = Bivalve, P = Polychaete

ind. = no. of individual / 0.1 m^2; wt. = wet weight, g / 0.1 m^2 (wt = 0.00 g / 0.1 m^2 : The specimen with total biomass less than 0.01 g / 0.1 m^2)

Appendix III (Cont'd) List of collected specimens at every sampling site

Sampling site: B2		Sampling date: 06/12/2020								
No	Group	Species	1		2		3		row sum	
			ind.	wt.	ind.	wt.	ind.	wt.	ind.	wt.
1	B	*Nitidotellina lischkei*					1	0.03	1	0.03
		column sum	0	0.00	0	0.00	1	0.03	1	0.03

B = Bivalve

ind. = no. of individual / 0.1 m^2; wt. = wet weight, g / 0.1 m^2 (wt = 0.00 g / 0.1 m^2 : The specimen with total biomass less than 0.01 g / 0.1 m^2)

- End of Report -