

Appendix 13.1 Literature Review Excluding CWD

1. Introduction

Desktop study and literature review have been conducted on subtidal shores and coral communities, artificial reefs, marine benthic communities, intertidal ecology, estuarine fauna and marine fishes to assess the existing conditions within the study area and to identify habitats or species of conservation importance. The available relevant information including government and private sector reports, published literature and academic studies were covered in the literature review. A series of literature including published scientific studies and approved EIAs for relevant projects or potential concurrent projects have been reviewed, including but not limited to the following:

- Biodiversity Survey data collected by AFCD (February 2002 – January 2013);
- Hong Kong Biodiversity Newsletter published by AFCD;
- Previously approved EIA and EM&A reports;
 - Black Point Gas Supply Project – EIA Study (2010);
 - Hong Kong-Zhuhai-Macao Bridge Hong Kong Boundary Crossing Facilities (hereafter as “HZMB-HKBCF”) – Investigation EIA (2009);
 - Hong Kong-Zhuhai-Macao Bridge Hong Kong Link Road (hereafter as “HZMB-HKLR”) EIA Report (2009), Baseline Environmental Monitoring Report, Environmental Permits Submissions and EM&A Monthly Reports (March 2012 to On-going);
 - Tuen Mun – Chek Lap Kok Link (hereafter as “TMCLKL”) – Investigation EIA Report (2009) and EM&A (ERM, 2013a and 2013b);
 - Harbour Area Treatment Scheme (HATS) Stage 2A – Investigation EIA Report (2008);
 - Liquefied Natural Gas (LNG) Receiving Terminal and Associated Facilities EIA (2006);
 - Permanent Aviation Fuel Facility for Hong Kong International Airport EIA and EM&A reports (2006);
 - EM&A reports for Contaminated Mud Pits at Sha Chau (2006-2013);
 - EIA Report for New Contaminated Mud Marine Disposal Facility at Airport East / East Sha Chau Area (2005);
 - EIA Study for Construction of Lung Kwu Chau Jetty (2002);
 - Castle Peak Road Improvement between Area 2 and Ka Loon Tsuen Wan Marine Ecology Baseline Survey EIA (2001);
 - Northshore Lantau Development Feasibility Study, Environmental Impact Assessment: Final Report, CEDD (2000);
 - Route 10 - North Lantau to Yuen Long Highway, Investigation and Preliminary Design, EIA Final Assessment Report, HyD (1999);
 - Lantau and Airport Railway : Environmental Impact Study, MTRC (1994);

- North Lantau Expressway - Yan O and Tai Ho Sections EIA, HyD (1991);
- Previous Environmental Studies:
 - CE 32/2011 (CE) Tung Chung New Town Extension Study (On-going);
 - Pilot Research – Searching for Pipefish in Hong Kong, by Green Power (2012);
 - Ecological, Fisheries and Water Quality Impact Assessment Study for the Proposed Port Development at Northwest Lantau - Final Report, THB (2007);
 - ECF Project (No. 12/2003) Conservation of Horseshoe Crabs in Hong Kong;
 - Consultancy Study on Marine Benthic Communities in Hong Kong, Final Report, AFCD (2002);
 - Sha Chau and Lung Kwu Chau Marine Park (SCLKCMP) Monitoring Programme (2000 – 2006);
 - Hong Kong Mangroves (Tam and Wong, 2000); and
 - ECF Project (No. 23/99) A Study of Soft Shore Habitats in Hong Kong for Conservation and Education Purposes.

Major findings that are relevant to this 3RS EIA Study are summarised in the following sections.

2. Literature Review on Subtidal Shores and Coral Communities

Hard corals are protected in Hong Kong by the Protection of Endangered Species of Animals and Plants Ordinance (Cap. 586) which includes the protection of all stony (hard) corals. Some other types of corals are listed in Schedule 1 and 2 of this Ordinance (Cap. 586). Import, export and possession of those corals, no matter dead or living, are restricted. All corals and organisms in Marine Parks and Marine Reserve are protected under the Marine Parks Ordinance (Cap. 476).

North Lantau waters are within the estuarine western waters. In contrast to the oceanic eastern waters, the abundance and diversity of corals are low in western Hong Kong waters (in particular northwestern waters which are closer to Pearl River Estuary). North Lantau waters are thus characterised by the presence of soft corals. Hard corals were recorded in the wider study area. The coral communities were, however, sparse compared to rocky reefs of similar depth in the oceanic eastern and southern waters of Hong Kong. A few solitary ahermatypic cup corals (thought to be *Balanophyllia* sp. or *Phyllangia* sp.) were recorded in the vicinity of the Brothers and soft corals and sea pens were also present throughout northwestern waters (Mouchel, 2002 & 2003). Solitary corals were also reported from Sham Tseng and Tsing Lung Tau adjacent to Castle Peak Road (Mouchel, 2001). A number of ahermatypic cup corals (*Balanophyllia* sp. or *Phyllangia* sp.) and octocorals (gorgonian *Euplexaura* sp., occasional soft coral *Dendronephthya* sp. colonies and isolated sea pens (*Virgularia* sp. or *Pteroides* sp.)) and one hermatypic coral *Oulastrea crispata* were also recorded at Sham Tseng and Tsing Lung Tau (Mouchel, 2001). There were also records of hard corals at Sha Chau. Dive surveys conducted in late 1994 at locations around Sha Chau revealed the presence of hard corals (Faviidae; not identified to a higher taxonomic resolution) in subtidal areas (ERM, 1995). On the other hand, dive survey conducted at a location north of the bay on the eastern side of Lung Kwu Chau did not detect the presence of corals on the soft seabed, while small colonies of the gorgonian *Euplexaura* sp. was observed growing on steel bars of a jetty in the southern section of the bay (Maunsell, 2002). The hard coral species recorded in northwestern waters are generally common in local waters although they are more abundant in eastern waters, and the study area (comprising northwestern waters) may represent their westernmost distribution in Hong Kong. It is notable that the ahermatypic cup coral (*Balanophyllia* sp. or *Phyllangia* sp.) and the gorgonian *Euplexaura* sp. were rarely recorded in the oceanic eastern and southern waters of Hong Kong and it is likely that these species were adapted to the hyposaline waters of the study area (Mouchel, 2001). The hermatypic (containing zooxanthellae) coral

Oulastrea crispata was described as common and widespread in Hong Kong marine waters, including the western waters where the sediment loading is high (Chan *et al.*, 2005), due to its ability to tolerate a wide range of adverse environmental conditions (Chen *et al.*, 2003). However, the total cover recorded at Sham Tseng and Tsing Lung Tau was sparse (<1%) and many individuals were in poor condition (Mouchel, 2001).

For the TMCLKL EIA investigation (AECOM, 2009a), coral dive surveys were conducted at the northern landfall and southern landing point of the marine viaduct of TMCLKL, along the proposed alignment of the tunnel, Tai Mo To and the area around the proposed southern landing point. The results showed that populations of the gorgonian *Guaiaogorgia* sp. and the ahermatypic cup coral *Paracyathus rotundatus* were recorded on the exposed surfaces of the vertical and sloping seawalls along Pillar Point, around Tai Mo To and along the seawall at North Lantau Highway section near Tai Ho Wan.

In the HZMB-HKBCF EIA report (Arup, 2009a), it was reported that AFCD commissioned intensive underwater surveys in 2001-2002 to survey corals at 240 sites covering about 70 km of coastline in territorial waters. Hard corals were found in western waters of Hong Kong, but in southern Lantau waters (Tong Fuk, Soko Islands) and eastern (Cheung Chau, Hei Ling Chau) Lantau waters, only sparse colonies or low-coverage communities composing of extremely tolerant species were found. A dive survey targeting corals was conducted along the coastline from Sham Wat to Kei Tau Kok (to the east of Tung Chung near Tai Ho) during the ecological baseline survey for the HZMB-HKBCF and HZMB-HKLR EIA studies (Arup, 2009a and 2009b). No hermatypic hard coral was found at any of the 27 dive sites. Although ahermatypic cup corals *Balanophyllia* sp. were recorded, they were concentrated in sites to the west of the airport island. The only widespread and common coral recorded in the survey was one species of gorgonian *Echinomuricea* sp. which was found both to the east and to the west of the airport island, but not inside the Airport Channel. *Echinomuricea* sp. is common in Hong Kong western waters and is not considered as a species of conservation importance. The species composition at the dive sites near the southeast coast of the airport island consisted of gorgonians and ahermatypic corals, and their coverage were all found at below 5%. The gorgonians near the airport island suffered high level of partial mortality. The findings were consistent with that recorded in the western waters during the AFCD study.

Dive surveys were also conducted in 2008 during the ecological verification survey for HZMB study (Arup, 2009b). Surveys were conducted at seven dive survey sites near Sham Wat, at the western shore of Sha Lo Wan headland, inside the Airport Channel, on the southeast shore of the airport island, and on Tung Chung. The results revealed that no coral was found within the Channel while the diversity and abundance of hard corals and gorgonians outside the Airport channel were low. Most hard substrates were dominated by barnacles, mussels and rock oysters. Only ahermatypic cup coral *Balanophyllia* (Dendrophylliidae) and gorgonian *Echinomuricea* sp. (Plexauridae) were recorded respectively from two and four of the seven survey sites, near Sha Lo Wan and San Shek Wan. Both the hard corals and gorgonians were only present outside the Airport Channel. No coral was found within the Channel. No other taxa of conservation importance were recorded in the seven survey sites (Arup, 2009b).

A marine supplementary survey was conducted under HZMB-HKBCF study (Arup, 2009a) covering eight locations along the southeast shore of the airport island investigated by spot dive with two of them further surveyed with Rapid Ecological Assessment (REA) technique. Dive surveys were also conducted at seven locations along the northeast shore of the airport island and nine locations within the HKBCF reclamation site, with two of the shore locations further studied by REA technique. In the survey along the southeast shore of the airport island, only two out of the eight dive locations had records of the gorgonian *Echinomuricea* sp., both locations being sloping boulder seawalls. The percentage cover of the gorgonians recorded was less than 1% and they were of fair condition (Arup, 2009a). In the survey within the HKBCF reclamation site, the seabed was found to be homogeneously muddy, lacking the hard bottom substrate required for coral colonisation and thus was not a habitat for corals (Arup, 2009a). The sediment was very fine and no demersal fauna was sighted. As there was no hard substrate in these locations, no coral (both

hard and soft) was found in the seabed within the reclamation site (Arup, 2009a). In the survey along the northeast shore of the airport island, the artificial seawall was the only hard bottom substrate in the area, to the west of the HKBCF reclamation site (Arup, 2009a). No hermatypic hard corals were found, but sparsely distributed small-sized gorgonian colonies (*Echinomuricea* sp.) were found at seawall along all dive survey points. The existing artificial seawalls comprised both vertical (at Marine Cargo Terminal and Sky Pier) and sloping seawalls (fire fighting and rescue vessel mooring and to the south of Marine Cargo Terminal). The vertical seawalls had no hard corals and low coverage of gorgonians recorded, but with more common epifauna such as rock oysters. The boulders of the sloping seawalls had no hermatypic hard coral, but a low coverage percentage of small-sized gorgonian colonies (*Echinomuricea* sp.). Furthermore, partial mortality was observed on some branches of the gorgonian colonies, demonstrating the poor condition of the gorgonians. Very low coverage of ahermatypic cup coral *Balanophyllia* sp. was found at the Northern REA transect at the fire fighting and rescue vessel mooring sloping seawall. Other epifauna on the boulders were mainly sessile bivalves including green mussel *Perna viridis* and oyster *Ostrea* sp., and predatory snail *Thais* sp. except the boulders at the seawalls, the seabed in the area was almost solely muddy substrate. Other fauna recorded on both the muddy seabed and the boulders of the seawall were also of low conservation importance including green mussels and oysters (Arup, 2009a).

For the Tuen Mun-Chek Lap Kok Link (TM-CLKL) EM&A, pre-construction coral dive surveys were conducted prior to major construction works at Tai Ho Wan, Tai Mo To and Pillar Point. The surveys identified the ahermatypic cup coral *Balanophyllia* sp. and the gorgonian *Guaiaigorgia* sp. of low coverage (< 1%) and fair health condition on boulder surfaces off Tai Ho Wan and Tai Mo To (ERM, 2013a). At Pillar Point, hard coral *Oulastrea crispata*, ahermatypic cup coral *Balanophyllia* sp. and gorgonian *Guaiaigorgia* sp. of lower percentage cover were found on boulder and seawall surfaces. All these species were common in local Hong Kong waters (ERM, 2013b).

Hard corals *Oulastrea crispata* and *Balanophyllia* sp and gorgonian *Guaiaigorgia* sp. have been reported at Yam Tsai Wan of North Lantau in coral surveys under HZMB HKLR Environmental Monitoring and Audit. Yam Tsai Wan is a relatively less exposed site. Therefore it was selected as the receptor site for the coral translocation exercise of HZMB HKLR and TMCLKL projects (ERM, 2013b).

Trawl surveys were conducted at western and northern Chek Lap Kok waters and SCLKCMP waters in 2012 under the Contaminated Mud Pits Environmental Monitoring and Audit. Octocorals (gorgonian (*Gorgonia* sp.), alcyonaceans (*Ellisella laevis*) and pennatulaceans (*Cavernularia habereri*, *Pteroeides chinense* and *Virgularia gustaviana*) were recorded in these waters.

The octocorals will not be considered as species of conservation importance in this EIA study as they have no protection status locally, regionally or internationally. Furthermore, they are all considered as common and widespread in Hong Kong waters, except for *Guaiaigorgia* sp. of which distribution is localised in western waters but still commonly found along the Lantau coast (AECOM, 2009b; AECOM, 2011; Arup, 2013; ERM, 2008). Although *Oulastrea crispata* is protected by the Protection of Endangered Species of Animals and Plants Ordinance (Cap. 586), it is excluded from the assessment in the current EIA study due to its relatively far distance (Sham Tseng, Tsing Lung Tau, Pillar Point and Yam Tsai Wan) from the project footprint which makes it less likely to be affected. Species of conservation importance which will be assessed in the EIA study include *Balanophyllia* sp., *Paracyathus rotundatus* and the hard corals (Faviidae) recorded at Sha Chau which are all protected by Cap. 586, and were recorded at locations which are potentially affected by the proposed project.

3. Literature Review on Artificial Reef

AFCD has been implementing an Artificial Reef (AR) project since 1996 to enhance fisheries resources and promote biodiversity in Hong Kong's marine waters (AFCD, 2013a). There are two ARs within the study area, located at the northeastern area of the Hong Kong International Airport Approach Area (HKIAAA) of Chek Lap Kok waters and at SCLKCMP (Figure 3-1).

Figure 3-1. Indicative locations of ARs located at HKIAAA and SCLKCMP (modified from AFCD, 2013a)



There are five AR deployment sites in the Chek Lap Kok waters, established with the objectives of serving as feeding station for Chinese White Dolphin and enhancement of habitat quality and marine resources (AFCD, 2013a). They comprise eight river barges with a total volume of 3,100 m³ and two units of quarry rocks with a total volume of 500 m³, deployed in the HKIAAA in 2000. However, since the AR sites in the Chek Lap Kok waters are significantly affected by the construction of the HKBCF (and re-provision of AR in other suitable location will be implemented as a mitigation measure), they are not considered as a marine ecological sensitive receiver and therefore are excluded from the impact assessment. While it is in the HZMB-HKBCF EIA report (Arup, 2009a) that ARs (with a total volume of not less than 10,800 m³) would be provided as mitigation measure, and part of them might be deployed in the proposed Brothers Marine Park, details of the new ARs are not yet available at the time of the current EIA study and hence they will not be considered in the impact assessment also.

There are six AR deployment sites at the SCLKCMP, established with the objectives of prevention of fish trawling, as feeding stations for Chinese White Dolphins and to enhance habitat quality and marine resources (AFCD, 2013a). They comprise 24 units of ferro-cement river barges with a total volume of 4,640 m³ and 42 concrete-coated container of a volume of 940 m³ deployed in the SCLKCMP in 2000.

For the ARs deployed at SCLKCMP, the monitoring data collected under AFCD's monitoring programme between 2000 and 2006 provide some information on the fish diversity in the location (Put *et al.*, 2004 – 2006; Tsang *et al.*, 2000 – 2003). However, due to the application of different fishing methods and

sampling efforts, it is not appropriate to compare the results such as abundance and biomass across years in this instance. Fishing methods employed included gill net, hand line and traps. Throughout the monitoring period, the AR site did not exhibit significantly higher fish abundance and biomass when compared to other survey sites within the Marine Park. However, it was noted that after the deployment of AR in March 2000, the fish abundance at the AR site increased threefold in the following wet season as compared to 1999 before the AR was deployed (Tsang *et al.*, 2001). Furthermore, species of high commercial value (e.g. *Eleutheronema tetradactylus*) and rocky/hard bottom habitat species (e.g. *Apogon kinesis* and *Epinephelus awoara*), which were not recorded in 1999 prior to the AR deployment, were also found at the AR site in 2000 (Tsang *et al.*, 2001). As the seabed in that region generally consisted of soft mud, the AR might have attracted the rocky/hard habitat species to the area through provision of hard substrates and shelters. One species of conservation importance, *Nemipterus virgatus* (golden threadfin bream), was recorded during the entire survey period. It is listed in the IUCN Red List as “Vulnerable”, while its local population status is unknown. Therefore it is considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text. Aside from the monitoring programme between 2000 and 2006, no other literature or survey data was available for the ARs at both SCLKCMP and HKIAAA, due to the high turbidity conditions at these sites and high vessel traffic around HKIAAA.

4. Literature Review on Benthic Macro-infauna Communities

Macro-fauna consist of organisms larger than 1 mm living within the sediment (predominantly in the upper well-oxygenated layers). There is no known benthic macro-fauna species of conservation importance in Hong Kong, except the cephalochordate *Branchiostoma belcheri*. This species is regarded as a living fossil link in the evolution of marine invertebrates to vertebrates and is, therefore, considered a potentially important species by CCPC (2002). The species is typically recorded in the eastern waters of Hong Kong (CCPC, 2002), with some individuals recorded to the south of Cheung Chau (Mouchel, 2003). This species was also recorded at South Soko Islands (ERM, 2006). From the survey result of the study of benthic communities in Hong Kong, *Branchiostoma belcheri* was recorded in Taihong Channel (Station 80), east of Ninepins (Station 83), outer Port Shelter (Station 87 and 88), Long Ke Wan (Station 95) and Tai Long Wan of Sia Kung Peninsula (Station 97 and 99). Except in Tai Long Wan, only one or two individual were recorded in each sampling station. Tai Long Wan with soft sediment and sandy substrate is considered as the preferred habitat for *Branchiostoma belcheri*. A relative high density was recorded in both summer (98 m⁻² in Station 97 and 102 m⁻² in station 99) and winter (56 m⁻² in Station 97 and 76 m⁻² in station 99). It is apparent that there is residing population of *Branchiostoma belcheri* in Tai Long Wan with abundance over 50 m⁻² (Chan, 2007)

Study of Marine Benthic Communities in Hong Kong

A comprehensive study on marine benthic communities in Hong Kong waters was conducted by CityU Professional Services Limited (CPSL) commissioned by the AFCD in 2002. Information on the subtidal benthic communities, with respect to spatial distribution, abundance, and species composition, was collected at 120 sampling stations over the territorial waters of Hong Kong which was divided into five strata (regions). One of the strata, Western waters with 29 sampling stations, covers Urmston Road, Deep Bay and North Lantau, and is more relevant with the works areas of the project. In this study, Stations 12 and 16 were within SCLKCMP, Stations 18 and 19 were near the project footprint, Station 20 was within the proposed Brothers Marine Park, Station 21 was at western Chek Lap Kok while Station 22 was within the proposed Southwest Lantau Marine Park. Therefore results for these stations were extracted for the evaluation of the ecological values of different areas in this EIA study.

Species richness, diversity and evenness indices are inter-related. A diversity index integrates two components: the total number of species and the distribution of individuals among species, into a single number (H'). H' is usually high (e.g. >3 or 4) in environmentally undisturbed benthic communities, and low

(e.g. <1) in highly disturbed communities (Gray, 1989). Values for richness, diversity, and evenness would be high, with $d > 10$, $H > 3$ and J (evenness) > 0.8 for a diverse community structure. In benthic habitats where organic matter is concentrated or dissolved oxygen is low, such values are low, with $d < 5$, $H < 2$, and $J < 0.5$.

Stations 18 and 19 were located to the north of the airport's northeast and northwest corners, respectively. They had moderate species richness, low to moderate diversity, and low to moderate evenness during summer and winter (Table 4-1 and Table 4-2). Common species included polychaetes and sipunculid worms. No species of conservation importance was recorded.

Stations 12 and 16 were located in SCLKCMP. They had low to high species richness, moderate to high diversity, and high evenness during summer and winter (Table 4-1 and Table 4-2). No species of conservation importance was recorded.

Station 20 in the proposed Brothers Marine Park had low to moderate species richness, moderate species diversity and high evenness during summer and winter (Table 4-1 and Table 4-2). No species of conservation importance was recorded.

Station 21 was located to the west of the airport island. It had moderate species richness, moderate species diversity and moderate to high evenness during summer and winter (Table 4-1 and Table 4-2). No species of conservation importance was recorded.

Station 22, which was within the proposed Southwest Lantau Marine Park, had moderate species richness, moderate species diversity and moderate evenness during summer and winter (Table 4-1 and Table 4-2). No species of conservation importance was recorded.

Figure 4-1: Sampling stations for benthic field survey (CPSL, 2002)

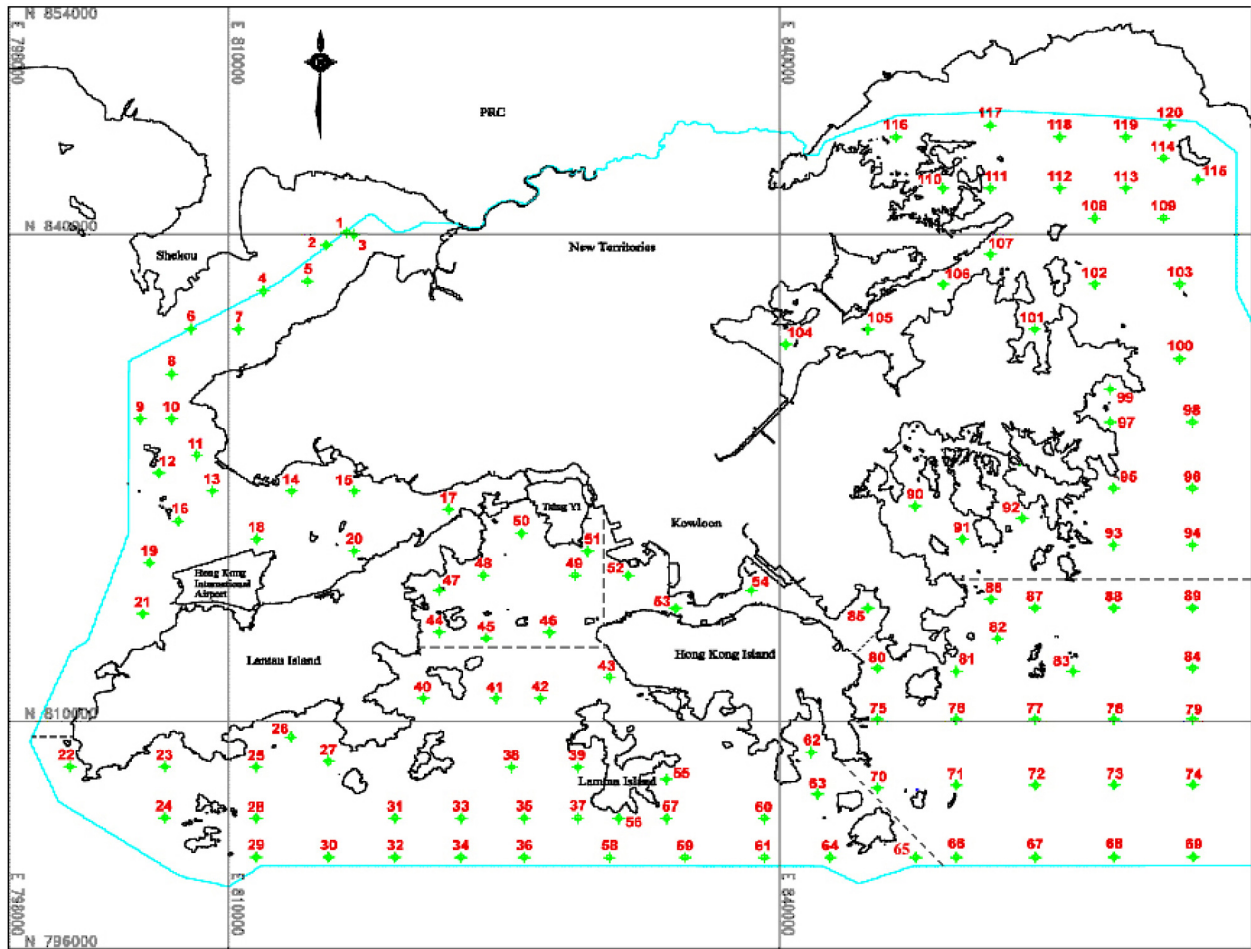


Table 4-1: Summary of survey results and statistical analyses of summer surveys (CPSL, 2002)

Station	No. of species (0.5 m ²)	No. of individual (m ²)	Wet Weight (g m ²)	Species richness <i>d</i>	Species diversity <i>H'</i>	Evenness <i>J</i>	Taxonomic diversity Δ	Taxonomic distinctness Δ^*	W statistic
12	13	66	3.66	3.43	2.26	0.88	70.36	78.38	0.336
16	33	220	25.38	6.81	2.73	0.78	59.16	66.90	0.291
18	38	1444	1347.68	5.62	1.52	0.42	57.31	88.39	0.097
19	41	650	77.80	6.92	2.64	0.71	65.86	74.62	0.186
20	27	218	38.58	5.54	2.69	0.82	57.01	63.16	0.365
21	38	460	11.52	6.80	2.66	0.73	68.38	78.66	0.077
22	34	426	4.08	6.16	2.61	0.74	55.55	64.09	-0.070

Table 4-2: Summary of survey results and statistical analyses of winter surveys (CPSL 2002)

Station	No. of species (0.5 m ²)	No. of individual (m ²)	Wet Weight (g m ²)	Species richness	Species diversity	Evenness	Taxonomic diversity	Taxonomic distinctness	W statistic
12	57	482	9.88	10.21	3.23	0.80	66.67	72.45	0.049
16	52	328	6.08	10.00	3.53	0.89	74.43	77.15	0.186
18	52	1120	263.38	8.06	2.14	0.54	44.83	66.96	0.177
19	54	664	15.12	9.13	2.94	0.74	64.92	73.68	0.138
20	13	36	18.38	4.15	2.48	0.97	75.60	78.68	0.750
21	37	296	38.62	7.20	2.98	0.83	78.51	84.91	0.294
22	38	1436	37.62	5.63	2.27	0.62	53.20	63.85	-0.057

HZMB Study

Grab sampling was conducted at 15 sampling stations in North Lantau inshore waters at both wet and dry seasons during the ecological baseline survey for HZMB study (Arup, 2009a). The marine benthic macro-fauna comprised a high diversity of polychaete species, in which *Sigambra hanaokai* was the most abundant species in the wet season, while *Eunice indica* and *Prionospio* sp. was the most abundant species in the dry season (Arup, 2009a). Species diversity of other taxa (mainly crustaceans, echinoderms and molluscs) and the overall biomass were low, which is typical in the north-western waters of Hong Kong (CPCC, 2002). All the species recorded occur frequently in Hong Kong and no rare species was observed. The biotic index and the dominant species recorded for HZMB study (Arup, 2009a) implied the community was slightly disturbed.

As recorded for the HZMB study (Arup, 2009a), benthic macro-fauna diversity to the east of Airport Channel was relatively low compared to other areas in Hong Kong. The impoverished assemblages is likely due to the proximity of Pearl River Estuary (estuarine areas are often less diverse owing to their highly dynamic physical and chemical nature) and possibly due to the predominantly silt-clay composition of the seabed that tends not to support high diversity (CCPC, 2002).

The major finding from other previous work on marine benthic surveys in the north-western waters as summarised in Mouchel (2002b) was that benthic macro-fauna present are impoverished and relatively similar throughout the north-western waters and are representative of the general study area.

Marine benthic grab surveys for ecological verification survey for HZMB study (Arup, 2009b) were conducted for benthic communities in soft substrate seabed at nine stations along the HKLR alignment during both wet and dry seasons in 2008. A total of 985 macro-faunal specimens, comprising 90 species from 59 families in nine phyla (Annelida, Arthropoda, Branchiopoda, Chordata, Cnidaria, Echinodermata, Mollusca, Nemertea and Platyhelminthes), were recorded in the wet season. In the dry season, a total of 383 macro-faunal specimens comprising 58 species from 44 families in six phyla (Annelida, Arthropoda, Cnidaria, Echinodermata, Mollusca and Nemertea) were recorded. Only 28 species were found in both

seasons. Polychaetes (Annelida) were collected at all stations and represented the highest species richness and abundance in both seasons (Arup, 2009b).

During this batch of surveys, the bivalves *Donax* sp. and *Theora lata* and the brittle star *Macrophiothrix longipeda* were the most abundant species recorded in the wet season, whilst the polychaetes *Notomastus latericens* and *Euclymene* sp. and the pea crab *Xenopthalmus* sp. were the most abundant species recorded in the dry season (Arup, 2009b).

The overall patterns of species abundance and richness were similar in both seasons: higher in open waters and declining gradually towards the Airport Channel. The Pielou's Index was similar between seasons (wet season: 0.75 – 0.93, dry season: 0.79 – 0.99). The overall biomass was higher in the dry season than in the wet season as determined by using two-way ANOVA ($p < 0.05$) (Arup, 2009b). The values in both seasons were, however, variable between stations and no general patterns could be deduced. Total biomass in the wet season was 30.94 g mainly due to the relatively high mass of molluscs (22.1 g) and arthropods (5.5 g). Juveniles of bivalves and gastropods were recorded in the survey (Arup, 2009b). Total biomass in the dry season was 131.53 g mainly due to the relatively high mass of molluscs (67.92 g), echinoderms (40.77 g) and arthropods (20.77 g). The biomass of other taxa in both seasons were low because of their small sizes and/or low abundance.

In both wet and dry seasons, none of the species recorded in the surveys was mentioned in the IUCN Red List (Arup, 2009b). The marine benthic macro-fauna in North Lantau was composed of a high diversity of polychaete species and a low diversity of other taxa, which is characteristic of the north-western waters of Hong Kong. There was, however, a distinct spatial and temporal pattern (Arup, 2009b).

The marine supplementary surveys under HZMB-HKBCF study was conducted with 9 sampling stations within the HKBCF reclamation area in 2008 (Arup, 2009a). A total of 558 organisms (210 from wet season survey and 348 from dry season survey) from 80 taxa, including eight phyla (Annelida, Arthropoda, Chordata, Cnidarian, Echinodermata, Mollusca, Nemertea and Phoronida) were recorded. No species of conservation importance was found. The results were in general similar to those from the previous grab sampling surveys for the HZMB study (Arup, 2009a).

During the Tuen Mun-Chek Lap Kok Link (TM-CLKL) study, benthic samplings were conducted at eight stations along TM-CLKL alignment in October 2008 and February 2009. The wet season survey collected 917 individuals from 50 families comprising eight different phyla. The total recorded biomass was 58.0 g due to the high mass of molluscs, echinoderms, annelids and arthropods. The infauna density was 382 individuals/m², and the average biomass was 24.2g/m². The dry season survey collected 1,579 individuals from 50 families comprising 7 different phyla. The total recorded biomass was 73.1g. The density was 658 individuals/m² and the average biomass was 30.46 g/m².

In summary, no species of conservation importance was identified or recorded from the study area for benthic macro-infauna communities.

5. Literature Review on Intertidal Habitats and Species Groups

Among the available relevant information reviewed, information providing more up-to-date conditions of intertidal habitats and species of conservation importance within the study area was incorporated into the ecological baseline condition of intertidal habitats.

Some areas of conservation importance, while situated inside the broad study area within Deep Bay Water Control Zone, are at a notable distance away from the project site, such as Mai Po Inner Deep Bay Ramsar Site and Sites of Special Scientific Interest (SSSIs) (Pak Nai, Inner Deep Bay and Tsim Bei Tsui), mangroves (at Sheung Pak Nai and Ngau Hom Shek), intertidal mudflats (at Ha Pak Nai), seagrass beds

(at Ha Pak Nai and Pak Nai), and horseshoe crab nursery grounds (at Ha Pak Nai, Pak Nai, Sheung Pak Nai and Ngau Hom Shek) (ERM, 2010). As confirmed by the water quality assessment results (see **Section 8** of the EIA report, most of these sites are unlikely to be impacted by the project. The review of ecological baseline condition has largely focused on the North Western Water Control Zone.

Hong Kong Biodiversity Survey by AFCD

Records of mangrove plant and associated fauna species from AFCD's Biodiversity Survey at Tai Ho Wan, Tung Chung Bay, San Tau, Sham Wat Wan and Yan O from February 2002 to January 2013 were obtained. A total of 50 species were recorded at Tai Ho Wan; 39 species were recorded at Tung Chung Bay; 69 species were recorded at San Tau; 42 species were recorded at Yan O; and 32 species were recorded at Sham Wat Wan. In the lists of intertidal fauna record, species of conservation importance recorded included horseshoe crab *Tachypleus tridentatus* at Tai Ho and Yan O, *Halophila ovalis* at San Tau and Yan O and *Zostera japonica* at San Tau.

Hong Kong-Zhuhai-Macao Bridge Hong Kong Boundary Cross Facilities & Hong Kong Link Road Environmental Impact Assessment (HZMB HKBCF & HKLR EIA)

Four sets of intertidal field surveys were undertaken separately during the EIA study for the HZMB project, in order to assess the ecological environment within eight soft shore sites on North Lantau and Airport Island (Arup, 2009a & 2009b).

From the ecological baseline survey (EBS) report in 2004, wet season intertidal transect surveys were undertaken in September and October 2003 at San Tau, Sha Lo Wan, San Shek Wan, Tung Chung Bay, Tai Ho Wan and Sham Wat Wan. Dry season transect surveys were undertaken in November 2003 and January 2004 at Kau Liu, Sha Lo Wan, Sham Wat Wan, Tai Ho Wan, Hau Hok Wan and San Shek Wan. All of the species recorded were typical soft shore intertidal fauna and can be found in similar habitats throughout Hong Kong. Snail species *Cerithidea djadjariensis* was the most abundant at Tung Chung Bay and Tai Ho Wan. Common species including *Balanus* sp., *Hemigrapsus sanguineus* and *Nerita polita* were abundant at the entire coastal study area. Species abundance during the wet and dry seasons was similar. All intertidal species recorded are common and characteristic of intertidal habitats throughout Hong Kong.

According to the verification survey for ecological baseline (VES) reported in 2009, six soft shore locations (Sham Wat Wan, Sha Lo Wan, Hau Hok Wan, Tung Chung Bay, San Tau and San Shek Wan) along the north coast of Lantau were surveyed in September and December 2008 covering wet and dry seasons. A total of 155 species from several faunal groups, including echinoderms (sea cucumber), arthropods (shrimp, crab and horseshoe crab), molluscs (bivalve, gastropod and tusk shell), annelids (segmented worm), sipunculids (peanut worm), nemertean (ribbon worm), cnidarians (sea anemone) and poriferans (sponge) were recorded.

Investigation conducted in supplementary ecological survey (SES) involved intertidal surveys at four sites during dry and wet seasons in 2009. The majority of the survey area was artificial shores or modified shorelines. Sections of rocky shore remnants and patchy sandy beaches were scattered among the artificial shores. Surveys were also conducted along part of the east coastal line of the airport, near Dragonair / CNAC Building and airport signal lighthouse, and artificial seawall at the southeast end of the airport. A total of 19 taxa were recorded with low species richness. The most frequently recorded species included rock oyster *Saccostrea cucullata*, snails *Monodonta labio* and *Nerita yoldii*, littorid snails *Echinolittorina radiata* and *Echinolittorina pascua*, and crab *Gaetice depressus*. All the species found were common and widespread intertidal fauna in Hong Kong. The abundance of the intertidal fauna recorded was generally low, especially in areas covered by sandy substrates. A total of 26 species of intertidal epifauna and flora were observed during the walk-through surveys. The species recorded were similar to that from the transect surveys. All the species recorded are common and widespread.

In the ecological surveys (ES) conducted near HKBCF project area in 2008, epifauna communities on the coastline at the northeast of the airport island were surveyed during wet and dry seasons. Two types of intertidal habitats were present, including artificial seawalls immediately landward to the reclamation area and rocky shore to the north and south of the artificial seawalls, which included a small section of sandy shore further south of the southern rocky shore. A total of 21 taxa were recorded during the surveys. All were common intertidal organisms in Hong Kong.

Contract No. HY/2011/03 Hong Kong-Zhuhai-Macao Bridge Hong Kong Link Road – Section between Scenic Hill and Hong Kong Boundary Crossing Facilities: Baseline Environmental Monitoring Report (HZMB BEMR)

Mudflat monitoring was part of the baseline environmental monitoring prior to the commencement of construction of road section between Scenic Hill and HKBCF for HZMB-HKLR project. Surveys for horseshoe crabs, seagrass beds and intertidal soft shore communities were conducted in September 2012 at Tung Chung Bay and San Tau (CSCE, 2012).

Horseshoe crabs were recorded at mudflat next to Ma Wan Chung, western part of Tung Chung Bay and San Tau. Patches of seagrass species *Halophila ovalis* were observed at San Tau while no patches of seagrass were observed at Tung Chung Bay.

For intertidal soft shore communities, the number of species (in spp. 0.25 m²) ranged from 5 to 12 at Tung Chung Bay whilst number of species (in spp. 0.25 m²) ranged from 5 to 9 at San Tau. Species diversity index across tidal level at Tung Chung Bay ranged from 1.17 to 1.43 and species evenness index from 0.58 to 0.64, whilst species diversity and evenness indices across tidal level at San Tau were 1.30 and 0.66 respectively. In general, molluscs were the most abundant taxon followed by arthropods. There was no consistent pattern of species distribution observed across zones and tidal levels in Tung Chung Bay and San Tau. *Batillaria multiformis*, *Cerithidea djadjariensis* and *Saccostrea cucullata* were the most common species among the surveyed area.

Tuen Mun-Chek Lap Kok Link EIA (TM-CLKL)

During TM-CLKL study, the intertidal transect surveys were conducted at Tai Ho Wan on between August 2008 and April 2009 (AECOM, 2009a). In the 2008 wet season survey, mud snails (*Cerithidea djadjariensis*) were found to be abundant. The acorn barnacle (*Balanus* sp.), sand snail (*Batillaria* spp.), the fresh water nerites (*Clithon* sp.), rock oyster (*Saccostrea cucullata*) and the nerite (*Nerita polita*) were all found to be common in Tai Ho. In the 2008 dry season survey, the most abundant species recorded were the sand snails (*Batillaria* spp.) and mud snails (*Cerithidea djadjariensis*). The hermit crab, *Balanus* sp., *Clithon* sp., *Nerita polita* and *Saccostrea cucullata* were common species found in Tai Ho (AECOM, 2009a).

In addition to the above quantitative surveys, walk-through surveys were also conducted in the study area. The result of the TM-CLKL walk-through survey at Tai Ho Wan indicated that the species diversity in the wet season (18 species recorded) was lower than dry season (45 recorded). The *Uca crassipes*, *Cerithidea* sp., and *Monodonta labio* were common in both the wet and dry seasons (AECOM, 2009a). *Saccostrea cucullata* was common in wet season while *Uca* spp. and Hermit crab were common in dry season. The *Batillaria* spp., *Cerithidea djadjariensis* and *Saccostrea cucullata* were abundant species in dry season. All species were common and widespread in Hong Kong (AECOM, 2009a).

Intertidal surveys were undertaken along the Pillar Point Tuen Mun coastline including the sloping and vertical seawall along the coastline as well as sandy beach habitat at Butterfly Beach between August 2008 and February 2009, under the Tuen Mun Western Bypass study. No intertidal fauna was recorded at the sandy beach habitat at Butterfly Beach. In the wet season, a total of 17 taxa were recorded at the sloping

and vertical seawalls. The most abundant species recorded was *Ligia exotica* which are common in Hong Kong (AECOM, 2009a). In the dry season, a total of 24 taxa were recorded with *Echinolittorina radiata* being the most abundant species. *Ulva spp.* and *Hildenbrandia rubra* had high coverage at the sloping seawall whilst *Saccostrea cucullata* had the highest coverage at the vertical seawall (AECOM, 2009a).

5.1. Artificial Shores

From a desktop review of aerial photographs of the study area, the coastlines on the northern, western and southern shore of the airport island, some sections of the southeastern and northeast shores of the airport island, and the coastline along North Lantau from Tung Chung waterfront to Sham Shui Kok are artificial shores. On the airport island, approximately 13.5 km of artificial coastlines are reclamation seawalls, largely (approx. 11.8 km in total) constructed of sloping armour rock with some sections such as outfalls and berthing points (approx. 1.7 km in total) constructed of vertical concrete.

The intertidal habitats on the artificial shores to the south and east of airport island were studied in the HZMB-HKLR EIA (Arup, 2009b). A total of 38 fauna species were recorded. The species diversity index and species evenness index of artificial shores were lower than other natural rocky shores in North Lantau. Species with large abundance recorded were sessile organisms such as *Septifer virgatus*, *Saccostrea cucullata* and *Balanus amphitrite*. Other abundant species observed were *Nerita yoldii*, *Barbatia virescens*, limpets and periwinkles. No rare intertidal species or species of conservation importance was recorded. Those abundant species found were common and widespread in exposed rocky shores of Hong Kong.

The sloping seawalls in the northeast of the airport island were surveyed during the ecological survey for HZMB-HKBCF EIA (Arup, 2009a). The artificial seawalls were colonised by intertidal fauna with low abundance and diversity. A total of 21 taxa of intertidal fauna were recorded, including *Tetraclita squamosa*, *Saccostrea cucullata*, *Siphonaria japonica*, *Patelloida pygmaea*, *Patelloida saccharina* and *Nerita sp.* All fauna recorded were very common in intertidal habitats in Hong Kong. No fauna species of conservation importance was found.

5.2. Rocky Shores

Rocky shores were observed at the airport island, Tai Mo To, Sha Chau and along the north-western coast of Lantau, from desktop review of aerial photographs.

On the airport island, remnant rocky shores were observed along the south coast from desktop review of aerial photographs. These rocky shores originated from the old Chek Lap Kok Island.

Survey of the remnant rocky shore at the southeast airport island was undertaken for the HZMB-HKLR EIA (Arup, 2009b). The EIA report noted that the remnant rocky shore was isolated though not being completely converted to artificial coastline. It has been subject to disturbance and modification to various extents, including the elimination of backshores and conversion to seawalls. A total of 26 taxa were recorded from both quantitative and wall-through survey during wet and dry seasons. Low abundance of intertidal fauna was recorded while all the species found are common and widespread in Hong Kong.

From a desktop review of aerial photographs, natural and undisturbed rocky shore habitats were observed at the north-western coast of Lantau. The natural rocky shores near the Sha Lo Wan Pier and at the western and eastern sides of Sha Lo Wan headland were surveyed for the HZMB-HKLR EIA (Arup, 2009b). A total of 54 intertidal species were recorded whilst no species of conservation importance was recorded.

5.3. Sandy Shores

Sandy shores were observed along the coastline of Sha Chau and in small patches at Sha Lo Wan, Hau Hok Wan and Yan O Wan from desktop review of aerial photographs.

Several surveys of the sandy shore habitats at Sha Chau and Lung Kwu Chau were undertaken as reported in the EIA study for Construction of Lung Kwu Chau Jetty (Maunsell, 2002). The sandy shore habitats in the Marine Park were identified as poor. Among the surveys undertaken, sandy shore macrofauna were only encountered at Sha Chau during one survey and their abundance and diversity was low. At Sha Chau, only five species with 24 individuals were recorded: gastropods (*Nerita albicilla*, *Nassarius* sp.), bivalves (*Tapes philippinarum*), annelids (*Nephtys* sp.), and sipunculids (*Phascolosoma scolops*), with *Nerita albicilla* as the most abundant species. Other surveys showed that no sandy shore macro-fauna was encountered at the western side of Sha Chau and the eastern side of the sandbar at Lung Kwu Chau. The sandy shores were found to have coarse sand grain size, resulting in intolerable conditions for sandy shore infauna.

There are also some patchy sandy beaches on the southeastern shore of the airport island. The survey results for the HZMB-HKBCF EIA revealed that these patchy sandy beaches were of very low abundance of intertidal fauna while no infauna was recorded in the sandy substrate (Arup, 2009a).

5.4. Mangroves and Intertidal Mudflats

From the literature review, intertidal mudflats and mangroves are observed at several locations on North Lantau including Tai Ho Wan, Tung Chung Bay, San Tau, Yan O and Sham Wat Wan. These mangrove and intertidal mudflat habitats are discussed by locations in the following paragraphs.

Seagrass and horseshoe crab can be found within intertidal mudflats, which are discussed in Section 5.5 and 5.6 respectively.

San Tau and Tung Chung Bay

Tung Chung Estuary is the largest embayment on North Lantau with extensive mudflats located from San Tau in the west to Sha Tsui Tau in the east of the estuary. The estuary is influenced by marine waters flushing through the Airport Channel and freshwater running from Tung Chung River. San Tau Beach SSSI is located on the western shore of the estuary at about 5.3 km from the west of the project site, while Tung Chung Bay is referring to the more southern part of the estuary connecting to Tung Chung River and locating at about 6.1 km from the project site.

The mudflat habitats at both San Tau and Tung Chung Bay have been identified as nursery grounds for horseshoe crabs, with well-documented records of juvenile individuals of two horseshoe crab species *Tachypleus tridentatus* and *Carcinoscorpius rotundicauda* found there.

During the surveys of intertidal mudflat habitats for the HZMB-HKLR EIA, a total of 76 species were recorded at San Tau and Tung Chung Bay. All the species recorded were typical soft shore intertidal fauna that can be found in similar habitats throughout Hong Kong. Snails *Cerithidea djadjariensis* were common on the mudflats of Tung Chung Bay.

Within Tung Chung Estuary, there are two separate mangrove stands, both relatively large, approximately 2.7 ha at San Tau and 2.14 ha at Tung Chung Bay (ERM, 2005).

The mangrove habitat at San Tau is considered to be of particular ecological importance because of its large size and its association with seagrass beds. This habitat is dominated by a number of mangrove species, especially *Aegiceras corniculatum*, *Avicennia marina*, *Bruguiera gymnorrhiza*, *Kandelia obovata* and *Acanthus ilicifolius*. Among these, *Bruguiera gymnorrhiza* was previously thought to be rare but more

recently has been considered as locally uncommon (Arup, 2009b). The restricted mangrove *Lumnitzera racemosa* was also present (Tam and Wong, 2000). Some locally restricted species were also recorded in the vicinity of the habitats and these included *Thespesia populnea*, *Stenoloma biflorum* and *Ipomoea imperati* (AECOM, 2009a). According to the investigations of Tam and Wong (1997), the San Tau mangrove has the highest species richness of mangrove/ mangrove associate species in the HKSAR.

The mangrove habitat at Tung Chung Bay was ranked highly in species richness according to the investigations of Tam and Wong (1997). The habitat was identified as of high floristic diversity with 18 mangrove species and associated flora. The true mangrove community at the Tung Chung mangrove is to the same as that of San Tau, except the absence of *L. racemosa* (Tam and Wong, 2000).

Sham Wat Wan

Sham Wat Wan is located at about 4.2 km from the west of the project site. Mudflats with small and patchy mangroves are present in the bay.

Mudflats in Sham Wat Wan were surveyed for the HZMB-HKLR EIA. A total of 55 species were recorded.

Mangroves are also found in Sham Wat Wan and they were surveyed for the HZMB-HKLR EIA. There were only small areas of mangroves fringing the eastern and western shores of Sham Wat Wan, and no species of conservation importance were recorded (Arup, 2009b).

Tai Ho Wan

Tai Ho Wan is located in the estuarine area of North Lantau, at about 5.9 km from the east of the project site. Though it has been partly cut off from the sea by the construction of the North Lantau Expressway, a culvert at the western end of the bay maintains tidal exchange within the bay. The southern end of the bay is dominated by mangroves and extensive mudflats where Tai Ho Stream enters the bay.

The intertidal habitats at Tai Ho Wan are dominated by intertidal mudflats which are silty in nature, with patches of mangroves along the coastline. Seagrass *Halophila beccarii* was also reported present at Tai Ho Wan (Arup, 2009a).

Referring to the survey results obtained at Tai Ho Wan for the HZMB-HKBCF EIA, the intertidal species recorded at the mudflats were typical soft shore intertidal fauna. The mudflats were considered as of moderate biodiversity (Arup, 2009a). The snail *Cerithidea djadjariensis* was the most abundant species on the mudflat, while common species including barnacle *Balanus* sp., crab *Hemigrapsus sanguineus* and snail *Nerita polita* were abundant on hard surfaces present on the mudflat. Species abundance during the wet and dry seasons was similar. Horseshoe crabs were also recorded at Tai Ho Wan during the survey, which is further described in **section 5.6** below.

Field surveys in Tai Ho and Pak Mong have also been conducted during 2008-2009 under the TM-CLKL study. A total of 17 plant species were recorded in mangroves within the study area. Despite the comparatively small habitat size, the coastal habitats are rich in species, with the number of floral species recorded in Tai Ho being fairly high (AECOM, 2009a). There were four true mangrove species including *Kandelia candel*, *Bruguiera gymnorrhiza*, *Aegiceras corniculatum* and *Acanthus ilicifolius*. Among the true mangrove species recorded, *Bruguiera gymnorrhiza* is considered to have a restricted distribution in Hong Kong. This species has established a relatively large population in Tai Ho and it is known to adapt to hardened and stiff mud (AECOM, 2009a). In addition to these true mangrove species, mangrove associated flora such as *Acrostichum aureum* and *Thespesia populnea* was also recorded within the mangrove habitat (AECOM, 2009a).

Tam and Wong (1997) surveyed the main mangrove stand in Tai Ho Wan and found this 1.86 ha stand to be the third largest mangrove on Lantau, after Tung Chung and San Tau. During the survey for the HZMB-HKBCF EIA, six true mangrove species including *Lumnitzera racemosa*, *Kandelia candel*, *Bruguiera gymnorrhiza*, *Avicennia marina*, *Aegiceras corniculatum* and *Acanthus ilicifolius* were recorded at Tai Ho Wan (Arup, 2009a). In addition to these true mangrove species, a number of mangrove-associated flora such as *Limonium sinense*, *Clerodendrum inerme* and *Acrostichum aureum* were also recorded.

5.5. Seagrass Beds

Seagrass is the only flowering plant which can survive when wholly submerged in coastal marine and estuarine waters (AFCD, 2013c). It is important to the coastal ecology due to its high primary production rate and major contribution as primary resources for marine ecosystems (Fong, 1999a). It is a vital component of coastal and marine ecosystems as it stabilizes coastlines and sediments. Moreover, seagrass beds act as shelter, feeding grounds and food sources for a variety of organisms such as fish, crabs, gastropods, horseshoe crabs and turtle (AFCD, 2013c).

There are five seagrass species distributed in various areas of both the eastern and western waters of Hong Kong including *Halophila beccarii*, *Halophila ovalis*, *Halophila minor*, *Ruppia maritima* and *Zostera japonica*. All these seagrass species are considered rare but not legally protected in Hong Kong. It was reported that except *Halophila minor* (which was first confirmed in 2005), the four species shared the characteristic of co-occurring with mangroves in the low to mid-intertidal region of sand and mud flat areas (Fong, 1998). According to data collected by AFCD from 2002 to 2013, for Lantau Island, seagrass beds were recorded at San Tau, Sham Wat, Yan O Wan and Nim Shue Wan.

San Tau

The three seagrass species found at San Tau beach were *Halophila ovalis*, *Halophila minor* and *Zostera japonica*. According to the biodiversity survey of seagrass beds conducted by AFCD, a maximum extent of 3820 m² of *Halophila ovalis* and 20 m² of *Zostera japonica* has been recorded in San Tau Beach SSSI (Kwok *et al.*, 2005). The occurrence of these two species at San Tau mangrove stands was also confirmed by Tam and Wong (2000).

During the HZMB HKLR surveys conducted in San Tau Beach SSSI in October 2008 and January 2009, approximately 7 patches of *Zostera japonica* were found with size ranging from 0.1m² to 16m². It is noted that the number of patches and patch sizes increased during the survey. Three patches of *Halophila minor* with size of 0.2m² to 1.5m² were recorded in January 2009 along the mangrove fringe and found in association with the *Zostera japonica* patches (Arup, 2009b).

In the latest seagrass survey conducted in March 2013 at San Tau and Tung Chung Bay as part of the quarterly mudflat monitoring for HZMB HKLR EM&A programme, seagrass beds were recorded at San Tau only (CSCE, 2013). Three patches of *Halophila ovalis* were recorded nearby the mangroves at San Tau. The estimated total area and mean area were 528.8 m² and 176.3 m² respectively. One of the patches was a long seagrass strand with estimated total area 442.2 m². Three small patches of *Zostera japonica* were found within the long strand of *Halophila ovalis*. The estimated total area and mean area were 10.4 m² and 3.5 m² respectively. Relative to previous surveys, the total area and estimated coverage increased gradually. Since the location of seagrass was the same, it was believed that scattered patches of seagrass grew and merged into single, large patch.

The presence of seagrass bed was a key reason for San Tau Beach being designated as SSSI to reflect its ecological importance. The seagrass bed at San Tau is also an important nursery and feeding ground of horseshoe crabs.

Other locations on Lantau

At Yan O Wan, approximately 7,500 m² of *Halophila ovalis* was recorded during the territory-wide ecological field survey conducted by AFCD (Kwok *et al.*, 2005).

Seagrass species *Halophila beccarii* was recorded in Sham Wat by AFCD in 2013. *Halophila beccarii* was also reported present at Tai Ho Wan with size of about 30cm x 30 cm recorded (Arup, 2009a) during the ecological baseline survey in 2004 for HZMB-HKBCF EIA. The TM-CLKL field surveys for seagrass beds were undertaken during 2008-2009, but no seagrass was observed at Tai Ho Wan (AECOM, 2009a).

Other locations within study area

In other locations within the study area, *Halophila ovalis* was also recorded at mangrove stands in Sheung Pak Nai and Ha Pak Nai, while *Zostera japonica* was also recorded in Mai Po (Tam and Wong, 2000).

In summary, a total of four seagrass species were recorded within the study area.

5.6. Horseshoe Crab Breeding and Nursery Sites

Three Asian horseshoe crab species: *Tachypleus tridentatus*, *T. gigas* and *Carcinoscorpius rotundicauda*, represent all species known in the South China Sea, and three of the four species known worldwide, have been reported in Hong Kong waters (AFCD, 2013d; Chiu and Morton 1999). However, only *T. tridentatus* and *C. rotundicauda* were recorded in previous surveys. These two species are listed under the China Species Red List in which *T. tridentatus* is regarded as endangered and *C. rotundicauda* is regarded as vulnerable (Wang and Xie, 2004). Horseshoe crab in general is not considered as an endangered species by IUCN but global horseshoe crab populations are declining drastically due to habitat loss, pollution and over exploitation (AFCD, 2013d; Arup 2009a). Though not currently protected under local law, horseshoe crabs have been identified as a species of conservation importance in Hong Kong.

In a population distribution study of horseshoe crabs by Shin *et al.*, (2009), 17 soft shores including San Tau, Tung Chung, Tai Ho Wan, Hau Hok Wan, Sham Wat Wan, Yi O, Shui Hau Wan and Pui O Wan on Lantau Island, and other locations on Lamma Island and in the northwestern and northeastern New Territories were surveyed. On Lantau Island, juvenile horseshoe crabs of species *T. tridentatus* were recorded at San Tau, Tung Chung, Sham Wat Wan, Yi O and Shui Hau Wan; juvenile horseshoe crabs of species *C. rotundicauda* were recorded at Tai Ho Wan, Tung Chung and Yi O.

Horseshoe crabs were recorded during the ecological study field surveys for HZMB-HKBCF & HKLR EIA (Arup, 2009a & 2009b). Juveniles of *T. tridentatus* were recorded at San Tau, Tung Chung Bay, Hau Hok Wan and Sham Wat Wan, while juveniles of *C. rotundicauda* were recorded at Tai Ho Wan and Pak Mong, San Tau and Hau Hok Wan. Horseshoe crabs were also recorded in the baseline mudflat monitoring for HZMB-HKLR (CSCE, 2012). There were 1, 9 and 16 individuals of horseshoe crab *T. tridentatus* recorded at mudflat next to Ma Wan Chung, western part of Tung Chung Bay and San Tau respectively.

During the TM-CLKL survey between July 2008 and February 2009, two *Tachypleus tridentatus* and three *Carcinoscorpius rotundicauda* were recorded at San Tau. In addition, two *Carcinoscorpius rotundicauda* were recorded at Tung Chung Bay. No horseshoe crabs or trails were found at Pak Mong and Tai Ho Wan (AECOM, 2009a).

Relatively higher population densities of juvenile horseshoe crabs were recorded at Ha Pak Nai, San Tau and Shui Hau Wan (Shin *et al.*, 2009). These locations were identified as nursery habitats for horseshoe crab. Tai Ho Wan has previously been identified as a breeding ground for *C. rotundicauda* and nursery ground for both *T. tridentatus* and *C. rotundicauda* (Fong, 1999b).

Apart from records of horseshoe crabs at intertidal mudflats, both *Carcinoscorpius rotundicauda* and *T. tridentatus* was recorded in the marine environment during a trawl survey at western Chek Lap Kok waters and SCLKCMP. The trawl survey was conducted under the Contaminated Mud Pits Environmental Monitoring and Audit in 2012 wet season.

In summary, six species of conservation importance were recorded from the intertidal habitats from literature review. These included the four seagrass species *Halophila beccarii*, *Halophila minor*, *Halophila ovalis* and *Zostera japonica*, and the two horseshoe crab species *Tachypleus tridentatus* and *Carcinoscorpius rotundicauda*. *H. beccarii* is listed as “Vulnerable” under IUCN Red List while seagrass beds of the other three species are designated as SSSIs. All four seagrass species are locally rare (Hu, 2003; Xing et al., 2000). For the two horseshoe crab species, *C. rotundicauda* is listed as “Vulnerable” while *T. tridentatus* is listed as “Endangered” under China Species Red List, and both species are described as declining in range in Hong Kong due to water pollution and loss of nursery grounds (Morton and Lee, 2003). Therefore these six species are all considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text.

6. Literature Review on Estuarine Fauna

6.1 Estuarine Macroinvertebrates

A total number of 95 species of estuarine macroinvertebrate species were recorded in the study area during previous biodiversity surveys and EIA studies (AEC, 2009, AECOM, 2009a; AFCD, 2002-2013) (**Annex A**). The majority of the recorded species were estuarine intertidal species. *Carcinoscorpius rotundicauda* and *Tachypleus tridentatus* which had been identified as species of conservation importance in Section 5 were also recorded by the estuarine fauna surveys. *C. rotundicauda* was previously recorded in several locations in North Lantau including San Tau, Hau Hok Wan, Tai Ho, and Tung Chung Bay while *Tachypleus tridentatus* were recorded in San Tau, Hau Hok Wan, Sham Wat and Tung Chung.

The echinoderm *Holothuria leucospilota* was previously recorded in Sham Wat by the TMCLKL study (AECOM, 2009a), and identified as a species of conservation importance by that study as it is listed as “Endangered” under the China Species Red List due to over-exploitation. However, it is actually found to be common in Hong Kong (Lai et al., 2006). Therefore, it is excluded from the ecological impact assessment in the current EIA study.

The greasyback shrimp *Metapenaeus ensis* was also considered as species of conservation importance by the HZMB-HKBCF, HZMB-LR and TMCLKL EIAs (AECOM, 2009a; Arup, 2009a; Arup, 2009b) as it is listed as “Vulnerable” under the China Species Red List due to over-exploitation. However, it is actually common in mangroves and estuarine areas in Hong Kong (Leung, 1999 and Vance, 1999). This species is also recorded commonly during 3RS EIA fisheries survey. Therefore, it is also excluded from the ecological impact assessment in the current EIA study.

The sesarmine crab species *Chiromantes sereni* was first recorded in Hong Kong (Soh, 1978). It is considered as species of conservation importance because it is endemic (Kwok & Tang, 2005). It was previously only recorded at four sites (Tai Tan, Siu Tan, Sham Chung and To Kwa Peng) in a territory-wide sesarmine crab survey (Kwok & Tang, 2005). During the HZMB-LR ecological baseline survey, this species was also recorded in Hau Hok Wan and Sha Lo Wan (Arup, 2009b). Therefore, it is considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text.

Estuarine Fishes

A total of 46 estuarine fish species were found during the AFCD's biodiversity survey from 2002 to 2013 (**Annex B**). Five potential species of conservation importance have been identified, which are discussed below.

The Largesnout goby *Awaous melanocephalus* found in Tung Chung from the AFCD biodiversity survey is regarded as a “Regional Concern” species (Fellowes *et al.*, 2002). It is described as rare in Hong Kong with records from a few streams on Hong Kong Island and Lantau Island (Lee *et al.*, 2004). It was recorded from Tung Chung Bay from the AFCD Biodiversity Survey. Due to its conservation status and rareness, it is considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text..

The Meggitt’s goby *Bathygobius meggitti* found at Tai Ho is evaluated as “Vulnerable” by the China Species Red List. It is described as common and widespread in Hong Kong (Lam, 2002), therefore it is excluded from the impact assessment in the current EIA study.

Indo-Pacific tropical sand goby *Favonigobius reichei*, recorded in Tai Ho, is listed as “Lower Risk/ Near Threatened” under IUCN Red List. It was previously identified as species of conservation importance by the HZMB-BCF, HZMB-LR and TMCLKL EIAs (AECOM 2009; Arup, 2009a; Arup, 2009b). However, as it is commonly found in intertidal waters throughout Hong Kong (Lee *et al.*, 2004). The 3RS EIA survey also found that it is widely distributed throughout the north Lantau estuarine waters. Therefore it is excluded from the impact assessment in the current EIA study.

The Mozambique Tilapia *Oreochromis mossambicus* was recorded in Tai Ho, Tung Chung and Sham Wat. Although it is regarded as “Near Threatened” under IUCN Red List, it is an invasive species to Hong Kong competing with indigenous fish for food resource and habitats. It is originally native to the eastern coast of Africa and Middle East, but has been popularly introduced throughout the world for culturing. It is common and widespread in brackish waters, freshwaters ponds ditches, rivers and reservoirs. The fish is also cultivated in some local fish farms. Therefore, the Mozambique Tilapia is not considered to be of conservation importance in the current EIA study.

The Archpatch puffer *Takifugu ocellatus* recorded in Sham Wat is regarded as a species of “Local Concern” (Fellowes *et al.*, 2002). It was also previously recorded in Pak Mong, San Tau, Sham Wat, Tai Ho and Tung Chung by the ecological baseline surveys conducted for HZMB-BCF and HZMB-LR EIAs, which recognised it as a species of conservation importance due to its conservation status. It is at the same time assessed as rare by AFCD (2013b), therefore it is considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text..

Other potential species of conservation importance had been identified by previous EIA studies (HZMB-BCF, HZMB-LR and TMCLKL) and published reports. They are discussed below.

Kuhlia marginata (dark-margined flagtail) was recorded in San Tau by the HZMB-BCF ecological baseline survey (Arup, 2009a). It is of “Regional Concern” (Fellowes *et al.*, 2002) and its status in Hong Kong is unknown (Lee *et al.*, 2004). Therefore it is considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text..

Takifugu niphobles (snowy puffer), which has records in San Tau, Hau Hok Wan and Tai Ho was considered as species of conservation importance by HZMB-BCF, HZMB-LR and TMCLKL EIAs as it is “Data Deficient” under IUCN Red List EIAs (AECOM 2009; Arup, 2009a; Arup, 2009b). However this conservation status, together with its commonness in Hong Kong (AFCD, 2013b), do not qualify it as a species of conservation importance in the current EIA study.

Scartelaos histophorus (green mudskipper) and *Luciogobius guttatus* (flat-headed goby) were recorded at the soft shores at San Shek Wan, Sha Lo Wan and Hau Hok Wan. They were considered as species of conservation importance by the TMCLKL EIA as they were uncommon species in Hong Kong (Lee *et al.*, 2004). However they are excluded from the impact assessment in the current EIA study as they have no protection status locally, regionally or internationally, nor are they rare species. In addition, the 3RS EIA

estuarine and stream survey indicates that these two species are widely distributed throughout the estuarine of north Lantau waters.

In a research named “Hong Kong’s First Systematic Survey of Pipefish and Seahorses” conducted by Green Power (2012), *Syngnathoides biaculeatus* (alligator pipefish) was identified at Tung Chung Bay, Hau Hok Wan, Sha Lo Wan and Sunny Bay, while juveniles of *Syngnathus schlegeli* (seaweed pipefish) were recorded in Tung Chung Bay and Sha Lo Wan (Green Power & EERC, 2012). *Syngnathoides biaculeatus* is listed as “Vulnerable” under China Species Red List with unknown local population (Green Power & EERC, 2012) while *Syngnathus schlegeli* is found to be rare in Hong Kong waters (To et al., 2013). Both of these species are considered as of conservation importance by the Study Brief, therefore they are considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text..

In the report “Ecological and Conservation Importance of Tung Chung, Lantau” published by KFBG (2013), five species of conservation importance were identified in that report, namely *Anguilla japonica* (Japanese eel), *Glossogobius olivaceus* (spotted band goby), *Eugnathogobius polylepis* (mangrove goby), *Hemigobius hoevenii* (mangrove goby) and *Scartelaos histophorus* (green mudskipper).

Anguilla japonica and *Glossogobius olivaceus*, the former of which was recorded in Tung Chung Bay and the latter in Tung Chung and Tai Ho Stream, were considered as species of conservation importance by KFBG (2013) as they were uncommon in Hong Kong (Lee et al., 2004). They are both excluded from the ecological impact assessment in the current EIA study as they are not rare species, nor are they protected locally, regionally or internationally (*Glossogobius olivaceus* is listed as “Least Concern” under IUCN Red List). In addition, they are widely distributed from the 3RS EIA estuarine and stream survey.

Eugnathogobius polylepis, reported in Tung Chung Bay, is listed as “Endangered” under the China Species Red List, and reported by KFBG to be restricted to mangrove areas and has only been found in several locations, usually in very low numbers. Due to its regional protection status and rareness in Hong Kong, it is considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text..

Banded mulletgoby *Hemigobius hoevenii* is rare in Hong Kong. It was only recorded in a few streams and estuaries on Lantau Island. Due to its rare status locally it is considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text.

In the Tung Chung New Town Extension Study, five species of conservation importance had been identified thus far, including *Butis melanostigma* (Crimson-tipped flathead), *Psammogobius biocellatus* (sleepy goby), *Syngnathus schlegeli* (seaweed pipefish), *Hippocampus kuda* (common seahorse) and *Scartelaos histophorus* (green mudskipper). *Butis melanostigma* and *Psammogobius biocellatus* were identified as species of conservation importance by the consultants for this study as they are uncommon locally (Lee et al., 2004), however they are both excluded from the ecological impact assessment in the current EIA study as they are not rare species, nor are they protected locally, regionally or internationally.

Hippocampus kuda is listed as “Vulnerable” by IUCN Red List and “Endangered” by China Species Red List. It is also evaluated as uncommon in Hong Kong waters (To et al., 2013). Due to its protection status regionally and internationally, it is considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text..

7. Literature Review on Marine Fishes and Other Fauna

7.1 Contaminated Mud Pit Environmental Monitoring and Audit (CMP EM&A)

Trawl surveys were conducted as part of the CMP EM&A, and data for 2006 and 2013 were obtained for this EIA study. Survey areas in this EM&A included western Chek Lap Kok waters (TSA and TSB), SCLKCMP (TNA and TNB), and northern Chek Lap Kok waters (INA and INB). Locations of the trawl stations are shown in **Drawing No. MCL/P132/EIA/14-002**. A list of the species recorded from the CMP EM&A is provided in **Annex A**.

Based on the CMP EM&A data (CEDD, 2013), from 2006 to 2013, a total of 397 species (including 171 fishes, 22 shrimps, 49 crabs, 9 mantis shrimps, 2 horseshoe crab, 60 gastropods, 43 bivalves, 6 cephalopods, 15 cnidarians, 10 echinoderms, 2 barnacles, 2 polychaete, 1 Echiura species, 1 Tunica species and 4 Sipuncula species) were caught by trawl survey conducted in the northwestern waters of Lantau (including SCLKCMP, northern and western waters of Chek Lap Kok) during both wet and dry seasons. Horseshoe crabs (*Carcinoscorpius rotundicauda* and *Tachypleus tridentatus*), the estuarine fishes (*Takifugu ocellatus*) and *Syngnathus schlegeli* (seaweed pipefish) which had been identified in previous sections as species of conservation importance, were also collected in open marine waters by the trawl surveys.

Four marine fish species are listed under the IUCN Red list, including *Dasyatis akajei* (red stingray), *Dasyatis zugei* (pale-edged stingray), *Epinephelus coioides* (orange-spotted grouper) and *Epinephelus bruneus* (longtooth grouper). Orange-spotted grouper is listed as “Near Threatened” by the IUCN Red List of Threatened Species while Longtooth grouper is listed as “Vulnerable” in IUCN Red List. All of them are considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text.

The Archpatch puffer *Takifugu ocellatus* which had been recognised as species of conservation importance relevant to impact assessment in the current EIA study, was also recorded in SCLKCMP, and northern and western Chek Lap Kok waters. This species was recorded with wide distribution in north Lantau waters.

Another 11 marine fish species are listed under the China Species Red List. *Zebrias crossolepis* is listed as “Endangered” while *Chrysochir aureus* (Reeve’s croaker), *Clupanodon thrissa* (Chinese gizzard shad), *Collichthys lucidus* (Lion head croaker), *Diagramma pictum* (Painted sweetlips), *Inimicus japonicus* (Devil stinger), *Johnius amblycephalus* (Bearded croaker), *Johnius macrorhynchus* (Big-snout croaker), *Larimichthys crocea* (Yellow croaker), *Nemichthys scolopaceus* (Slender snipe eel) and *Otolithes ruber* (Tiger-toothed croaker) are listed as “Vulnerable” in the China Species Red List.

Clupanodon thrissa (Chinese gizzard shad) was recorded in SCLKCMP and western Chek Lap Kok water. It is considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text as the local status is unknown.

Chrysochir aureus (Reeve’s croaker), *Collichthys lucidus* (Lion head croaker), *Johnius amblycephalus* (Bearded croaker) and *Johnius macrorhynchus* (Big-snout croaker) were recorded in SCLKCMP and the northern and western Chek Lap Kok waters. Lion head croaker and Big-snout croaker are also recorded in 3RS EIA fisheries surveys with wide distribution in north Lantau waters. These four species are therefore excluded from the ecological impact assessment in the current EIA study as they were common fish species recorded in trawl survey.

Diagramma pictum (Painted sweetlips) was recorded in SCLKCMP and northern Chek Lap Kok. It was considered as common to moderately abundant (Sadovy, 2000; To et al. 2013). The species is therefore excluded from the ecological impact assessment in the current EIA study.

Inimicus japonicus (Devil stinger) was recorded in SCLKCMP, and northern and western Chek Lap Kok waters. It is considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text as the local status is unknown.

Larimichthys crocea (Yellow croaker) was recorded in the western Chek Lap Kok waters. It is considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text as the wild catch reported to be great decline (Cheung and Sadovy, 2004).

Nemichthys scolopaceus (Slender snipe eel) was recorded in the SCLKCMP, northern and western Chek Lap Kok waters. It is considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text as the local status is unknown.

Otolithes ruber (Tiger-toothed croaker) was recorded in the northern and western Chek Lap Kok waters. It is considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text as it was encountered infrequently during the survey and the local status is unknown.

Zebrias crossolepis was recorded in SCLKCMP only. It is considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text as the local status is unknown.

Other marine fauna include two sea cucumbers, one sea snail, one clam and eight prawn species. Sea cucumbers *Acaudina molpadioides* and *Colochirus quadrangularis* are listed as “Endangered” and “Vulnerable” under the China Species Red List respectively. Both clams *Coelomactra antiquate* and sea snail *Oliva mustelina* are listed as “Endangered” in the China Species Red List. Prawn species *Fenneropenaeus merguensis* and *Fenneropenaeus penicillatus* are listed as “Endangered” while *Metapenaeus affinis*, *Metapenaeus ensis*, *Metapenaeus intermedius*, *Metapenaeus joyneri*, *Metapenaeus moyebi* and *Metapenaeus moyebi* are listed as “Vulnerable” under the China Species Red List.

Acaudina molpadioides was recorded with wide distribution in SCLKCMP and northern and western Chek Lap Kok waters. It is excluded from the ecological impact assessment in the current EIA study as it is a common species recorded in trawl survey.

Colochirus quadrangularis was recorded in northern Chek Lap Kok waters. It is evaluated as common by AFCD (AFCD, 2013e) and hence do not require further impact assessment in the current EIA study.

Coelomactra antiquate was recorded in SCLKCMP and is a common species in Hong Kong (Morton and Morton, 1983). Therefore no further impact assessment is required in the current EIA study.

Oliva mustelina was recorded in SCLKCMP and western Chek Lap Kok waters. It is considered relevant to this EIA study and would be subject to more detailed assessment as presented in the main text as the local status is unknown.

All the prawn species recorded are common prawn species recorded in the CMP field survey and they are therefore excluded from the ecological impact assessment in the current EIA study.

7.2 Spawning and Nursery Ground

Surveys conducted to identify spawning seasons, habitats and nursery areas of fisheries resources identified northeast Lantau waters as spawning grounds for fish and crustacean species such as *Leiognathus brevirostris* (shortnose ponyfish), *Lateolabrax japonicus* (Japanese seabass), *Konosirus punctatus* (Konoshiro gizzard shad), *Solenocera crassicornis* (coastal mud shrimp), *Metapenaeus affinis* (jinga shrimp) and *Oratosquilla oratoria* (mantis shrimp) (ERM, 1998) (**Drawing No. MCL/P132/EIA/14-001**). None of the species above is of conservation importance. Furthermore, the area was not recognised as important nursery grounds for juvenile fish, crustaceans or molluscs (ERM 1998). Therefore the study area is not identified to be the spawning and nursery ground for species of conservation importance.

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