8. MARINE ECOLOGY

8.1 Background

8.1.1.1 This section of the EIA presents details of the assessment of the potential impacts of the construction and operation of the Tuen Mun – Chek Lap Kok Link (TM-CLKL) on marine ecological resources within the study area and describes the sensitive receivers present, potential impacts from the project and recommends suitable mitigation measures. The terrestrial ecological impact assessment is presented in Section 7 of this report. The potential impacts to all avifauna is discussed under the Terrestrial Ecology section and not covered in the chapter. In order to achieve the aforementioned measures, the major objectives of the assessment are broadly as follows:

- Evaluation of the ecological importance of the marine and inter-tidal flora, fauna and habitats found;
- Identification, prediction and evaluation as far as possible of any direct or indirect and on-site or off-site impacts to marine ecology; and
- Proposals for any practicable alternatives or mitigation measures to prevent or minimise adverse impacts on marine ecology.

8.1.1.2 Further details of the key objectives of the marine ecological assessment are provided in Section 8.4 below.

8.1.1.3 The marine ecological baseline has been determined via a combination of literature review and ecological survey to cover any data gaps and provide more recent and project specific data on the existing ecological conditions in the study area for the ecological impact assessment. The ecological baseline study for the Hong Kong Section of Hong Kong – Zhuhai – Macao Bridge and Connection with North Lantau Highway (HZMB) was undertaken in the marine waters along the coastal area of North Lantau between September 2003 and May 2004 (Mouchel, 2004b) while the ecological surveys for the Tuen Mun Western Bypass (TMWB) have been undertaken in the intertidal areas of Pillar Point, Tuen Mun between 2008 and 2009. The surveys are relatively recent and of particular relevance to the Study Area and the findings have been discussed together with the findings of the project specific TM-CLKL ecological surveys undertaken.

8.1.1.4 In addition, the verification survey for ecological baseline and supplementary ecological survey for the Hong Kong – Zhuhai – Macao Bridge Hong Kong Link Road (HKLR) were undertaken along the shoreline from Sham Wan to the southeast of Airport Island between August 2008 and February 2009 (Asia Ecological consultants, 2009; ENSR, 2009). The ecological baseline study of the Hong Kong – Zhuhai – Macao Bridge Hong Kong Boundary Crossing Facilities (HKBCF) EIA Study has been conducted in the same study area as HKLR projects between September 2008 and May 2009. The findings of both HKLR and HKBCF surveys are appropriate for the evaluation of the marine environment in the wider area owing to the higher mobility of certain faunal groups (such as Chinese White Dolphins and horseshoe crabs) which are potentially capable of colonising suitable substrata over wide areas. These extensive data facilitate an improved description of the existing ecological conditions in the waters of the wider study area and have been included in the literature review detailed below.

8.1.1.5 As described in Section 2 of this report, the proposed alignment has been selected on the basis of a comprehensive option assessment of three northern, two southern and three main crossing alternative option combinations. The main relevance to the marine ecological assessment are the reclamations for the northern and southern landfalls, the tunnel itself and also the southern elevated viaduct connecting the southern reclamation to north Lantau. Section 3 provides the details of these elements of the project. The key issue to note is that the tunnel will be formed by Tunnel Boring Machine (TBM) and as such, will not require any dredging which will reduce the level of impacts on the marine environment, as compared to the immersed tube tunnel.

8.2 Environmental Legislation

8.2.1.1 A number of international and local regulations, legislation and guidelines provide the framework for the protection of species and habitats of marine ecological importance and these include:

- ***Marine Parks Ordinance*** (Cap. 476) which applies to the marine park at Sha Chau and Lung Kwu Chau and limits certain activities in this area;
- ***Wild Animals Protection Ordinance*** (Cap. 170) which protects all birds and most mammals;
- ***Protection of Endangered Species of Animals and Plants Ordinance*** (Cap. 586) which controls the trade in threatened and endangered species and local possession of them. Cap. 586 replaced the "Animals and Plants (Protection of Endangered Species) Ordinance (Cap. 187)" on 1 December 2006. The Ordinance is the local legislation that implement CITES;
- ***Hong Kong Planning Standards and Guidelines Chapter 10*** (HKPSG) which covers planning considerations relevant to conservation. This chapter details the principles of conservation, the conservation of natural landscape and habitats, historic buildings, archaeological sites and other antiquities. It also addresses the issue of enforcement. The appendices list the legislation and administrative controls for conservation, other conservation related measures in Hong Kong and government departments involved in conservation;
- ***Technical Memorandum for the EIAO*** (Cap. 499). Annexes 8 and 16 of TM-EIAO which sets out general criteria for evaluating the ecological importance of and hence the significance of potential ecological impacts and guidance for ecological assessment, respectively;
- **The World Conservation Union IUCN (version 2009.1)** maintains, through its Species Survival Commission, a "Redlist" of globally threatened species of wild plants and animals (see http//www.iucnredlist.org). The Redlist is considered the authoritative publication to classify species as critically endangered, endangered, vulnerable, or lower-risk.

- ***United Nations Convention on Biodiversity*** (1992) which requires signatories to make active efforts to protect and manage their biodiversity resources. Hong Kong Government has stated that it will be "committed to meeting the environmental objectives' of the Convention (PELB 1996). The convention includes the Indo-Pacific Hump-backed Dolphin (*Sousa chinensis*; Osbeck, 1765), locally known as Chinese White Dolphin (CWD), as a protected species; and

- ***Convention on the International Trade in Endangered Species of Flora and Fauna*** (CITES) which lists *Sousa chinensis* in Appendix I. Certain types of corals are also listed in CITES, including blue coral (*Heliopora coerulea*), organ pipe corals (family Tubiporidae), Black corals (order Antipatharia), Stony coral (order Scleractinia), fire corals (family Milleporidae) and lace corals (family Stylasteridae). The import, export and possession of the listed species are locally regulated via Cap 586.

8.3 Key Ecological Sensitive Receivers

8.3.1.1 The marine ecological receivers potentially impacted by the project comprise the following:

- Chinese White Dolphins (*Sousa chinensis*);
- Marine benthic macrofauna;
- Intertidal flora and fauna including seagrasses, mangroves and horseshoe crabs (*Tachypleus tridentatus* and *Carcinoscorpius rotundicauda*);
- Corals;
- Artificial reefs (ARs) at Airport East Exclusion Zone and Sha Chau;
- the Sha Chau and Lung Kwu Chau Marine Park; and
- SSSIs at San Tau Beach and Tai Ho Wan.

8.3.1.2 Location maps showing the distribution of the key species of conservation importance and important ecological features in the study area are presented in **Figures 8.1a and 8.1b**.

8.3.1.3 The proposed alignment of TM-CLKL passes through habitat utilised by the Chinese White Dolphins (CWD). The CWD is a "Grade I National Key Protected Species" in the Mainland and also listed as highly endangered by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES – Appendix I, which includes species threatened with extinction and trade in specimens of these species is permitted only in exceptional circumstances) and 'Near Threatened' by IUCN Red List (version 2009.1) (DD; IUCN, 2006). In Hong Kong it is protected under the Protection of Endangered Species of Animals and Plants Ordinance (Cap. 586).

8.3.1.4 It is one of the two local resident cetacean species and the local residence belongs to a wilder Pearl River Estuary population. Including Chinese White Dolphins in Mainland waters, the total population size was considered to be about 1300-1500 animals with the highest estimates for any season in Hong Kong being 193 in autumn (Jefferson (2007)). The local population concentrates at the North and West Lantau waters. The species in North Lantau showed a decline in abundance in late nineties possibly related to the intense developments in North Lantau at that time but overall the abundance is more or less stable with no clear consistent trend. Recent sighting data indicates that while the Lung Kwu Chau area remained the most important site in the North Lantau, the waters around Brothers were moderately used by CWD.

8.3.1.5 Young calves have been recently observed around the Brothers suggesting that CWD might be exploring the Brothers as the nursing site although encounter rate was very low. In recent years, although a decline in encounter rate of young calves was observed from 2002-08, this trend was reversed in 2008-09. It is, thus, essential that suitable nursing habitats should be appropriately protected.

8.3.1.6 The North Lantau waters have been the focus of recent developments (e.g., the new airport, the River Trade Terminal, mud pits) and the associated disturbance, together with general habitat degradation/destruction, represent significant potential threats to the long-term sustainability of this precious species.

8.3.1.7 The construction of the TM-CLKL, and cumulatively the HZMB and associated HKBCF and HKLR, could introduce further potential stresses and impacts to this important species. Construction of the TM-CLKL project will involve reclamation works comprising dredging and filling activities and also bored piling for the marine viaduct. Apart from habitat loss, noise disturbance, sediment plumes, increased marine traffic, etc., associated with the project construction would be another source of impacts to CWD.

8.3.1.8 Liu and Hills (1997) have stressed that in situations where an endangered species, such as the CWD, is subjected to aggregated impacts, there is a strong case for a species-based ecological assessment which would seek an integrated and coordinated solution to predict and mitigate potential impacts. For this reason, owing to the status and conservation importance of the dolphin, a species-based ecological assessment is required for the Chinese White Dolphin.

8.3.1.9 There is one designated Marine Park located within the Study Area which is the Sha Chau and Lung Kwu Chau Marine Park. The park was designated specifically for the protection of the Chinese White Dolphin (*Sousa chinensis*).

8.3.1.10 There are two gazetted Artificial Reef Deployment (ARD) Sites within the Study Area. They are Airport ARD site and Sha Chau and Lung Kwu Chau ARD site situated within the Sha Chau and Lung Kwu Chau Marine Park. The ARD sites are proposed as a fisheries resource enhancement tool to encourage growth and development of a variety of marine organisms and provide feeding opportunities for the Chinese White Dolphin.

8.3.1.11 The hard and soft corals were present in subtidal hard bottom habitats within the Study Area but in both limited density and of limited diversity. Scattered hermatypic hard corals (family Faviidae), ahermatypic gorgonian seawhips and seapens have been identified within the Sha Chau and Lung Kwu Chau Marine Park, whereas, ahermatypic cup corals, soft corals such as *Dendronephthya* spp and seapens have also been recorded on the northern shore of the Study Area in the vicinity of Sham Tseng.

8.3.1.12 Within the wider study area, the mudflats at San Tau support seagrass beds of *Halophila ovalis* and *Zostera japonica*. In respect of *Zostera japonica*, although this species has been recorded elsewhere in Hong Kong, San Tau represents the only habitat on Lantau where it is found, albeit of a relatively small size ($15m^2$). In contrast, the seagrass beds ($500m^2$) at Tai Ho Wan are seasonal and consist solely of the species *Halophila beccarii*. Studies on this species appear to indicate that the habitat is an important nursery ground for juvenile horseshoe crabs. Tai Ho Wan also have mangrove habitat of conservation important. A total of 6 species of true mangrove was previously recorded at Tai Ho Mangal.

8.4 Objectives of the Ecological Impact Assessment

8.4.1.1 The ecological assessment examines the faunal, floral and ecological attributes of the study area with an aim to protect, maintain or rehabilitate the existing condition and particular emphasis was placed on avoiding impacts to recognised sites of conservation importance such as the Sha Chau and Lung Kwu Chau Marine Park, the Artificial Reefs placed in the Marine Park and east of Airport Island as well as species of conservation interest such as the Indo-Pacific Humpback dolphin (*Sousa chinensis*), the two Horseshoe crab species present in Hong Kong waters (*T. tridentatus* and *Carcinoscorpius rotundicauda*), benthic communities and corals.

8.4.1.2 The objective of the assessment is to identify and quantify, as far as possible, the potential ecological impacts to the natural environment and the associated wildlife groups and habitats/species arising from the proposed Project including its construction and operational phases as well as the subsequent management and maintenance of the proposals.

8.5 Ecological Baseline

8.5.1.1 The ecological baseline has been determined via a combination of literature review and ecological survey to cover any data gaps and provide more recent and project specific data on the existing ecological conditions in the study area on which to base the ecological impact assessment.

8.5.1.2 The ecological baseline study for the Hong Kong Section of Hong Kong – Zhuhai – Macao Bridge and Connection with North Lantau Highway (HZMB) was undertaken between September 2003 and May 2004 (Mouchel, 2004b) and covered the coastal area of North Lantau shore. The surveys comprised nine months of comprehensive marine ecological survey and, while the data obtained is essentially part of the literature review of existing data, as this survey is relatively recent and of particular relevance to the Study Area, the findings have been discussed together with the findings of the project specific TM-CLKL ecological surveys undertaken.

8.5.1.3 The ecological surveys for the Tuen Mun Western Bypass (TMWB) have been undertaken in the coastal area of Pillar Point, Tuen Mun with 6 months of surveys being conducted between September 2008 and February 2009 to establish the baseline ecological conditions of the Study Area at Tuen Mun. The inter-tidal surveys from this work are also very relevant to the TM-CLKL study area and the data obtained from these surveys have also been discussed with the findings of the TM-CLKL surveys undertaken.

8.5.1.4 In addition, an ecological baseline verification survey (Asia Ecological Consultants, 2009) and supplementary ecological survey (ENSR, 2009) for the HKLR have been undertaken. The verification survey was undertaken along the shoreline of North Lantau (from Sham Wan to east of airport island) covering both dry and wet seasons between the end of August 2008 and January 2009. The supplementary ecological survey has been undertaken at the southeast of the Airport with 2 months of the dry season surveys, between January to February 2009 and with 2 months of the wet season surveys, between April and May. The data of marine grab surveys, dive surveys and intertidal surveys from the HKLR project are considered relevant to the TM-CLKL study area and included in the literature review below.

8.6 Literature Review

8.6.1 Assessment Area and Scope

Background

8.6.1.1 The EIA study brief indicated the marine ecology study area shall cover the wider northwestern waters, which shall be the same as the assessment area for Water Quality Impact Assessment covering the North Western Water Control Zone, North Western Supplementary Water Control Zone, Deep Bay Water Control Zone, and Western Buffer Water Control Zone as designated under the Water Pollution Control Ordinance (WPCO), and other areas likely to be impacted by the Project. The recognised sites of conservation importance, as defined in the EIA Study brief, closer to the project site include the Tai Ho Stream SSSI, San Tau Beach SSSI, Sha Chau and Lung Kwu Chau Marine Park (including the Lung Kwu Chau, Tree Island & Sha Chau SSSI inside the park). There are also other areas of conservation importance, while inside the broad study area, are a notable distance away from the TM-CLKL, eg, Pak Nai SSSI, Mai Po Inner Deep Bay Ramsar Site, Inner Deep Bay SSSI, Tsim Bei Tsui SSSI and a proposed potential Marine Park at Fan Lau. As most of these sites are some distance away, they would be unlikely to be impacted by the TM-CLKL, as confirmed by the water quality assessment results (see **Section 6**). Therefore, the ecological assessment will largely focus on the North Western Water Control Zone.

Scope of Review

8.6.1.2 A review of relevant scientific literature, reports and EIA's has been conducted in order to assist the assessment of baseline ecological conditions. The study area comprising the North-western waters is arguably one of the most extensively surveyed marine locations in Hong Kong and reports from the ongoing environmental monitoring and audit conducted at the contaminated mud pits (CMP's) at East of Sha Chau (Mouchel, 1996; 2001a; Meinhardt, 2006a) provided a large amount of the marine ecological information. The data of 2000-2005 East Sha Chau EM&A Programme represents relevant and recent ecological information for the study area.

8.6.1.3 Relevant scientific reports and papers have also been reviewed and a full list of studies cited is provided in the Reference section of this chapter. The major scientific studies and reports include the following:

- New Airport Master Plan (Greiner-Maunsell, 1991);
- Proposed Aviation Fuel Receiving Facility at Sha Chau: Environmental Impact Assessment (ERM, 1995);
- Feasibility Study & Environmental Impact Assessment for Aviation Fuel Pipeline (Montgomery Watson, 1996);
- EIA Study for Disposal of Contaminated Mud in the East Sha Chau Marine Borrow Pit (ERM, 1997);
- Feasibility Study for Additional Cross-border Links Stage 2 (Mouchel, 1998);
- EIA for the Proposed Sand Extraction from The Brothers' Marine Borrow Area (Hyder Consulting, 1998);
- Population Biology of the Indo-Pacific Hump-backed Dolphin (Sousa chinensis Osbeck 1765) in Hong Kong Waters. AFCD-funded study (Jefferson, 1998, 2000a , 2005; Hung, 2005);
- Environmental Monitoring and Audit for Contaminated Mud Pit IV at East of Sha Chau (ERM, 1999; Mouchel, 2001a; Meinhardt, 2006a);
- EIA Study for Permanent Aviation Fuel Facility for Hong Kong International Airport (Meinhardt, 2006b);
- EA Study for Backfilling of Marine Borrow Pits at North of the Brothers (Mouchel, 2002a);
- EIA study for Hong Kong EIA study for the Hong Kong – Zhuhai – Macao Bridge Hong Kong Link Road (ENSR, 2009);
- EIA study for the Tuen Mun Western Bypass (Maunsell, 2009); and
- EIA study for the Hong Kong – Zhuhai – Macao Bridge Hong Kong Boundary Crossing Facilities and Hong Kong Link Road (OAP, 2009).

8.6.1.4 The study area is located in the North-western waters of Hong Kong. The TM-CLKL project alignment consists of two sections: the submarine tunnel section from Tuen Mun to Hong Kong Boundary Crossing Facilities (HKBCF) in the East of Chek Lap Kok and the elevated structure section from HKBCF to Tai Ho at North Lantau. The project alignment and broad ecological study area are presented in **Figures 8.1a** and **8.1b**. Photographs of habitat and species of conservation interest present around the study area are shown in **Figures 8.2a, 8.2b** and **8.2c** and discussed in detail below. Habitat maps showing the types and locations of habitat in the study area are presented in **Figures 8.1c** and **8.1d**. The detail geophysical result within the study area was summersied in **Appendix F13**.

8.6.1.5 The study area is located within the Pearl River Estuary and is strongly influenced by freshwater discharges especially during the wet season when the summer monsoon brings high levels of precipitation (peak wet season discharge of 1,800 Mm^3day^{-1}; Broom and Ng, 1996). The western waters are, therefore, predominantly low in salinity, high in turbidity and show a marked seasonality.

8.6.1.6 The Sites of Special Scientific Interest (SSSIs) at San Tau and Tai Ho are the recognised areas of conservation interest in the wide Study Area. The intertidal marine habitat at San Tau supports mangrove stands, mudflats and seagrass beds. As such, this diverse habitat, which covers an area of approximately 2.7 ha, has been designated as a SSSI. The second of the SSSIs within the Study Area is the Tai Ho Stream. This stream has several tributaries running from the uplands to its estuary, and passes through Tin Liu, Tai Ho San Tsuen and Ngau Kwu Long to Tai Ho Wan, with stands of mangrove in the estuary area. The Tai Ho Stream is unique in the local context. It is one of the few remaining medium-sized natural streams stretching from uplands to the lowland estuary. Tai Ho Stream has a variety of different habitat types and harbours a diverse fish community including the rare Ayu *Plecoglossus altivelis*.

8.6.2 Present Eco-Physical Characteristics of the Study Area

8.6.2.1 There have been numerous assessments of the physical, chemical and biological environment conducted in the study area (Greiner-Maunsell, 1991; Binnie Consultants, 1995; Mouchel, 1996; ERM, 1997, 2005; Hyder Consultants, 1998; Meinhardt, 2006a). There have, also, been several past and on-going studies conducted and notable are those involving investigations of Marine Borrow Areas and the on-going monitoring at the Contaminated Mud Pits at East of Sha Chau conducted for the Civil Engineering and Development Department (CEDD). Several of these studies provide pertinent marine ecological baseline information for the current study and field visits have also been conducted. The field survey data that form the basis of the assessment are presented in subsequent sections below.

8.6.2.2 The northern landing of TM-CLKL at Tuen Mun is located on reclaimed land adjacent to Tuen Mun special industrial area where the coastal line has been highly modified due to past activities. Similarly, the landing at north Lantau is at the North Lantau Highway (NLH) adjacent to the Siu Ho Wan MTR depot and again the coastal area here has been highly modified during the construction for NLH and the MTR depot.

8.6.2.3 The major conclusion from the previous work conducted in the study area is that the marine benthic environment in the western waters of Hong Kong are generally characterised by soft-bottom material composed of silts and clay as a homogenous layer or in loosely packed mud clasts bound in a puzzle fabric (Binnie Consultants, 1995; ERM, 1999; Mouchel, 2001a) although coarser material under the influence of strong tidal currents has been reported from the area to the Northeast of The Brothers (Greiner-Maunsell, 1991). There are also some hard substrates present although the soft-bottom sediments are characteristic of the study area. The upper sediment layers are reported to be well oxygenated (EVS, 1996). The heterogeneity of sediments present in the study area provides a wide variety of niches although owing to the prevailing estuarine conditions that lead to fluctuations in physico-chemical parameters, it is nevertheless a 'naturally stressed' environment and this is reflected in the relatively low to moderate diversity of burrowing in-fauna present compared to other locations in Hong Kong (Shannon-Weiner index H' typically < 2; Mouchel, 2001a; Meinhardt, 2006c).

8.6.3 Present Pollution Status

8.6.3.1 The North Western WCZ have been constantly subject to localised pollution and disturbance including reclamation works, dredging and disposal activities. Other than these relatively short-term pollution sources, there are also significant sewage outfalls (Pillar Point, Northwest New Territories and Siu Ho Wan) and cooling water discharges from a number of users including Castle Peak Power Station, Hong Kong International Airport (HKIA) and Shiu Wing Steelworks. Comprehensive ecological surveys were conducted at the North of The Brothers Marine Borrow Area (MBA) and around Chek Lap Kok in 1990 as part of the new airport core construction EIA (Greiner-Maunsell, 1991). These data together with the past ten years of extensive monitoring data obtained during the contaminated mud pit (CMP) monitoring at East of Sha Chau collected from various stations in North-western waters (ERM, 2001; Mouchel, 2001a; Meinhardt, 2006c) are the most relevant to the current study. The findings from the two aforementioned studies have, therefore, formed the basis for much of the following discussion.

8.6.3.2 The sediments in the North-western waters have recently been assessed using a suite of measurements to calculate a Pollution Index. The index is derived through chemical contaminant analysis, assessment of the benthic macro-infauna present and toxicity testing with a marine amphipod. Results indicated that the Sediment Pollution Index for North-western waters was average and similar to the majority of other locations in Hong Kong with the exception of Victoria and Tolo Harbours which were ranked as poor and Port Shelter that was ranked as good (Shin and Lam, 2001).

8.6.3.3 The pollution status of the marine sediments has been evaluated at stations located to the south of Sha Chau (between the airport and Sha Chau) using key biological indicator organisms (to facilitate the calculation of biotic indices) present in the benthic communities. Biotic indices are considered to be sensitive, easily-understood measures of pollution and provide a synoptic evaluation of both the prevailing sediment quality and overlying water chemistry thus adding further information on the benthic communities present in the study area. Biotic indices calculated for benthic macro-invertebrates collected at locations to the south of Sha Chau in May 2001 were indicative of slight pollution and an unbalanced benthic community (Mouchel, 2001a; Meinhardt, 2006c). A low biotic index is, however, often typical of estuaries owing to their highly dynamic physical and chemical nature and the benthic community diversity is, also, typically lower at these locations (Mouchel, 2001a; Meinhardt, 2006c).

8.6.4 Marine Waters

8.6.4.1 The North-western waters are situated at the mouth of the Pearl River Estuary and as such are heavily influenced by the massive freshwater flows from the hinterland. The area shows a distinct seasonality as a result of the seasonal influx of freshwater from the Pearl River. The estuarine influence is especially pronounced in the wet summer months when the freshwater flows are greatest and a strong salinity and temperature stratification is evident. During winter months water conditions are more typically marine and the salinity and other parameters vary less with depth. Ebb tide currents are towards the southeast where the flood tide currents move to the northwest.

8.6.4.2 As the waters in the North-western WCZ are generally heavily influenced by the Pearl River discharges which is to some extent dictated by the level of precipitation. Water temperature typically ranges between about 15°C and 30°C over an annual cycle with a mean of about 22-23°C. Salinity typically varies within the range 10-32ppt. The inter-year variation is comparatively smaller and for example between 2006 and 2007 (Tables 6.6a and 6.6b) the inter-year varation was the range of 0.2 °C to 0.7 °C for temperature and -0.7ppt to -1.5ppt for salinity.

8.6.4.3 The Pearl River carries very heavy loads of suspended sediment and nitrates and as a consequence concentrations of these parameters within North-western waters are variable but generally far higher than in the more oceanic influenced waters to the south and east of Hong Kong. In a recent review of the suspended sediment loading in the PRE, Parry (2000) noted that a high natural fluctuation in suspended sediments and levels up 10,000 mg/L have been reported although there are also strong asymmetry of the suspended sediment in the PRE.

Cetaceans (Chinese White Dolphins and Finless Porpoises)

8.6.4.4 There are sixteen confirmed cetacean species in Hong Kong waters, and recently in March 2009, a humpback whale was reported in Hong Kong. The number is added up to seventeen, although only two of these species, the Chinese White Dolphin (*Sousa chinensis*) and Finless porpoise (*Neophocaena phocaenoides*) are resident (Parsons et al., 1995: Jefferson and Hung 2007). Until the early 1990s there were few records of the CWD in Hong Kong waters (Jefferson and Leatherwood, 1997; Jefferson 2000), although construction of the international airport at Chek Lap Kok drew attention to the presence of the CWD in local waters and intensive research into the distribution, status, and conservation requirements of the species have been on-going since the mid 1990s (see Jefferson 2000, 2005, 2007; Hung 2008).

8.6.4.5 Although other cetaceans (e.g., Finless porpoise, Bottlenose dolphin, and False killer whale) have been found in the North-western waters, these are probably extralimital records and only the CWD has been consistently reported from the study area (comprising the area from Tuen Mun to the southwest of the airport), where it is widely distributed (Parsons et al., 1995; Jefferson and Leatherwood, 1997; Jefferson, 2000a, 2005; Hung, 2005). There appears to be only limited overlap in distribution of the CWD and Finless porpoise in local waters, as the dolphin tends to be predominantly distributed in the western waters, whereas the porpoise is usually recorded from areas further to the east of Hong Kong. The southern coast of Lantau around Fan Lau and the Soko Islands represent the only areas of Hong Kong where both species are commonly seen (Parsons et al., 1995; Jefferson, 2000a; Hung, 2005).

8.6.4.6 Globally, the CWD is widely distributed throughout shallow (< 20 m) coastal waters of the Indian and Western Pacific Oceans, from South Africa in the west to northern Australia and Southern China in the east (Jefferson, 2000a; Jefferson and Karczmarski, 2001). In Hong Kong, the CWD predominantly frequents the less saline brackish waters around the Pearl River Estuary, although loss of habitat to numerous developments, fishing, shipping activity and pollution from various sources have apparently placed increasing pressure on the local Chinese White Dolphin population (e.g., Liu and Hills, 1997; Jefferson, 2000a; Hung 2008). Locally, the CWD population is centred around the Pearl River Estuary and in Hong Kong, Tuen Mun to Ma Wan represent the eastern part of this population's range (Jefferson, 2000a, 2005; Hung, 2005). The total size of the Pearl River breeding population is difficult to determine accurately although it has been estimated to comprise at least 1,300-1,500 individuals with about 103-193 inhabiting Hong Kong's waters at various times of the year (Jefferson, 2007). Analysis of trends in abundance showed that temporal patterns in abundance estimates were inconsistent across survey areas, and there was no indication of a sustained decline in overall population size (Jefferson 2007).

8.6.4.7 Groups of Chinese White dolphin are consistently recorded from waters near Tuen Mun and off Lung Kwu Chau, Sha Chau and around the Hong Kong International Airport (HKIA), although the distribution in Hong Kong may be presently more restricted than when the population presumably contained more individuals in the past (Parsons et al., 1995). It should be noted, however, that no reliable survey data are available for the period prior to the construction of the HKIA and the hypothesis that the population was larger in the past is only an assumption. The distribution of the dolphin tends to show a slight seasonal response (possibly related to feeding opportunities, as the species is known to feed predominantly on estuarine fish), as individuals tend to move further to the east of the study area during the summer monsoon season, when ambient seawater is lower in salinity (Jefferson, 2000a).

8.6.4.8 In the dry season (winter and spring) the population tends to be concentrated in the waters around the Sha Chau and Lung Kwu Chau Marine Park and off the area of Chek Lap Kok, although individuals are recorded within the study area throughout the year (Jefferson, 2000a, 2007; Hung, 2008). Chinese White Dolphins in Hong Kong usually occur in small groups, ranging from singles to groups of 23 individuals (Jefferson 2000). Chinese White Dolphins are often seen associating with fishing vessels in Hong Kong and the Pearl River Estuary. Over 600 individual Chinese White Dolphins have been identified in both Hong Kong and the Pearl River Estuary since 1995 (S. K. Hung, pers. comm.). Photo-identification data revealed that individual associations were unstable, with low association indices between pairs or among groups of individuals, and the social structure was very fluid. Moreover, individual home range sizes and patterns were found to vary substantially among individuals. Some individuals only had ranges in a small area (about 30 km^2), while other individuals used large ranges (nearly 400 km^2), encompassing many regions within Hong Kong waters and the rest of the Pearl River Estuary (Hung and Jefferson 2004).

8.6.5 Marine Benthic Macro-infauna

8.6.5.1 The macro-infauna consist of the organisms larger than 1mm living within the sediment (predominantly in the upper well-oxygenated layers). The foregoing discussion on the benthic macro-infauna present throughout the study area comprises data reviewed from several benthic community studies (review mostly based on Greiner-Maunsell, 1991; Binnie Consultants, 1995; ERM, 2001; Mouchel, 2001a, 2002b; CCPC, 2002; Meinhardt, 2006c). Species present are relatively similar throughout the North-western waters (and other areas in Hong Kong) and are representative of the general study area. As indicated below, the major difference in the faunal groups/species recorded both in different studies and between locations in North-western waters is the occasional absence of echinoderms although this is more likely to be a reflection of freshwater inputs from the Pearl River (the larvae of these organisms are stenohaline) driving the distribution pattern. The benthic community results presented are, therefore, considered to be representative of the study area.

8.6.5.2 The previous monitoring results in the North-western waters have tended to indicate that the benthic community recorded over approximately the past ten years has remained of similar composition and as with most benthic communities polychaetes are numerically abundant comprising between 44-71% of individuals present and molluscs, crustaceans and echinoderms are well represented components of the soft-bottom community (Binnie Consultants, 1995). Echinoderms are, however, not always recorded in the study area (Greiner-Maunsell, 1991) as the larvae of these organisms are often stenohaline (Nicholson, 2001) and unlikely to tolerate the wide salinity fluctuations associated with freshwater exposures from the Pearl River in the wet season.

8.6.5.3 The environmental monitoring and audit conducted at the contaminated mud pits (CMP's) at East of Sha Chau (Mouchel, 1996; 2001a; Meinhardt, 2006a) has provided a large amount of the long term marine ecological information and presents a typical example of recolonisation, which represents relevant and recent ecological information for the study area. The EM&A generally obtained sampled at specific sets of monitoring stations once every six months, comprising a set of three reference stations on the western side of the North-western waters, and also a set of three mobile stations on the capped pits. Twelve replicated sediment samples were generally collected although the number of replicates has now reduced been to three. Results of benthic sampling (collected with a Van Veen grab) conducted in East Sha Chau in the late wet season in August 2000 resulted in the collection of 72 sediment samples containing 6,512 macro-infaunal specimens belonging to 84 families comprising 9 different phyla (ERM, 2001). In terms of dominant families present in the soft sediments, the annelids, arthropods and molluscs were dominant and the latter group also constituted most of the biomass present (see **Table 8.1**). Results of sampling conducted in May 2001 resulted in the collection of 72 sediment samples containing 9,283 macro-infaunal specimens belonging to 67 families comprising 9 different phyla (Mouchel, 2001a; **Table 8.2** below). The total recorded biomass in May 2001 was 188.85g and was largely due to the high mass of annelids and molluscs collected (see **Table 8.2**).

8.6.5.4 The benthic survey data collected in the late wet season in August 2001 (Mouchel, 2002b) showed that in terms of families present, the annelids, arthropods and molluscs were again the most dominant, as shown in **Table 8.3**. These families, also, comprised the majority of individuals present. Compared to the monitoring conducted in August 2000, there were fewer families recorded in both May and August 2001 although the annelids, arthropods and molluscs were consistently the most dominant families recorded. Comparing data within the early and late wet season of the same year, there were both more families and individuals recorded during the late wet season in August compared with May 2001. There was, also, a higher biomass recorded in August compared to the previous monitoring in May 2001. In May 2001, a total biomass (wet weight) of 188.85g was recorded whereas 662.07g was recorded in August 2001. The reasons for the recorded differences between the data collected in May and August 2001 are difficult to ascertain although they may represent differences in recruitment variation between the late dry/early wet (May) and late wet (August) season months.

Table 8.1 Summary of the Macro-infauna Collected in East Sha Chau in August 2000

Phylum	Number of Identified Families	Total Number of Individuals	Total Biomass (g)
Annelida	34	4,914	27.88
Arthropoda	20	1,131	39.25
Chordata	3	5	3.24
Coelenterata	7	35	3.05
Echinodermata	4	80	53.75
Echiura	1	1	0.45
Mollusca	14	301	847.72
Nemertinea	0	19	1.51
Sipuncula	1	26	0.11
Total	**84**	**6,512**	**976.97**

Source: ERM (2001)

Table 8.2 Summary of the Macro-infauna Collected in East Sha Chau in May 2001

Phylum	Number of Identified Families	Total Number of Individuals	Total Biomass (g)
Annelida	30	2,204	45.609
Arthropoda	13	405	26.526
Chordata	2	2	2.352
Coelenterata	4	13	1.329
Echinodermata	2	15	0.723
Echinodetmata	0	1	0.194
Mollusca	11	6,600	95.562
Nemertea	1	1	0.261
Sipuncula	4	42	16.301
Total	**67**	**9,283**	**188.85**

Source: Mouchel (2001a)

Table 8.3 Summary of the Macro-infauna Collected in East Sha Chau in August 2001

Phylum	Number of Identified Families	Total Number of Individuals	Total Biomass (g)
Annelida	35	2,928	17.94
Arthropoda	17	902	42.26
Chordata	2	6	35.12
Coelenterata	4	10	6.330
Echinodermata	2	12	39.75
Mollusca	10	9,460[1]	515.47[1]
Sipuncula	2	18	5.21
Total	**72**	**13,336**	**662.07**

Note: [1] including Potamocorbula sp. comprising 9390 individuals and biomass of 509.906 g. Source: Mouchel (2002b).

8.6.5.5 The 2000/2001 data available for the area of East Sha Chau comprising data collected over 12 months (wet season data only), showed that in terms of families present, the annelids, arthropods and molluscs were dominant. The annelids, molluscs and arthropods usually comprised the majority of individuals present. Although the number of families and biomass were lower than previously recorded in August 2000, there were a higher number of total individuals recorded in both May and August 2001 (Mouchel, 2001a, 2002b). During the sampling conducted in August 2000, 84 families and a total of 6,512 individuals were recorded for a total biomass of 976.9g (ERM, 2001). The recorded differences between the data collected in August 2000 and the recent data collected in May and August 2001 may, however, represent seasonal variation between the late dry/ early wet and late wet season months inducing subtle changes to the benthic macro-infauna assemblages present.

8.6.5.6 However, the most recent data available are from the surveys conducted in January and October 2005 (Mouchel, 2005a; Meinhardt, 2006b) covering both the dry and late wet seasons and the results are summarised in **Table 8.4** below. The results were consistent with earlier surveys conducted under the EM&A programme. The annelids, molluscs and arthropods comprised the majority of individuals present and subtle seasonal variations, slightly higher abundance during the wet season, were frequently recorded.

Table 8.4 Summary of the Macro-infauna Collected in East Sha Chau in 2005

Phylum	Number of Identified Families		Total Number of Individuals		Total Biomass (g)	
	January	October	January	October	January	October
Annelida	40	39	4,365	3,051	25.48	19.39
Arthropoda	17	11	617	264	25.35	16.66
Chordata	1	1	5	2	27.12	1.29
Coelenterata	7	7	28	33	64.17	59.86
Echinodermata	4	2	108	124	5.31	5.43
Echiura	1	1	1	1	0.00	0.06
Mollusca	10	12	164	70	171.92	81.75
Nemertinea	-	-	-	-	0.57	0.03
Sipuncula	1	2	43	67	0.31	23.01
Unidentified	-	-	-	-	1.04	-
Total	**81**	**75**	**5,331**	**3,612**	**321.26**	**207.48**

Source: Mouchel (2005a) and Meinhardt (2006b).

8.6.5.7 High numbers of macro-infauna (67-81 families; Mouchel, 2001a, 2002b and 2005a) have been recorded in the study area. Consistent with the results of grab sampling in the North-western waters, annelids, arthropods and molluscs were dominant.

8.6.5.8 The HKLR verification surveys for ecological baseline reported a total of 985 macro-faunal specimens in the wet season (September 2008), comprising 90 species from 59 families in 9 phyla (Annelida, Arthropoda, Branchiopoda, Chordata, Cnidaria, Echinodermata, Mollusca, Nemertea and Platyhelminthes). In the dry season (December 2008), a total of 383 macro-faunal specimens, comprising 58 species from 44 families in 6 phyla (Annelida, Arthropoda, Coelenterata, Echinodermata, Mollusca and Nemertea) were recorded. Only 28 species were found in both seasons. Polychaetes (Annelida) were collected at all stations (see **Figure 8.7**) and represented the highest species richness and abundance in both seasons.

8.6.5.9 The bivalves *Donax* sp. and *Theora lata* and the brittle star *Macrophiothrix longipeda* were the commonest species recorded in the wet season, whilst the polychaetes *Notomastus latericens* and *Euclymene* sp. and the pea crab *Xenophthalmus* sp. were the most abundant species recorded in the dry season. Most species recorded occur frequently in Hong Kong and no species of conservation importance were observed.

8.6.5.10 Infauna diversity in the Study Area of HKLR was shown to be relatively low when compared to other areas in Hong Kong (HyD 2004). The impoverished assemblages present are likely to be due to the proximity of the Pearl River Estuary, leading to low salinity and possibly due to the predominantly silt-clay composition of the seabed which does not lend itself to supporting high diversity

(HyD 2004). The wet and dry seasons results for species diversity (H') ranged between 2.68-3.37 and 1.84-2.70 respectively from the nine sampling stations. These are comparable to other soft-bottom benthic communities in Hong Kong, which are characteristsed by an extensive homogeneous assemblage dominated by polychaete annelids, where species diversity was calculated to be 2.87 in the summer (wet season) and 2.82 in the winter (dry season). These data are averaged from 97 sampling stations from across Hong Kong. (Shin et al. 2004).

8.6.5.11 The benthic communities in the waters offshore to the southeast coast of Airport Island (see **Figure 8.8)** were investigated in the HKLR supplementary survey. From the 8 sampling stations, a total of 917 organisms from 83 taxa were identified from the dry season survey. The most diverse group was polychaetes (46 species). In terms of number of individuals, 43% of collected organisms were polychaetes, followed by crustaceans (35%).

8.6.5.12 During the wet season benthic survey under the HKLR supplementary study, 345 organisms were identified from the sediment samples collected. In wet season, 58%, 15%, 12%, 8% and 7% of organisms collected were polychaetes, molluscs, crustaceans, echinoderms and other phyla, respectively. The total biomass was 130.87 g, in which 52%, 27%, 15% and 6% of total biomass were accounted by echinoderms, molluscs, crustaceans and other phyla, respectively. All the species recorded are common and no rare species or species with conservation interest was found.

8.6.5.13 AFCD commenced a terrestrial-wide study on the marine benthic communities in Hong Kong in 2001 (CCPC, 2002) and concluded that in Hong Kong waters, polychaetes, crustaceans and bivalves were the most abundant benthic fauna comprising over 70% of the total species. In terms of spatial pattern, it noted that the western waters, together with the north-eastern waters and Victoria Harbour showed distinct benthic composition as compared with the rest of the locations and the benthic species diversity and ecological importance of these three strata was generally lower. The estuarine conditions in the western waters largely accounted for the lower species diversity in the western waters.

8.6.5.14 Infauna diversity in the North-western waters is relatively low (H' < 2) compared to other areas in Hong Kong which 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 (Shin, 1998; Mouchel, 2001a, 2002b).

8.6.5.15 There is no known macrofauna species of conservation interest in Hong Kong, other than the cephalochorate *Branchiostoma belcheri*. The species is regarded as a living fossil link in the evolution of marine invertebrates to vertebrates and is, therefore, considered a potentially important species. The species, however, is typically recorded in the eastern waters of Hong Kong (CCPC, 2002) although these were also recently recorded to the south of Cheung Chau (Mouchel, 2003a).

8.6.6 Intertidal Habitats

8.6.6.1 The intertidal ecology of Hong Kong is well studied (Morton and Morton, 1983). There were also recent publications that are particularly relevant to the intertidal fauna and flora within areas covered under this Project and these included Mouchel (2000, 2002a), Tam and Wong (2000), Williams (2003) and Chan and Caley (2003). The HKLR verification surveys for ecological baseline and the HKLR supplementary survey are relatively up-to-date and of particular relevance to TM-CLKL study area.

8.6.6.2 Various studies of the coastal areas of Northern Lantau (ERM, 2000; Mouchel, 2000, 2002b; Tam and Wong, 2000; Mott, 2003) have revealed that the intertidal fauna and flora present in the study area are typical of other locations in Hong Kong, although important species and habitats such as horseshoe crabs, seagrass and mangrove are present within certain bays in the study area and are discussed further below.

Soft Shore

8.6.6.3 In the recent HKLR verification surveys, six soft shore locations (Sham Wat, Sha Lo Wan, Hau Hok Wan, Tung Chung Bay, San Tau and San Shek Wan) along the northern coast of Lantau were surveyed in September and December 2008 to cover wet and dry seasons. The soft shores in Sham Wat (SW), Sha Lo Wan (SLW), Hau Hok Wan (HHW), Tung Chung Bay (TCB) and San Tau (ST) are natural sandy mudflats while the one in San Shek Wan (SSW) is natural sandy shore with numerous bloulders present. They are generally medium to large in size. There are also small patches of isolated sandy shore at the remnant coastlines at the southeast shore of Airport Island which although not being completely converted to artificial coastlines, have been subject to disturbance and modification of various extents, including the elimination of backshores and conversion to seawalls, and thus should not be considered as natural coastlines. Nonetheless, the HKLR has surveyed these areas and noted that the abundance of the intertidal fauna was generally low, especially in the areas with isolated sandy substrates. The locations of these soft shore survey areas can be seen in **Figures 8.7** and **8.8**.

8.6.6.4 A total of 155 species were recorded during qualitative and quantitative surveys. They are from several faunal groups, including ichthyofauna (fish), echinoderms (sea cucumber), arthropods (shrimp, crab and horseshoe crab), molluscs (bivalve, gastropod and tusk shell), annelids (segmented worm), sipunculids (peanut worm), nemerteans (ribbon worm), cnidarians (sea anemone) and poriferans (sponge). Of these six sites, the highest species number was recorded at ST and TCB (76), and the lowest number was recorded at SW (57). Species numbers recorded at SSW, SLW and HHW were 69, 72 and 75, respectively.

8.6.6.5 During the quantitative (transect and quadrat) surveys, a total of 26,627 individuals belonging to 104 species were recorded, including a single horseshoe crab individual. A total of 1,019 individuals belonging to 56 fauna species were found in the core samples. The findings of quantitative surveys are summarised in **Table 8.5** below.

Table 8.5 Results of Quantitative Surveys at Soft Shore Sites

	SW	SSW	SLW	HHW	ST	TCB
Epifauna						
Number of Species	29	42	44	49	55	50
Abundance	1259	4147	5079	3899	4222	8021
J’	0.46	0.49	0.47	0.53	0.55	0.43
H’ (Log_e)	1.56	1.82	1.79	2.07	2.20	1.67
Infauna						
Number of Species	12	20	17	18	19	24
Abundance	164	265	83	56	115	336
J’	0.45	0.52	0.74	0.86	0.81	0.48
H’ (Log_e)	1.11	1.56	2.10	2.47	2.38	1.51

8.6.6.6 Although most species found are common and widespread in Hong Kong, six species of conservation importance were recorded. They are Indo-Pacific Tropical Sand Goby *Favonigobius reichei*, Walking Goby *Scartelaos histophorus*, Flat-headed Goby *Luciogobius guttatus*, Snowy Puffer *Takifugu niphobles*, Predaceous Chub *Parazacco spilurus*, Sea Cucumber *Holothuria leucospilota*, Horseshoe Crab *Tachypleus tridentatus* and Greasyback Shrimp *Metapenaeus ensis*, as summarised in **Table 8.6** below.

Table 8.6 Species of Conservation Importance or Potential Conservation Interest at Soft Shore Sites

Species	SW	SSW	SLW	HHW	ST	TCB
Indo-Pacific Tropical Sand Goby *Favonigobius reichei*	+	+	+	+	+	+
Walking Goby *Scartelaos histophorus*		+	+	+		
Flat-headed Goby *Luciogobius guttatus*		+				
Snowy Puffer *Takifugu niphobles*				+	+	
Predaceous Chub *Parazacco spilurus*		+				
Sea Cucumber *Holothuria leucospilota*	+					
Horseshoe Crab *Tachypleus tridentatus*	+				+	+
Greasyback Shrimp *Metapenaeus ensis*	+	+		+	+	

8.6.6.7 This habitat are generally linked to terrestrial and marine waters, and provides nursery and/or breeding grounds for horseshoe crabs, fishes, crustaceans and other intertidal fauna.

8.6.6.8 In addition, there is a sandy shore (Butterfly Beach) present at Tuen Mun within the study area. Butterfly Beach was gazetted in 1987 as a bathing beach and is one of the popular recreational beaches in the Tuen Mun area, and is thus constantly subject to human disturbance.

Natural Rocky Shore

8.6.6.9 Natural rocky shores were present on the eastern shore of Airport Island, and North Lantau coastlines from Tung Chung Bay to Sham Wat. Rocky shores are not rare in Hong Kong, and are not characterised by high productivity, species richness or diversity compared to the intertidal mudflats.

8.6.6.10 Three natural rocky shores, including those on the western and eastern sides of San Shek Wan headland (SSWW and SSWE), and near the Sha Lo Wan Pier (SLWP), were surveyed during the HKLR study. The locations of these hard shore survey areas can be seen in **Figure 8.7.** A total length of approximately 5.5km was surveyed. During the quantitative survey, 30, 28 and 24 species were recorded in SSWW, SSE and SLWP respectively. None of the recorded species are listed as being of conservation concern (IUCN 2008, CSIS 2009). The diversity indices (H') recorded in SSWW, SSWE and SLWP are 1.25, 1.25 and 0.82 respectively.

8.6.6.11 The coastline on the eastern shore of Airport Island is the only remnant of the original Chek Lap Kok Island after the construction of Airport and was surveyed during the Marine Supplementary Survey for the HKLR. Although not being completely converted to artificial coastline, it was subjected to disturbance and modification to various extent. This area is isolated from other natural shores. Only 26 taxa were recorded from both quantitative and walk-through survey during the dry and wet season surveys and all the species found were common and widespread intertidal fauna in Hong Kong. The abundance of the intertidal fauna was generally low, especially in areas with isolated sandy substrates.

Artificial Seawalls

8.6.6.12 All the coastlines on the southern and south-eastern shores of the Airport Island are artificial shores. The intertidal habitats on the artificial seawalls of Airport Island were studied during the HKLR study (ENSR, 2009). Two artificial shores to the south and east of the Airport (AS and AE) were surveyed. The locations of these artificial seawall survey areas can be seen in **Figure 8.7.** During the quantitative survey, 21 and 26 species were recorded in AS and AE respectively. None of the recorded species are listed as being of conservation concern (IUCN 2008, CSIS 2009). The diversity indices (H') recorded in AE and AS are 0.79 and 1.09 respectively. None of the species recorded are considered to be rare or of conservation importance. The areas are man-made.

8.6.6.13 The HKLR result indicated that the number of species and diversity of natural rocky shore were, in general, slightly higher than those of the artificial hard shore.

8.6.6.14 The HKLR supplementary survey mainly conducted at artificial shores or modified shorelines at southeast of Airport Island. The intertidal community have low species richness with a total of 19 taxa recorded. The most frequently recorded species included rock oyster *Saccostrea cucullata*, snail *Monodonta labio* and *Nerita yoldii*, Littorid snail *Echinolittorina radata* and *Echinolittorina trochoides*, and crab *Gaetice depressus*. The abundance of the intertidal fauna recorded was generally low and all species recorded are common and widespread in Hong Kong.

8.6.6.15 The sloping seawalls in the Northeast of Airport Island were, also, surveyed during the HKBCF study (OAP, 2009). The artificial seawalls were colonised by intertidal fauna, but the abundance and diversity were low. The species recorded were all common in Hong Kong, including Acorn Barnacle *Tetraclita squamosa*, Rock oyster *Saccostrea cucullata*, False limpet *Siphonaria japonica*, Limpet *Patelloida pygmaea* and *P. saccharina*, and Nerite snails. No fauna of special conservation interest was found. The area was found to be of low diversity and density of intertidal fauna as well as the man-made nature of the seawall.

Mangrove

8.6.6.16 Mangrove communities are found at San Tau, Tung Chung Bay, Tai Ho Wan, Sham Wat and Sunny Bay in North Lantau within the wider Study Area. Other than the San Tau - Tung Chung Bay and Tai Ho Bay mangrove stands, the other mangrove habitats are relatively distant from the project site and not likely to be affected by the project works. Thus, the following discussion foucses on the stands at San Tau, Tung Chung Bay, Tai Ho Wan close to the project site in which the project works could have a higher potential to affect them.

8.6.6.17 The mangrove at San Tau was recorded to cover an area of 2.1ha and have 7 out of 8 true mangrove species and 4 out of 5 associate mangrove species. The restricted species *Bruguiera gymnorrhiza* occurred in substantial numbers in this stand. San Tau was dominated by a mixture of dense patches of *Aegiceras corniculatum*, *Bruguiera gymnorrhiza* and *Kandelia candel*. The mangroves *Avecinnia marina* and *Acanthus ilicifolius* are well represented, and the restricted mangrove *Lumnitzera racemosa* is also present. The backshore of the mangal includes *Excoecaria agallocha* and the restricted mangrove associate *Thespesia populnea*. The true mangrove community at the Tung Chung mangal of 2.2ha is similar, with the exception being the absence of *L. racemosa*.

8.6.6.18 The recent HKLR verification surveys reported low plant species diversity at San Tau dominating by common mangrove such as *Aegiceras cornculatum*, *Avicennia marina*, *Bruguiera gymnorrhiza*, *Kandelia obovata*, herbs and associated mangrove species.

8.6.6.19 The mangrove at Tai Ho Wan was recorded to cover an area of 1.9ha and consist of 4 true mangrove species and 3 associate mangrove species. It was dominated by *Aegiceras corniculatum* with patches of *Bruguiera gymnorrhiza* interspersed. The benthic macrofauna at the stand is extremely sparse (only 15 species), dominated by crabs but at a low density.

Seagrass

8.6.6.20 The survey on mudflat communities at San Tau for the "Tung Chung – Ngong Ping Cable Car Project EIA" (2003) were conducted in June and July 2002. The mudflats beside the San Tau mangal found colonies of the rare seagrass *Halophila ovalis* and *Zostera japonica*. The seaweeds *Enteromorpha* sp. and *Colpomenia sinuosa* were, also, seasonally abundant on the mudflat near the seagrass beds.

8.6.6.21 The recent HKLR verification survey reported two seagrass species (*Halophila minor* and *Zostera japonica*) within the San Tau Beach SSSI. Small patches of seagrass *Z. japonica* were recorded in both seagrass surveys conducted in October 2008 and January 2009. Approximately seven patches of *Z. japonica* were identified, with sizes ranging from 0.1 m^2 to 16 m^2. The number of patches and patch sizes increased during the survey period. Three small patches of *Halophila minor*, with sizes of 0.2 m^2 to 1.5 m^2, were identified in surveys conducted in January 2009 and all were found in association with the *Z. japonica* patches. The seagrass bed at San Tau mudflat and mangrove stands is regarded to be of high conservation value and its locality is designated as San Tau Beach SSSI for better protection.

8.6.6.22 Surveys between September 2002 to January 2003 at Yam O mudflat, Sunny Bay discovered an extensive seagrass bed estimated to cover an area of at least 0.8ha from "EIA Study for Road P1 Advance Works at Yam O on Lantau Island" by CED (2003). The seagrass bed was formed by a dense cover of the *Halophila ovalis*. The seagrasses appeared to be in good condition with new growths appearing as sparsely arranged leaves fringing the dense beds.

8.6.6.23 Seagrass is not a protected species in Hong Kong, but is of locally rare and of conservation interest. All established seagrass beds are considered to be an importance habitat under the Environmental Impact Assessment Ordinances and any potential developmental disturbances and/or impacts should be avoided or minimized (Kwok et al. 2005). Seagrass was recorded in the North-western WCZ with *Halophila ovalis* recorded in Yam O and San Tau, *Zostera japonica* recorded in San Tau mudflat, and *Halophila beccarii* recorded in Tai Ho Wan (HKU, 1999).

Horseshoe Crab

8.6.6.24 Horseshoe crabs are an ancient and taxonomically isolated group (class Merostomata). Three species have been reported in Hong Kong waters namely *Tachypleus tridentatus*, *Tachypleus gigas* and *Carcinoscorpius rotundicauda*. The conservation status of these three Indo-Pacific species is listed as "Near Threatened" by the IUCN, indicating that existing knowledge is insufficient to determine whether they are threatened or endangered. Although these species are distributed throughout Southeast Asia, they are considered to be scarce locally. Horseshoe crabs have recently been identified as a species of potential conservation concern in Hong Kong but are not presently protected under local law. All three species appear to be undergoing rapid population decline and are thought to be under severe pressure in the South China Sea, including Hong Kong waters, due to habitat loss, pollution and over exploitation (Huang, 1997; Chiu and Morton, 1999, 2003; Chiu, 2003; Morton and Lee, 2003).

8.6.6.25 The horseshoe crabs are mostly distributed in the western waters of Hong Kong and have been recorded in locations throughout the North-western waters. Most of the horseshoe crabs recorded in the Tuen Mun area have been previously identified as *Tachypleus gigas* (ERM, 1997; Chiu and Morton, 1999). In an extensive study of the distribution of horseshoe crabs in Hong Kong conducted between March 1995 and June 1998, however, *Tachypleus gigas* was not recorded although *T. tridentatus* (both adults and juveniles) was reported from locations both within and to the north of Tuen Mun at Nim Wan and Lung Kwu Sheung Tan (Chiu and Morton, 1999). Nim Wan and Lung Kwu Sheung Tan are reported to be nursery grounds of horseshoe crabs. *Carcinoscorpius rotundicauda* was previously recorded from Sha Chau although records for all species of horseshoe crab tend to be variable with only the occasional individual either observed or landed accidentally during trawling. *T. tridentatus* and *C. rotundicauda* have also been recorded in the west of the North-western waters at Sha Lo Wan and Sham Wat Wan (Chiu and Morton, 1999). Although all three horseshoe crab species have been reported to occur in Hong Kong, it is likely that only two species of horseshoe crab (*Tachypleus tridentatus* and *Carcinoscorpius rotundicauda*) are currently resident in Hong Kong as no recent records of *T. gigas* are available (Chiu and Morton, 1999). Liao *et al.* (2001) also did not record *T. gigas* in their extensive surveys (September 1994 to June 1998) of the South China Sea (from Hainan to Xiamen).

8.6.6.26 It has been suggested that the horseshoe crabs show a seasonal trend in Hong Kong coastal waters and spawning activity is pronounced in February to March although they remain abundant in local waters from April to May (ERM, 1995). Although trends in abundance may be evident due to spawning, the local distribution of *Tachypleus tridentatus* and *Carcinoscorpius rotundicauda* may also be influenced by hydrological conditions as both species tend to be predominantly found in the less saline western waters (Chiu and Morton, 1999).

8.6.6.27 Within the study area, *T. tridentatus* and *C. rotundicauda* have been recorded at Tai Ho Wan, Tung Chung Bay, San Tau and The Brothers (Huang, 1997; Chiu and Morton, 1999; Fong, 1999b; Mouchel, 2000, 2002b; Mott, 2003). Specimens of horseshoe crabs collected in the vicinity of the study area during March to September 1996 (ERM, 1997), records mostly from March 1995 to June 1998 (Chiu and Morton, 1999) are presented below in **Table 8.19.**

8.6.6.28 The Agriculture, Fisheries and Conservation Department (AFCD) recorded 20 individuals of *C. rotundicauda* at Tai Ho Wan during their surveys in December 2003. Apart from Tai Ho Wan, some *C. rotundicauda* have been reported from Tung Chung Bay and Sham Wat. The demersal trawl surveys of the East of Sha Chau contaminated mud pits (Mouchel, 2004b), also, recorded a juvenile *T. tridentatus* in the waters north of the HKIA in January 2004. Interviews with the fisherman at Pak Mong in September 2003 indicated juvenile horseshoe crabs were still occasionally netted in the water channel between Pak Mong and the North-Lantau Express Highway.

8.6.6.29 The recent HKLR verification survey recorded the horseshoe crab *Tachypleus tridentatus* at two of the soft shore sites, Tung Chung Bay and San Tau. Two records from Tung Chung Bay included a juvenile (maximum width of prosoma was 40mm) and one dead sub-adult (maximum width of prosoma of 150mm). The single crab at San Tau was one small juvenile (maximum width of prosoma of 5mm). This Horseshoe Crab species is regarded as Vulnerable by CSIS (2008).

8.6.7 Corals

8.6.7.1 All hard (stony) corals are protected in Hong Kong by Protection of Endangered Species of Animals and Plants Ordinance (Cap 586). The distribution of hermatypic corals is largely controlled by the requirements of their photosynthesising zooxanthellae which require strong light and hence shallower water, whereas many of the soft corals that do not possess symbiotic algae can survive at greater depths (Morton, 1994; Morton and Morton, 1983). Corals are usually adversely affected by reduced salinity (hyposalinity) and coupled to the high levels of suspended solids discharged by the Pearl River (and hence low light penetration).

8.6.7.2 Hard corals have been recorded in the wider study area. The coral communities in western waters are sparse compared to rocky reefs of similar depth and exposure in the higher saline oceanic eastern and southern waters of Hong Kong although a number of ahermatypic cup corals (thought to be *Balanophyllia* or *Phyllangia* sp.), pale-blue gorgonian (*Euplexaura* sp.), *Dendronephthya* sp. colonies, isolated sea pens (*Virgularia* or *Pteroides* sp.) and one hermatypic coral *Oulastrea crispata* were recorded in June 2001 in the far eastern Northwest waters (at Sham Tseng and Tsing Lung Tau; Mouchel, 2001b).

8.6.7.3 A few solitary hermatypic corals (thought to be *Balanophyllia* or *Phyllangia* sp.) have also been recorded in the vicinity of The Brothers and soft corals, sea pens and gorgonian corals (sea fans) are also present throughout the North-western waters (Mouchel, 2002b, 2003a). Solitary corals have also been reported from Sham Tseng and Tsing Lung Tau adjacent to Castle Peak Road (Mouchel, 2001a). A number of ahermatypic cup corals, pale-blue gorgonian (*Euplexaura* sp.), occasional *Dendronephthya* sp. colonies, isolated sea pens (*Virgularia* or *Pteroides* sp.) and one hermatypic coral *Oulastrea crispata* were also recently recorded at Sham Tseng and Tsing Lung Tau (Mouchel, 2001b). There are records of hard corals at Sha Chau. Dive surveys conducted in late 1994 at locations around Sha Chau revealed the presence of protected hard corals (Faviidae) in subtidal areas (ERM, 1995). The hard coral species recorded in the North-western waters are generally common in local waters (Scott, 1984) although are more abundant in the eastern waters and the study area (comprising the North-western waters) may represent their westernmost distribution in Hong Kong.

8.6.7.4 It is notable that the ahermatypic cup coral and the pale-blue gorgonian (*Euplexaura* sp.) have only rarely been recorded in the oceanic eastern and southern waters of Hong Kong and it is likely that these species are adapted to the hyposaline waters (Mouchel, 2001b). The presence of the hermatypic (containing zooxanthellae) coral *Oulastrea crispata* is unusual owing to the prevailing hydrological conditions although total cover was sparse (<1%) and many individuals were in poor condition (Mouchel, 2001b).

8.6.7.5 Dive surveys for the HKLR verification survey revealed that the diversity and abundance of hard and soft corals within and outside the Airport channel were low, with most hard substrates dominated by barnacles, mussels and rock oysters (see **Figure 8.7**).

8.6.7.6 The hard coral *Balanophyllia* (Dendrophylliidae) was recorded at the natural shoreline and sandy beach, located outside Airport Channel to the west (Station DS1 and DS2, see **Figure 8.7)**. The recorded colonies were solitary in form and occurred in patches of 5 to 20 colonies, the corallite size was <1cm^2. In both area, all the observed colonies were associated with boulders of diameter >50cm. No colonies showed signs of suffering from sedimentation, bleaching or partial mortality.

8.6.7.7 Octocoral *Echinomuricea* sp. (Plexauridae) were, also, recorded at the natural shoreline and sandy beach to the west of airport channel and at the natural cobble beach at the south-eastern side of the Airport and the artificial boulder shore at Tung Chung (Station DS1, DS2, DS6 and DS7, see **Figure 8.7)**. *Echinomuricea* sp. is a common octocoral in local seas, usually recorded at greater depth in eastern waters but occurring in shallow habitat in the more murky southern and western waters. In these four survey sites, 37 *Echinomuricea* colonies were found sparsely distributed on the rock surface. All colonies recorded suffered from different levels of partial mortality, with colonies at Sites DS1 and DS2 generally exhibiting higher percentages of sedimentation and mortality than those in other sites.

8.6.7.8 Both the hard and soft corals were only present outside the Airport Channel and no coral was found within the channel. No other taxa of high conservation interest were recorded in the seven survey sites.

8.6.7.9 The HKLR supplementary ecological survey, also, reported the soft coral *Echinomuricea* sp. at southeast of Airport Island (Station D1 and D8, see **Figure 8.8**). The area supported sparse and patchy cover (less than 1%) of *Echinomuricea* sp. The gorgonians were small in size (generally about 5-20cm) and recorded in low coverage. Most of the colonies were in fair condition with some of them exhibited a mortality of 10-30%.

8.6.8 Artificial Reefs

8.6.8.1 Artificial reefs have been deployed in Sha Chau and Lung Kwu Chau Marine Park and at the Chek Lap Kok Marine Exclusion Zone since 2000. The aims of artificial reefs deployment are to enhance and protect these marine areas for the benefit of the Chinese White Dolphin and general marine resources. A total of 76 artificial reefs, with a total volume of 9,180 m^3 were deployed within the wide study area.

8.6.8.2 The results of AFCD monitoring have indicated that the artificial reef deployed in eastern waters is an effective resource enhancement device. Biodiversity and abundance of commercial fishes found around the artificial reefs are much higher than those observed in nearby natural rocky shore areas. More than 220 fish species, including many commercially important as well as some rare species, have been recorded at the habitats of artificial reef. The reefs serve as refuge within which fishes can feed, shelter, spawn and nurse their young.

8.6.8.3 The artificial reef in Sha Chau and Lung Kwu Chau Marine Park is located approximately 7.5 km to the west from the proposed TM-CLKL northern landfall reclamation construction (at the nearest point) and, as such, is not expected to be significantly impacted by this project as it is some distance from the project site. However, the nearest artificial reef at the Chek Lap Kok Marine Exclusion Zone is only approximately 1km away from the proposed alignment (**Figure 8.1a**) and could be affected by the works. Because of the poor visibility in western waters, the enhancement effects of artificial reefs deployed in the Sha Chau and Lung Kwu Chau Marine Park and the Chek Lap Kok Exclusion Zone are yet to be confirmed

8.6.9 Sha Chau and Lung Kwu Chau Marine Park

8.6.9.1 There is one designated Marine Park located within the wide Study Area which is the Sha Chau and Lung Kwu Chau Marine Park (**Figure 8.1a**). Covering an area of approximately 1,200ha, the Marine Park encloses the Lung Kwu Chau, Tree Island and Sha Chau SSSI, which was designated for ornithological interest.

8.6.9.2 The Sha Chau and Lung Kwu Chau Marine Park is one of the important habitats in the western water for the Chinese White Dolphin. The distribution of the Chinese White Dolphins is related to the freshwater input from the Pearl River. The majority of dolphin sighting appears on the eastern coast, the northwest and southwestern tips of Lung Kwu Chau; and near the north east and south west coast of Sha Chau. The estimated abundance of dolphins in Hong Kong waters ranges from 103 in spring to 193 in autumn (Jefferson, 2007). According to recent studies, the marine park is an important feeding ground and nursery habitat for the Chinese White Dolphin.

8.6.9.3 The marine environment of the Marine Park is greatly affected by the Pearl River freshwater run-off, with high organic loading and suspended sediments. As such, marine organisms that are present within these waters are highly adapted to salinity fluctuations with periods of continuous low salinity, and highly turbid environments. Nevertheless, the Marine Park acts as a protected habitat for fish species and the CWD within the western waters.

8.6.10 San Tau Beach and Tai Ho Wan SSSIs

8.6.10.1 The Sites of Special Scientific Interest (SSSIs) at San Tau Beach and Tai Ho are the recognised areas of conservation interest in the wide Study Area (**Figure 8.1a**). The seagrass bed and mangrove stand at San Tau Beach was designated as a SSSI in 1994. Reclamation and construction works for the development of the Chek Lap Kok international airport increased the sediment loading of the seawater and hence threatened the populations of *Zostera japonica* and *Halophila ovalis* at San Tau (HKU, 1998). *Z. japonica* and *H. ovalis* survived but most plants died during the peak period of reclamation. The population of *Z. japonica* recovered gradually after the completion of the Chek Lap Kok international airport. Under the highly turbid water, the health of the perennial plant *Z. japonica* was very weak. Once the construction was completed and the water quality improved, and the *Z. japonica* started to recover.

8.6.10.2 Tai Ho Stream has been a designated SSSI since 1999. It is recognised as one of the most ecologically valuable fresh water streams in Hong Kong with record of 49 rare fish species. There are diverse ecological habitats nearby Tai Ho Stream, i.e. mangrove and mudflat, supporting many flora and fauna including the seaweed *Halophila beccarii*, horseshoe crab and sea slug *Elysia flavomacula*. A total of 6 species of true mangrove was previously recorded at Tai Ho Mangal. The *H. beccarii* bed in Tai Ho Wan was identified as a breeding and nursery ground for horseshoe crabs.

8.7 Scope of Field Surveys

8.7.1.1 As noted above, two comprehensive ecological baseline surveys were previously conducted along the north Lantau shores for Hong Kong - Zhuhai - Macao Bridge (HZMB) Hong Kong Section (Meinhardt, 2004) and the Tuen Mun shores for Tuen Mun Western Bypass (TMWB) – Investigation (Maunsell, 2009). The HZMB baseline survey was conducted between September 2003 to May 2004 while the TMWB ecological survey was conducted between September 2008 to February 2009. The two surveys covered both the wet and dry seasons. The surveys conducted for HZMB and TMWB are highly relevant to the TM–CLKL project as the TM–CLKL interfaces with part of HZMB scheme (the Hong Kong Boundary Crossing Facilities (HKBCF), as described in Section 3), as well the TMWB at Pillar Point, Tuen Mun.

8.7.1.2 Notwithstanding the data obtained from the HZMB and TMWB surveys and the literature review, it was considered necessary to undertake further field surveys to provide more project specific ecological data for the TM-CLKL assessment. The field work was focussed on habitats and species identified in the literature review where adequate or recent data were not available. Other habitats and species groups were also surveyed to characterise the ecology of the study area and prepare an ecological profile.

8.7.1.3 The surveys for this Assignment comprised both the wet and dry seasons and covered a period of 10 months between July 2008 and April 2009 to supplement to ecological data already available and provide sufficient details on which to establish the baseline ecological conditions of the marine study area between Pillar Point, Tuen Mun and Tai Ho Wan, North Lantau.

8.7.1.4 The purpose of the ecological surveys was to focus on the optimal census technique and survey period when each animal group was likely to be encountered. The overall quality of the study is dependent on selecting the correct survey period and survey technique. The survey effort also focussed on those areas mostly likely to be impacted by the project such as landing points. The following TM-CLKL surveys were undertaken:

- Cetaceans;
- Benthic Macro-infauna;
- Intertidal Flora and Fauna; and
- Corals and Subtidal Macrobenthos.

8.7.1.5 The methodologies for each of the surveys are detailed in Section 8.8 below.

8.8 Field Survey Methodologies

8.8.1 Cetaceans (Chinese White Dolphins and Porpoises)

8.8.1.1 While studies sponsored by AFCD and other researchers, especially the Hong Kong Cetacean Research Project (HKCRP), provide extensive data on the local distribution of the Chinese White Dolphin (CWD) and their population biology (Hung, 2007, 2008; Jefferson, 2000, 2005; Jefferson & Hung, 2007, Jefferson & Leatherwood, 1997; Jefferson et al., 2002; Parsons et al., 1995; Parsons & Jefferson, 2000), site specific data has been considered necessary to enable a more precise and updated characterization of the CWD around the project site, as the endangered species could be negatively affected by the project during both the construction and operational stages.

8.8.1.2 A total of 18 days of systematic line-transect survey data in North Lantau waters, twice per month during the 9-month study period (i.e. July 2008 – March 2009). The territorial water of Hong Kong Special Administrative Region was divided into twelve survey areas (see Hung 2008a), and surveys were conducted within areas surrounding the project alignment, that overlapped with the eastern portion of Northwest Lantau (NWL) survey area and western portion of Northeast Lantau (NEL) survey area, as indicated in **Figure 8.3**. The total length of transect lines was 57 km, which were be completed within each survey day.

8.8.1.3 The survey team used standard line-transect methods (Buckland et al. 2001), and followed the same technique of data collection that has been adopted in the last 13 years of dolphin monitoring surveys in Hong Kong developed by HKCRP, especially for Airport Authority and AFCD (Hung 2007, 2008a; Jefferson 2000). In order to ensure consistency of data collection, the same research team, survey platform and boat driver from AFCD's long-term monitoring project were used. A 15-m inboard vessel (Standard 31516) with an open upper deck, which is 4.5m above water surface, was used to make observations from the flying bridge area.

8.8.1.4 Two experienced observers (a data recorder and a primary observer) made up the on-effort survey team, and the survey vessel transited different transect lines at a constant speed of 13-15 km per hour. The data recorder searched with unaided eyes and filled out the datasheets, while the primary observer searched for Chinese White Dolphins continuously through 7 x 35 Brunton marine binoculars. Both observers searched the sea ahead of the vessel, between 270^{o} and 90^{o} (in relation to the bow, which is defined as 0^{o}). Two additional experienced observers were available on the boat to work in shift (i.e. rotate every 30 minutes) in order to minimize fatigue of the survey team members. Project Director of Hong Kong Cetacean Research Project (HKCRP), Dr. Samuel Hung, was also on board to audit the surveys for quality control and assurance.

8.8.1.5 During on-effort survey periods, survey team recorded effort data including time, position (latitude and longitude), weather conditions (Beaufort sea state and visibility) and distance traveled in each series (a continuous period of search effort) with the assistance of a handheld GPS (Garmin Geko 201). When Chinese

White Dolphins were sighted, the survey team would end the survey effort, and immediately recorded the initial sighting distance and angle of the dolphin group from the survey vessel, as well as sighting time and position. Then the research vessel was diverted from its course to approach the animals for species identification, group size estimation, assessment of group composition, and behavioural observations. The perpendicular distance (PSD) of the dolphin group to the transect line was later calculated from the initial sighting distance and angle.

8.8.1.6 The line-transect data collected during the present study were compatible with the long-term databases maintained by HKCRP in a way that it can be analyzed by established computer programmes (for example, all recent versions of DISTANCE programme including version 5.0, ArcView© GIS programme) for examination of population status including trends in abundance, distribution and habitat use.

8.8.1.7 When a group of Chinese White Dolphins was sighted during line-transect surveys, the survey team would then end effort and approach the dolphin group slowly from the side and behind to take photographs of them. Every attempt was made to photograph every dolphin in the group, and even photograph both sides of the Chinese White Dolphins, since the colouration and markings on both sides may not be symmetrical.

8.8.1.8 Two professional digital camera (Canon EOS 40-D model and 20-D model), equipped with long telephoto lenses (100-400 mm zoom), were available on board for researchers to take sharp, close-up photographs of Chinese White Dolphins as they surfaced. All digital images taken in the field were first examined, and those containing potentially identifiable individuals were sorted. These photographs were then examined in detail and carefully compared to the 600+ identified Chinese White Dolphins in a PRE humpback dolphin photo-identification catalogue curated by HKCRP. Chinese White Dolphins can be identified by their natural markings, such as nicks, cuts, scars and deformities on their dorsal fin and body, and their unique spotting patterns were, also, used as secondary identifying features (Hung 2008a; Jefferson 2000).

8.8.1.9 All photographs of each individual were then compiled and arranged in chronological order, with data including the date and location first identified (initial sighting), re-sightings, associated Chinese White Dolphins, distinctive features, and age classes entered into a computer database. Any new individuals were given a new identification number, and their data were also added to the catalogue, along with text descriptions including age class, gender, any nickname or unique markings.

8.8.1.10 The line-transect survey data were integrated with Geographic Information System (GIS) in order to visualize and interpret seasonal and annual distribution of the Chinese White Dolphins using sighting positions. Location data of dolphin groups were plotted on map layers of Hong Kong using a desktop GIS to examine their distribution patterns at and near the proposed project site during the study period. The dataset was also stratified into different subsets to examine distribution patterns of dolphin groups with different categories of group sizes, fishing boat associations and age classes. The long-term sighting databases maintained by HKCRP (data mostly collected under AFCD's long-term monitoring study) were used to examine distribution patterns in past years for comparison with the one in the present study period.

8.8.1.11 When Chinese White Dolphins were sighted during vessel surveys, their behaviours were observed. Different behaviours were categorized (i.e. feeding, milling/resting, traveling, socializing) and recorded on sighting datasheets. These data were then input into a separate database with sighting information, which can be used to determine the distribution of behavioural data with desktop GIS. Distribution of sightings of Chinese White Dolphins engaged in different activities and behaviours would then be plotted on GIS and carefully examined to identify important areas for different activities.

8.8.2 Benthic Macro-infauna

8.8.2.1 Marine benthic sampling was carried out on 21 October 2008 (wet season) and 18 February 2009 (dry season). A modified van Veen grab (capacity of about 11.3 litres; top surface area of about $0.1m^2$) was used.

8.8.2.2 Three grab samples were collected in each of 8 sampling stations which were allocated to provide an even coverage over the footprint of the TM-CLKL alignment and each station is approximately 1km apart. The locations of the benthic macro-fauna sampling stations are presented in **Figure 8.5a**.

8.8.2.3 Sampling methodology, design and analysis are discussed in the following sections. During this reporting period, a suite of biological-based assessments have been carried out to determine the macrofaunal community structure of the study area.

<u>Sampling Design and Analysis</u>

8.8.2.4 The benthic macrofauna samples have been analysed for a suite of biological characteristics including composition and number of individuals present. The community diversity of benthic assemblages have also been calculated. The distribution of biomass amongst the benthic macrofauna present has also been plotted because ecological theory suggests that the distribution of numbers of individuals among species in macrobenthic communities are unbalanced through pollution and disturbance (Warwick, 1986). By plotting the abundance and biomass of the macrofaunal organisms present (abundance biomass comparisons referred to as ABC plots), it is possible to determine the prevailing level of disturbance at each location. The ABC plots were constructed using PRIMER (version 4.0) software.

<u>Field Sampling Procedures</u>

8.8.2.5 Following accurate positioning of the survey vessel (using the dGPS navigation system), a modified van Veen grab sampler was deployed at each of the sampling locations. A three replicate grab sample was obtained at each station (n = 24). Any grab sample showing uneven penetration into the seabed or only partially filled with sediment was rejected. Sediment sub-samples (approximately 1 kg) were also collected for particle size and total organic carbon analysis and the remaining sediment was processed for benthic macrofauna.

8.8.2.6 For preliminary sediment processing on the survey vessel, each sample was gently sieved through a 1.0 mm and 0.5 mm mesh sieve and carefully worked through the sieves using seawater. The material retained on each of the sieves was then washed gently into labelled, double-bagged plastic Ziploc bags and the contents fixed in 5% buffered formaldehyde in seawater containing Rose Bengal (the Rose Bengal vital stain assisted the differentiation of organisms from non-living material when processed in the laboratory because biota stains pink).

Laboratory Procedures

8.8.2.7 Adequate fixation of the benthic organisms was achieved through holding samples for a minimum of 24 hours in formaldehyde. Following fixation, the samples were gently rinsed with freshwater to remove excess formaldehyde into a 250 μm sieve. All faunal material retained in the sieve was then preserved in a 70% ethanol solution and placed in Petri dishes labelled with the original label from the time of collection. The organisms were then sorted from the sediments by twice scanning the samples held in the Petri dish under a dissecting microscope. The benthic organisms were identified in the laboratory to the lowest possible taxonomic level (usually genus although dominant macrofauna were identified wherever possible to species) and identification of smaller organisms was conducted using a high power compound microscope. Following sorting and identification, organisms were retained in labeled vials and preserved in 70% ethanol. Biomass was determined by taking the blotted wet mass of each taxon.

Diversity Index

8.8.2.8 Diversity indices are reasonably useful in determining the benthos condition (health) and provide a numerical value that is derived from both the number of species present in the community and also from the distribution of individuals between those species. Generally, the more stable the environment the higher the community diversity although note that there are exceptions. Diversity was assessed at the species/genus level and analysed using the Shannon-Wiener index (log10).

ABC Plots and W Statistic

8.8.2.9 The Abundance-Biomass Comparison (ABC) curve is a technique that plots abundance and biomass data for each station on the same graph and provides useful information on the prevailing ecological condition. When conditions are stable, interspecific competition results in a community composed of k-dominated species (i.e., those species that are typically of a larger size, long-lived and have a population that is reasonably constant in time). When the prevailing conditions are unstable such as due to pollution, r-selected (opportunist) species dominate and these organisms tend to be of a smaller size, have shorter life-spans and undergo wide fluctuations in their population size. By plotting the abundance and biomass of the macrofaunal organisms along the x-axis of the graph and cumulative percentage dominance on the y-axis, it is possible to determine the pollution status of each area.

8.8.2.10 The W statistic is calculated from the ABC procedures and can also serve as a useful measure of disturbance and/or pollution. The W statistic also reduces each plot to a single summary statistic that is helpful for interpretation of impacts in marine benthic communities by non-specialists. The W statistic has a range of –1 to 1 with the former value representing transposition of the abundance and biomass curve (i.e., the abundance curve overlies the biomass curve) representative of gross pollution whereas the latter value represents even abundance and biomass dominated by a single species although it is unlikely that either limit is reached in practice (Clarke and Warwick, 1994).

8.8.3 Intertidal Flora and Fauna

Intertidal Community

8.8.3.1 Marine intertidal biota show distinct patterns of zonation on the shore. The species present on the lower shore are typically marine-dependent whereas those species found higher up the shore are better adapted to a terrestrial habitat and this results in distinct patterns of distribution on intertidal shores. In addition to showing zonation patterns, intertidal shore fauna are also typically patchily distributed. In order to survey the shoreline accurately, belt transects were placed at different vertical heights up the shore and quadrats randomly placed along the transects in order to ensure that an accurate (non-biased) assessment was made of the species present.

8.8.3.2 Both qualitative and quantitative surveys of the natural intertidal habitat at Pak Mong – Tai Ho area were conducted during 2008/09. Two qualitative walk-through surveys were conducted on 11 August 2008 and 11 February 2009 to identify the intertidal species present and their occurrence. Based on the findings of qualitative walk-through surveys, representative survey locations were determined to carry out quantitative intertidal surveys. A total of 4 quantitative intertidal surveys were conducted on 11 August, 25 October 2008 and 11 February, 23 April 2009. Two-three 10m belt transects were laid parallel to the shoreline at approximate 1mCD intervals up the shore being surveyed. Seven to ten 0.25m^2 quadrats were placed randomly along each transect. Substrate type, faunal species abundance and percentage cover of macroalgae was recorded within each quadrat. The extent of walk-though survey and intertidal sampling points are presented in **Figure 8.5a**.

Mangrove, Mudflat, Horseshoe Crabs and Seagrass

8.8.3.3 Seagrass survey and horseshoe crab surveys were conducted at the soft shore sites. The sites were thoroughly searched for the seagrasses and horseshoe crabs during suitable ebbing tides. The species, number, sizes of horseshoe crabs and the species, area sizes and coverage percentages of seagrssses were recorded, and the locations of horseshoe crabs and the locations and extents of seagrasses were mapped. The presence of Horseshoe crab trails was also recorded. Photos of seagrasses and horseshoe crabs found during the surveys were taken.

8.8.3.4 During 2008/09, horseshoe crab and seagrass surveys were undertaken concurrent with intertidal walk-through surveys conducted on 11 August 2008 and 11 February 2009. An additional horseshoe crab survey was conducted on 30 July 2008. A total of 3 field surveys were conducted on 11, 12 and 28 August 2008 to identify mangrove stands. The location of horseshoe crab, seagrass and mangrove sites surveyed between 2008 and 2009 is presented in **Figure 8.5a**.

8.8.4 Corals and Subtidal Macrobenthos

Corals

8.8.4.1 Qualitative dive survey was conducted to determine the presence of corals. The survey technique used a tiered methodology which is applicable to the assessment of sub-littoral benthic communities and in particular, corals. The surveys were undertaken in the areas to be directly affected by the TM-CLKL. The survey design consisted of a suite of three standardised 'nested' survey methods, namely 'spot-check' dives, Rapid Ecological Assessment (REA) and video transects, if then required. In an effort to increase survey efficiency the spot-check dives was used to determine if more detailed quantitative surveys, that is, REA and video assessments, are necessary.

Spot-check Reconnaissance Dives

8.8.4.2 A qualitative dive survey was conducted to assess the substrate and other marine benthos for the presence of coral communities. These 'spot-check' dives were distributed in and around each survey area at a density that was sufficient to locate any major coral areas and to reliably assess the type of benthos existing in each survey area. The starting location and direction were chosen to ensure most of the area within the specified depth zone (to the end of the hard substrate) was examined. For each dive the following information was recorded:

- location (GPS);
- depth range;
- visibility;
- estimate of percentage of hard coral and soft coral cover;
- substrate type;
- distance surveyed;
- coral species and other invertebrates present; and
- health of any corals located.

8.8.4.3 In this way, areas with significant quantities of corals were located and suitable locations to carry out further surveys determined. In order to decide upon areas where REA and video surveys were necessary, the estimate of hard and soft coral was classified into one of four levels: no coral cover, less than 5% cover, between 5% and 10% cover and over 10% cover.

Rapid Ecological Assessment (REA) Survey

8.8.4.4 The Rapid Ecological Assessment (REA) methodology was first detailed in DeVantier et al. 1998. The survey is a two tier approach for underwater survey to assess the sub-littoral substrata and benthic organisms in an area. This methodology has been modified to suit Hong Kong conditions (Oceanway 2002b) and has become a standardized and widely adopted way to establish ecological baseline conditions. Two levels of information are recorded in a ~2m wide swath, 1m either side of a 100m long tape. The two tiers of assessment are as follows:

- Tier I - assesses the relative cover of major benthic groups and substrata.
- Tier II - provides an inventory of sedentary / sessile benthic taxa, which are also ranked in terms of their abundance in the community at the survey site.

8.8.4.5 Data was recorded by experts who are experienced in the field identification of sedentary / sessile benthic taxa, particularly corals. For each transect, ecological and substratum attributes should be categorised and ranked. The required Tier I benthic attributes categories are detailed in **Table 8.7** below and the Ordinal Ranks of Percentage Cover of Benthic Attributes provided in **Table 8.8**.

Table 8.7 Tier I Benthic Attribute Categories

Ecological Attributes	Substratum Attributes
Hard Corals	***Hard substrata***
Dead Coral	Bedrock / continuous pavement
Octocoral (Soft corals black and gorgonians)	Boulder blocks (diam. >50cm)
Anemone beds	Boulder blocks (diam. <50cm)
Dead standing corals	Rubble
Other benthos (sponges, zoanthids, ascidians and bryozoans)	Other
Macro-algae	***Soft substrata***
-	Sand
-	Mud / Silt
-	Mud

Table 8.8 Tier I Ordinal Ranks of Percentage Cover of Benthic Attributes

Rank	Percentage Cover
0	None Recorded
0.5	1-5%
1	6-10%
2	11-30%
3	31-50%
4	51-75%
5	76-100%

8.8.4.6 For substratum attributes, it is preferable to record actual estimates of cover. The percentage of hard substrata verses soft substrata can be provided (e.g. 80% and 20% respectively). The percentage cover of the types of hard or soft substrata could also then be presented (e.g. bedrock pavement 60%, rubble 20%, sand 15%, mud/silt 5%). Similarly, recording and presenting actual estimates of, for instance, hard and soft coral cover may be more informative (e.g. <1%) and is also approach adopted by similar recent survey reports.

8.8.4.7 The taxon categories have been ranked in terms of relative abundance of individuals, rather than the contribution to benthic cover along each transect. The ranks are visual assessments of abundance, rather then quantitative counts of each taxon, as detailed in **Table 8.9**. Representative photos of organisms were also taken.

Table 8.9 Taxonomic Inventory Identification

Taxon Abundance Rank	Abundance
0	Absent
1	Rare
2	Uncommon
3	Common
4	Abundant
5	Dominant

8.8.4.8 Under TM-CLKL, spot dive survey was conducted on 6 March 2009. Spot dive survey were conducted at both the northern and southern landing points, along the proposed alignment and around the Tai Mo To. The locations of the spot dive survey are shown in **Figure 8.5b**. After spot dive survey, four REA surveys were carried out on 23 March 2009. The REA surveys were conducted at the Northern Landing Point (REA 1), the Southern Landing Point (REA 4) and around Tai Mo To Island (REA 2 & REA 3). The spot dive records of coral populations at both landing points were the main criteria for carrying out REA surveys at these locations. The selection of the locations of the REA Survey stations at Tai Mo To Island was based the fact that the area was fairly typical of the whole island (REA 3) and, also, that the area with the highest recorded density of octocoral colonies was located there (REA 2). The locations of the REA surveys are shown in **Figure 8.5b**.

<u>Subtidal Macrobenthos</u>

8.8.4.9 Surveys for sub-tidal macrobenthos were undertaken concurrently with the corals surveys detailed above. The spot-check reconnaissance dives were undertaken at the same locations and at the same time as the coral dives. Species, health and abundance of macrobenthos species were recorded but only visual assessments of abundance are conducted.

8.9 Field Survey Results

8.9.1 Cetaceans (Chinese White Dolphins)

8.9.1.1 From July 2008 to March 2009, 18 sets of systematic line-transect surveys had been completed in Northeast Lantau and Northwest Lantau survey areas. Based upon these line-transect surveys, a total of 945.4 km of survey effort was conducted, including 637.5 km in Northeast Lantau and 307.9 km in Northwest Lantau (see Table 1 in **Appendix F1**). Almost all survey effort (97.1%) was conducted under favourable weather conditions (that is, sea state Beaufort 3 or below), which can be used in the line-transect analysis to estimate density and abundance of the CWD.

8.9.1.2 A total of 30 groups of Chinese White Dolphins numbering 100 individuals were sighted during these surveys in North Lantau waters. Among them, 24 groups were sighted during on-effort search, which can be used to estimate density and abundance (see Table 2 in **Appendix F1**). Most dolphin sightings were made in the western section of Northeast Lantau survey area (22 sightings), while another eight sightings were made in the eastern section of Northwest Lantau survey area. No finless porpoise was sighted in North Lantau survey area during the TM-CLKL surveys.

8.9.1.3 Distribution patterns of the CWD sightings made in North Lantau waters during the TM-CLKL surveys are shown in Figures 2 and 3 of **Appendix F1**. Based upon these surveys alone, it can be seen that dolphin groups were sighted sporadically in the central region of North Lantau waters which overlap with the proposed project site (see Figure 2 in **Appendix F1**). The dolphin sightings were mostly scattered, but appeared to be concentrated between and around the Brothers Islands. On the contrary, they were rarely sighted along the coastal waters of Northwest New Territories, that is, between Tuen Mun Area 38 to Siu Lam nor to the east of the airport platform.

8.9.1.4 Combined with AFCD monitoring data collected during the same period, dolphin sightings appear to be concentrated around the Brothers Islands and near Sham Shui Kok, as shown in Figure 3 of **Appendix F1**. Along the proposed route of the TM-CLKL, the number of dolphin sightings was not particularly high, with only a few dolphin sightings overlapping with the waters in the vicinity of the proposed project site. When examining dolphin distribution in the greater North Lantau region (see Figure 2 in **Appendix F1**), Chinese White Dolphins were more frequently sighted around Lung Kwu Chau and Sha Chau and along the Urmston Road (i.e. between Lung Kwu Chau and Black Point, although it should be noted that survey effort was less in the western section than the central section of North Lantau.

8.9.1.5 In order to examine dolphin distribution in the past years, on-effort CWD sightings from 2005-09 AFCD monitoring surveys have been plotted together with the ones collected under this study. The distribution pattern from 2005-09 showed that dolphin groups were frequently sighted in the central region of the North Lantau waters, with concentrations of sightings occurring at the northeast corner of Chek Lap Kok Airport Island, the waters between and around the

Brothers Islands and near Sham Shui Kok, as shown in Figure 5, **Appendix F1**.

8.9.1.6 Chinese White Dolphins were rarely sighted near Castle Peak Bay and along the coastline of Northwest New Territories. Notably, with the exception of a rare sighting in which two Chinese White Dolphins was made near Tung Chung, Chinese White Dolphins were largely absent to the east of airport platform and near Tai Ho Wan (see Figure 5 in **Appendix F1**). Dolphin sightings were made, however, on both sides of the proposed route of TM-CLKL, and dolphin usage was slightly higher along the section near Tai Mo To Chau (see Figure 5 in **Appendix F1**). The distribution of dolphin sightings throughout the greater North Lantau region from 2005-09 has, also, been examined (see Figure 6 in **Appendix F1**) and it has been shown that the dolphin groups are notably more concentrated near Lung Kwu Chau and the waters between Lung Kwu Chau and Black Point. This indicates that the waters in the western end of North Lantau (especially the area around the Sha Chau and Lung Kwu Chau Marine Park) are more important dolphin habitats than the central and eastern regions of North Lantau, where the proposed TM-CLKL will be constructed.

8.9.1.7 Distribution patterns of dolphin sightings from 2005-09 among the four seasons have also been compared within the study area (see Figure 7 in **Appendix F1**). In the spring months (March-May), Chinese White Dolphins were rarely sighted in the central region of North Lantau, with only a few sightings made sporadically throughout the area (see Figure 7 in **Appendix F1**). However, in summer (June to August) and autumn (September to November), the number of dolphin sightings markedly increased in Northeast Lantau, especially around the Brothers Islands and near Sham Shui Kok (see Figure 7 in **Appendix F1**). The data indicated that Chinese White Dolphins were, also, regularly sighted between Tuen Mun Area 38 and the airport platform but, in winter months (December to February), dolphin groups were less frequently sighted around the Brothers Islands than in summer and autumn months (see Figure 7 in **Appendix F1**). The seasonal distribution of Chinese White Dolphins within the study area should be driven by the estuarine influence from the Pearl River flow, which can affect the seasonal occurrence of Chinese White Dolphins' prey.

8.9.1.8 During the TM-CLKL surveys, the group sizes of CWD in North-east Lantau and North-west Lantau ranged from 1-12, with an average of 3.3 ± 2.58 animals per group. This average group size was slightly lower than the average in North Lantau waters recorded in 2005-09 (3.8 ± 2.99 animals per group). Since 2005, most large dolphin groups (that, is, those with more than 10 animals) in North Lantau region occurred near Lung Kwu Chau and along Urmston Road and the large groups were rarely sighted in Northeast Lantau (see Figure 8 in **Appendix F1**). However, small groups (with less than 5 animals) and medium groups (with 5-9 animals) dominated the central and eastern regions of North Lantau.

8.9.1.9 Although all dolphin sightings collected during the TM-CLKL surveys did not have any fishing boat association, 31 dolphin sightings recorded during 2005-09 in North Lantau were associated with fishing boats, including hang trawlers, shrimp trawlers, pair trawlers, single trawler, purse-seiner, and gill-netter. Most of these boat-associated sightings occurred to the west end of North Lantau waters near Lung Kwu Chau, with only a few made in the central and eastern regions of North Lantau (see Figure 9 in **Appendix F1**).

8.9.1.10 During the TM-CLKL surveys, only three unspotted juveniles (UJ) were sighted in North-east Lantau and North-west Lantau and no unspotted calves (UC) were encountered. Between 2005-2009, a total of 31 UCs and 84 UJs have been sighted within the North Lantau waters and their distribution patterns are shown in Figure 10 of **Appendix F1**. These calves were mostly located to the west end of Northwest Lantau, especially at the waters between Black Point and Lung Kwu Chau. On the contrary, calves were much less frequently sighted in the central and eastern regions of North Lantau, and most of them were sighted around the Brothers Islands and near Sham Shui Kok (see Figure 10 of **Appendix F1**). The areas with frequent occurrence of calves should be viewed as important areas for nursing activities, as the claves are still largely dependent on their mother and, as such, more susceptible to any disturbances in their surrounding environment.

8.9.1.11 When Chinese White Dolphins were sighted during the course of line-transect surveys, their activities were also recorded to determine important areas for feeding, socializing, traveling and milling/resting activities within the study area. Among the 30 dolphin groups sighted during the TM-CLKL surveys, seven of them were engaged in feeding activities, while another three were engaged in socializing activities. Between 2005-2009, a total of 104 and 61 dolphin sightings were engaged in feeding and socializing activities, respectively. Most of the feeding activities occurred in two main areas, namely the waters around Lung Kwu Chau and along Urmston Road and the waters between the Brothers Islands and Sham Shui Kok (see Figure 11 in **Appendix F1**). In addition, the dolphin groups engaging in socializing activities in North Lantau were mostly centered around Lung Kwu Chau, but were largely absent in Northeast Lantau with the exception near Sham Shui Kok (see Figure 12 in **Appendix F1**). Notably, Chinese White Dolphins were rarely engaged in both feeding and socializing activities in the central region of North Lantau. During 2005-2009, CWD rarely exhibited traveling and milling/resting behaviours in North Lantau waters, with only occasional sightings occurring near Black Point, the west side of the Sha Chau and Lung Kwu Chau Marine Park and near Sham Shui Kok (see Figure 13 in **Appendix F1)**.

8.9.1.12 During the nine months of line-transect surveys in North Lantau waters, over 1,200 digital photographs of CWD have been taken for photo-identification. Based upon these, a total of 30 individual Chinese White Dolphins had been identified 41 times (Table 3 of **Appendix F1**). Among the 30 identified individuals, one individual (NL24) was sighted three times, while another nine individuals were sighted twice (Table 3 of **Appendix F1**). Most of the identified individuals were sighted in Northeast Lantau (28 re-sightings), and the other 13 re-sightings were made in Northwest Lantau. Some of them (NL18, NL123 and NL220) were sighted in West Lantau waters during the same study period under AFCD's monitoring study, showing their wide-ranging behaviour within Hong Kong territorial waters.

8.9.2 Benthic Macro-infauna

8.9.2.1 The HZMB benthic sampling was conducted in October 2003 (late wet season) and January 2004 (dry season) at Tai Ho Wan. The sampling location is shown in **Figure 8.4a**. A summary of the results of benthic survey under the HZMB study are presented in **Appendix F2**.

8.9.2.2 The 2003 wet season survey resulted in the collection of 5 sediment samples containing 163 macro-faunal specimens belonging to 22 families comprising 4 different phyla with the total biomass of 3.8g. The 2004 dry season survey resulted in the collection of 5 sediment samples containing 115 macrofaunal specimens belonging to 24 families comprising 5 different phyla with the total biomass of 2.7g.

8.9.2.3 During the 2003 wet season survey, the macrofaunal density recorded from the areas off Tai Ho Wan was 32.6 individuals grab^{-1} and 4.4 families grab^{-1}. The average biomass was 0.76g grab^{-1}. During the 2004 dry season survey, the macrofaunal density was 23.0 individuals grab^{-1} and 4.8 families grab^{-1}. The average biomass was 0.54g grab^{-1}. The macrofauna characteristics recorded at Tai Ho Wan during both the wet (October 2003 and 2008) and dry season (January 2004) surveys are presented below in **Table 8.10**.

8.9.2.4 During the 2003/04 surveys, three species were considered dominant in terms of abundance in the grab samples (dominance is defined as greater than 10 individuals of the same species in each grab). All dominant species recorded were annelids (worms). The spionids *Prionospio* spp. was the most dominant species and more than 10 individuals of these species were recorded in both the wet and dry seasons.

Table 8.10 Summary of the Dominant Macrofauna Species Collected during October 2003 and January 2004 (> 10 Individuals in Each Grab)

Phylum	Class	Order	Family	Species	Wet Season 2003	Dry Season 2004
Annelida	Polychaete	Spionida	Spionidae	*Prionospio queenslandica*	TWH-1	THW-5
Annelida	Polychaete	Capitellida	Capitellidae	*Mediomastus californiensis*	TWH-4	-
Annelida	Polychaeta	Spionida	Poecilochaetidae	*Poecilochaetus serpens*	THW-1	-

8.9.2.5 The ABC plots of Tai Ho Wan showed that the biomass curve was above the abundance curve for its entire length. Therefore, the curves were indicative of stable communities which are considered to be unaffected by disturbance or pollution. In addition, the *W* statistics were all positive during the wet (*W*=0.293) and dry (*W*=0.299) seasons. Infauna diversity at Tai Ho Wan is low with the diversity index (H') of 0.95 and 0.97 in wet and dry seasons respectively.

8.9.2.6 The univariate analyses (number of species, number of individuals, biomass and diversity index), ABC plots and *W* statistics all suggested that the communities present in Tai Ho Wan in both wet and dry seasons were similar although the abundance in wet season was slightly higher than in dry season. **Table 8.11** below summarises the results.

Table 8.11 Summary of Benthic Macrofauna Surveys during 2003-2004

Item	Wet Season (October 2003)	Dry Season (January 2004)
Number of grabs	5	5
Number of Identified Family	22	24
Total Number of Individuals	163	115
Total Biomass (g)	3.8	2.7
Number of Families Grab^{-1}	4.4	4.8
Number of Individuals Grab^{-1}	32.6	23
Biomass (g) Grab^{-1}	0.76	0.54
Diversity (H')*	0.95	0.97
ABC Plot	Undisturbed	Undisturbed
W Statistic	0.293	0.299

Note: * = Diversity is at the species level and analysed using the Shannon-Wiener index (log10).

8.9.2.7 The TM-CLKL benthic sampling was conducted in October 2008 (late wet season) and February 2009 (dry season) along the proposed alignment of TM-CLKL. A summary of the results of the benthic surveys under TM-CLKL study are presented in **Appendix F3**.

8.9.2.8 The 2008 wet season survey resulted in the collection of 24 sediment samples containing 917 macro-faunal specimens belonging to 50 families comprising 8 different phyla. The total recorded biomass was 58.0g due to the high mass of molluscs, echinodermata, annelida and arthropoda. The macrofaunal density recorded from the areas along the proposed TM-CLKL alignment was 382 individuals per m^2 and the average biomass was 24.2g/m^2.

8.9.2.9 The 2008 TM-CLKL dry season survey resulted in the collection of 24 sediment samples containing 1579 macro-faunal specimens belonging to 50 families comprising 7 different phyla. Most of them, again, belong to annelida, mollusca and anthropoda. The total recorded biomass was 73.1g. The macrofaunal density recorded from the areas along the proposed TM-CLKL alignment was 658 individuals per m^2 and the average biomass was 30.46 g/m^2. The details of the survey findings are presented in **Table 8.12** below.

Table 8.12 Summary of the Macro-infauna Phylum (Abundance and Biomass) Collected During 2008 TM-CLKL Survey

Phylum	Number of Indentified Families		Total Abundance (individuals)		Total Biomass (wet weight, g)		Abundance (individuals m^{-2})		Biomass (wet weight, g m^{-2})	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Annelida	25	28	759	1141	8.30	15.08	316	475	3.46	6.28
Arthropoda	10	8	87	233	8.16	16.65	36	97	3.40	6.94
Coelenterata	2	2	5	3	3.98	1.80	2	1	1.66	0.75
Echinodermata	3	2	17	11	9.93	8.20	7	5	4.14	3.42
Mollusca	7	8	38	175	23.82	30.799	16	73	9.93	12.83
Nemertea	1	1	5	13	0.06	0.57	2	5	0.03	0.24

	Number of Indentified Families		Total Abundance (individuals)		Total Biomass (wet weight, g)		Abundance (individuals m^{-2})		Biomass (wet weight, g m^{-2})	
Sipuncula	1	1	5	3	0.04	0.02	2	1	0.01	0.01
Chordata	1	0	1	0	3.68	0	0	0	1.53	0
Total	**50**	**50**	**917**	**1579**	**57.97**	**73.12**	**382**	**658**	**24.15**	**30**

Note: The surface area of the modified van Veen grab is ~0.1m^2.

8.9.2.10 During 2008 wet and dry season survey, 8 and 13 species were considered dominant in terms of abundance in the grab samples (dominance is defined as greater than 10 individuals of the same species in 3 grabs) respectively. Of the dominant species recorded, almost all were annelids (worms). The capitellid *Mediomastus californiensis* were the most dominant species and more than 10 individuals of these species were recorded at 3 or more stations in both wet and dry season. *Sigambra hanaokai* (wet season) and *Melita sp.* (dry season) were also recorded more than 10 individuals of these species at 3 or more stations. A summary of the dominant macrofauna species collected is provided in **Table 8.13**.

Table 8.13 Summary of the Dominant Macrofauna Species Collected during 2008-2009 (> 10 Individuals in 3 Grabs)

Phylum	Class	Order	Family	Species	Wet Season 2008	Dry Season 2009
Annelida	Polychaete	Spionida	Spionidae	*Prionospio queenslandica*	B6, B8	B6
Annelida	Polychaete	Spionida	Spionidae	*Prionospio cirrifera*	B1, B4	-
Annelida	Polychaete	Spionida	Cirratulidae	*Cirratulus cirratulus*	B6	-
Annelida	Polychaete	Spionida	Cirratulidae	*Tharyx* sp.	B6, B8	-
Annelida	Polychaete	Capitellida	Capitellidae	*Mediomastus californiensis*	B1, B5, B6, B8	B2, B4, B5, B6, B7, B8
Annelida	Polychaete	Phyllodocida	Nephtyidae	*Aglaophamus dibranchis*	B6, B8	B6
Annelida	Polychaete	Phyllodocida	Pilargiidae	*Sigambra hanaokai*	B1, B2, B3	B1, B4
Arthropoda	Crustacea	Decapoda	Pinnotheridae	*Neoxenophthalmus obscurus*	B6	-
Annelida	Polychaete	Capitellida	Capitellidae	*Notomastus latericens*	-	B7
Annelida	Polychaete	Eunicida	Eunicidae	*Eunice indica*	-	B6
Annelida	Polychaete	Phyllodocida	Glyceridae	*Glycera onomichiensis*	-	B6
Annelida	Polychaete	Phyllodocida	Nereidae	*Neanthes janonica*	-	B6
Arthropoda	Crustacea	Amphipoda	Corophiidae	*Corophium sp.*	-	B2, B7
Arthropoda	Crustacea	Amphipoda	Melitidae	*Melita sp.*	-	B2, B6, B7
Mollusca	Bivalvia	Veneroida	Veneridae	*Paphia undulata*	-	B4, B5
Mollusca	Bivalvia	Veneroida	Tellinidae	*Moerella iridescens*	-	B6
Mollusca	Bivalvia	Veneroida	Veneridae	*Ruditapes philippinarum*	-	B6

8.9.2.11 The result of 2008 wet season survey indicated that the abundance ranged from the lowest at station B2 (123 individuals m^{-2}) to the highest at station B6 (1217 individuals m^{-2}). The average biomass value was ranged from the lowest at station B7 (1.90g m^{-2}) to the highest at station B3 (76.34g m^{-2}). The average size of a specimen, as determined by individual wet weight, was also very different among sites, with the highest of 313.7mg at station B3 and the lowest of 10.8mg at station

B7.

8.9.2.12 The species richness (S) of wet season ranged from the lowest at station B1 (3.81) to the highest at station B5 (7.39). The Pielou's eveness index (J') was ranged from the lowest at station B6 (0.63) to the highest at station B7 (0.93). The diversity index (H') was ranged from the highest of 3.10 at station B5 and the lowest of 2.08 at station B8.

8.9.2.13 The result of 2009 dry season survey indicated that the abundance ranged from the lowest at station B8 (167 individuals m^{-2}) to the highest at station B6 (3030 individuals m^{-2}). Noted that B6 was recorded to be the highest abundance station in wet season survey. The average biomass value was ranged from the lowest at station B1 (2.2g m^{-2}) to the highest at station B6 (103.7g m^{-2}). The average size of a specimen, as determined by individual wet weight, was also very different among sites, with the highest of 151.5mg at station B3 and the lowest of 9.2mg at station B7.

8.9.2.14 The species richness (S) of dry season ranged from the lowest at station B8 (2.56) to the highest at station B5 (5.63). The Pielou's Eveness index (J') was ranged from the lowest at station B6 (0.38) to the highest at station B3 (0.92). The diversity index (H') was ranged from the highest of 1.21 at station B3 and the lowest of 0.61 at station B6. Noted that B5 and B6 were again of highest S and of lowest J' value.

8.9.2.15 Wet Season ABC plots for each station showed that the curves were indicative of unpolluted environment, except B6 and B8. The biomass curves were all above abundance curves (i.e. dominance by K-selected/conservative species) indicating stable environment. For station B6 and B8, the abundance curve was either above or overlapped with the biomass curve indicating the area was moderately to grossly polluted. The W value recorded at the 2008 wet season survey ranged between 0.012 to 0.496 suggested that the benthic assemblages of the areas were unpolluted.

8.9.2.16 Dry season ABC plots for each station showed that the curves were indicative of unpolluted environment, except B1 and B6. The abundance curves of station B1 and B6 were either above or overlapped with the biomass curve indicating the area was moderately to grossly polluted. It was noted that the B6 was, again, assessed to be moderately to grossly polluted. The W value recorded at the 2008 dry season survey ranged between 0.061 to 0.554 suggested that the benthic assemblages of the areas were unpolluted. A summary of benthic macrofauna surveys at each station is provided in **Table 8.14** below.

Table 8.14 Summary of Benthic Macrofauna Surveys at each station on October 2003

Station	Abundance (individuals m^{-2})		Biomass (wet weight, g m^{-2})		Weight per individual (mg)		Species Richness (S)		Pielou's Eveness Index (J')		Diversity Index H' (log10)		W Statistic	
	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season
B1	223	170	8.91	2.2	39.9	13.1	3.81	2.80	0.84	0.78	2.37	0.84	0.262	0.101
B2	123	477	13.72	31.4	111.2	65.8	4.99	5.04	0.88	0.72	2.59	1.02	0.496	0.198
B3	243	190	76.34	28.8	313.7	151.5	4.20	4.95	0.88	0.92	2.58	1.21	0.378	0.554
B4	177	350	19.29	43.1	109.2	123.2	5.04	4.73	0.83	0.83	2.53	1.129	0.448	0.351
B5	253	337	26.22	20.5	103.5	60.9	7.39	5.63	0.89	0.82	3.10	1.18	0.480	0.325
B6	1217	3030	36.62	103.7	30.1	34.2	5.59	5.58	0.63	0.38	2.22	0.61	0.085	0.061
B7	177	543	1.90	5.0	10.8	9.2	4.53	4.52	0.93	0.81	2.74	1.12	0.467	0.133
B8	643	167	10.22	9.0	15.9	53.9	4.37	2.56	0.66	0.81	2.08	0.84	0.012	0.273

8.9.2.17 The benthic sampling results at Tai Ho Wan and the area along the proposed alignment were consistent with the previous benthic results obtained in the North-western waters, with annelids, arthropods and molluscs being dominant. The occasional absence of echinoderm was, however, recorded. This indicates that species present at Tai Ho Wan and the area along the proposed alignment are generally similar through-out the North-western waters. In addition, infauna diversities at Tai Ho Wan and the area along the proposed alignment are similar to other area in the North-western waters and are relatively low compared to other regions in Hong Kong.

8.9.3 Intertidal Flora and Fauna

Intertidal Community

8.9.3.1 The intertidal survey was conducted during September - October 2003 (Wet Season) and November 2003 - January 2004 (Dry Season) under the HZMB project. The sampling loctions were shown in **Figure 8.4a**. A summary and raw data of the results of the intertidal surveys under the HZMB study are presented in **Table 8.15** and **Appendix F4** respectively. The results indicated that the fauna were represented by 18 species comprising marine snails (whelks, top shells, littorina), barnacles, bivalves (oysters) and crabs.

8.9.3.2 Acorn barnacle (*Balanus* sp.), *Cerithidea microptera* and *Nerita polita* were found to be dominant on the hard surface such as Rocks and pebbles at Tai Ho Wan. Common species including *Striarca symmetrica*, sand snail (*Batillaria zonalis*) and common top shell (*Monodonta labio*) were recorded. Mud snails (*Cerithidea diadjariensis*) and acorn barnacle (*Balanus* sp.) were dominant on muddy surface at Tai Ho Wan. Common species including Sand snail (*Batillaria zonalis*), Fresh Water Nerite (*Clithon* sp.) Mud Snail (*Cerithidea rhizophorarum*) and Bivalve (*Terebralia sulcata*) are recorded. None of the recorded fauna were rare and were of low conservation interest. Species abundance during both the wet and dry seasons was similar.

8.9.3.3 During TM-CLKL study, the intertidal transect surveys were conducted at Tai Ho Wan on 11 August 2008 (wet season), 25 October 2008 (transitional month), 11 February 2009 (dry season) and 23 April 2009 (transitional month). The data from intertidal survey under the TM-CLKL study are presented in **Appendix F6** and summarized in **Table 8.17.**

8.9.3.4 In the 2008 wet season survey, mud snails (*Cerithidea diadjariensis*) were found to be dominant. 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 dominant species recorded were the sand snails (*Batillaria* spp.) and mud snails (*Cerithidea diadjariensis*). The Hermit crab, *Balanus* sp., *Clithon* sp., *Nerita polita* and *Saccostrea cucullata* are common species found in Tai Ho.

8.9.3.5 In addition to the above quantitative surveys, walk-through surveys were, also, conducted in the study area to facilitate the smooth implementation of the ecological survey and to help audit the survey findings. Undertaking an initial observation along the shore, for example, can highlight the species present and their occurrence and, hence, facilitates the determination of representative sites for conducting more detailed quantitative surveys. A walk-through survey along the transect during or after a quantitative sampling event also helps assess whether the sampling exercise has collected representative data (for example, the number and type of species encountered) and whether the sampling effort is deemed adequate.

8.9.3.6 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) is lower than dry season (45 recorded) and transitional month (53 species recorded). The *Uca crassipes, Cerithidea* sp., and *Monodonta labio* are common in both the wet and dry seasons. The *Saccostrea cucullata* are common in wet season while the *Uca* spp. and Hermit crab are common in dry season. The *Batillaria* spp., *Cerithidea djadjariensis* and *Saccostrea cucullata* are abundant species in dry season. All species are common and widespread in Hong Kong. The data from these intertidal surveys are presented in **Appendix F5** and summarized in **Table 8.18**.

8.9.3.7 Intertidal surveys were undertaken along the Tuen Mun coastline between August 2008 and February 2009 under the TMWB study including the sloping and vertical seawall along the coastline as well as sandy beach habitat at Butterfly Beach. The data from these intertidal surveys are presented in **Appendix F5** and summarized in **Table 8.16**. The sampling locations are shown in **Figure 8.6**.

8.9.3.8 In the wet season, Site 1 and Site 2 were shown to have higher densities of 46 and 44 individuals per m^2, respectively. The most abundant species recorded at Sites 1 and 2 (both at Northern reclamation area) were Sea Slaters (*Ligia exotica*) which are common in Hong Kong. Sites 3 and 4 were shown to have relatively less dense intertidal populations of 28 and 3 individuals per m^2, respectively, and no intertidal fauna was recorded at all at Site 5 as it is sandy beach, namely Butterfly Beach. In addition, Bivalve *Saccostrea cucullata* was found to cover the largest area (18%, 37% and 14% respectively) of Site 2, 3 and 4 while Encrusting Algae *Hildenbrandia rubra* was found to cover the largest area (20%) of Sites 1.

8.9.3.9 In the dry season, among all the sampling sites, Site 4 had the highest density (84.8 individuals per m^2) and species diversity (15 species recorded) with the most abundant species of the Periwinkle *Echinolittorina radiate*. The Ulva Spp. and *Hildenbrandia rubra* had the highest coverage of 23% and 48% at Sites 1 and 4, while *Saccostrea cucullata* has the highest coverage of 47% and 38% at Sites 2 and 3 respectively.

8.9.3.10 The survey results of the 2003/04 HZMB, 2008/09 TMWB and recent TM-CLKL intertidal surveys revealed that all intertidal species recorded are common and characteristic of intertidal habitats throughout Hong Kong. None of the recorded fauna and flora was rare or of conservation interest.

Table 8.15 Composition and Abundance of Intertidal Biota in Tai Ho Wan During 2003/04

Common name	Species	Wet Season						Dry Season				
		Date 26-Sep-03			Date 21-Oct-03			Date 18-Nov-03		Date 07-Jan-2004		
		Transect Number										
		1	2	3	1	2	3	1	2	1	2	3
		Level										
		2 (mCD)	1 (mCD)	0.5 (mCD)	1.5 (mCD)	1 (mCD)	0.5 (mCD)	0.9 (mCD)	1.1 (mCD)	1.2 (mCD)	1.6 (mCD)	1.8 (mCD)
		Substrate										
		Rocky	Pebble	Pebble	Mudflat	Mudflat	Mudflat	Muddy	Muddy	Muddy	Muddy	Muddy
		No of Quadrat										
		10	10	10	10	10	10	10	10	10	10	10
		Abundance										
Small Shore Crab	*Hemigrapsus sanguineus*	0	14	13	0	0	0	0	0	1	2	0
Crab	*Helice tientsinensis*	0	0	0	10	5	0	0	0	0	0	0
Acorn Barnacle	*Balanus sp.*	1	50	64	26	41	0	65	13	30	70	6
Hammer Oyster	*Isognomon isognomon*	0	0	1	0	0	0	0	0	0	0	0
Rock Oyster	*Saccostrea cucullata*	0	1	0	0	7	0	0	0	0	0	0
	Striarca symmetrica	0	11	15	0	0	0	0	0	0	0	0
Bivalve	*Terebralia sulcata*	0	4	0	3	0	0	6	4	0	0	0
Sand Snail	*Batillaria zonalis*	0	19	0	6	23	14	1	4	9	18	5
Sand Snail	*Cerithidea sp.*	0	0	0	0	0	0	3	0	0	0	0
Mud Snail	*Cerithidea diadjariensis*	0	0	0	716	488	1084	106	63	788	800	1076
Mud Snail	*Cerithidea microptera*	0	38	54	0	7	0	7	3	0	0	0
Littorinid	*Littoraria articulata*	1	0	0	0	0	0	0	0	0	0	0
Common Top Shell	*Monodonta labio*	1	25	0	0	0	0	0	0	0	0	0
Nerite	*Dostia violacea*	0	0	0	0	0	0	0	1	0	0	0
Nerite	*Nerita polita*	0	26	76	0	0	0	1	0	0	0	0
Common Whelk	*Thais clavigera*	0	0	2	0	0	0	0	0	0	0	0
Fresh Water Nerites	*Clithon sp.*	0	0	0	0	1	24	0	0	79	2	2
Scavenging Snail	*Nassarius sp.*	0	0	0	0	0	1	0	0	0	0	0
Total Abundance		**3**	**188**	**225**	**761**	**572**	**1123**	**189**	**88**	**907**	**892**	**1089**
Taxa		**3**	**9**	**7**	**5**	**7**	**4**	**7**	**6**	**5**	**5**	**4**
Average Density (individuals /m^2)		**1.2**	**75.2**	**90**	**304.4**	**228.8**	**449.2**	**75.6**	**35.2**	**362.8**	**356.8**	**435.6**

Table 8.16 Composition and Abundance of Intertidal Flora and Fauna in Tuen Mun during 2008/09

Species	Wet Season				Dry Season			
	Date 30-Sep-08				Date 11-Feb-09			
	Site 1	Site 2	Site 3	Site 4	Site 1	Site 2	Site 3	Site 4
	Substrate							
	Sloping Large Boulder Seawall	Vertical Seawall	Vertical Seawall	Sloping Large Boulder Seawall	Sloping Large Boulder Seawall	Vertical Seawall	Vertical Seawall	Sloping Large Boulder Seawall
	No. of Quadrat							
	4	3	3	4	4	3	3	5
	Abundance							
Echinolittorina radiata	0	0	0	0	0	0	0	80
Littoraria articulata	4	0	0	0	0	0	0	3
Echinolittorina vidua	0	0	0	0	0	0	0	3
Monodonta labio	17	0	0	0	0	0	0	6
Planaxis sulcatus	2	0	0	0	4	0	0	0
Thais clavigera	0	4	7	0	1	7	9	4
Morula musiva	0	0	2	3	0	0	0	0
Cellana toreuma	0	0	0	0	10	0	2	1
Nipponacmea concinna	0	0	0	0	0	0	16	8
Patelloida pygmaea	0	0	1	0	0	8	5	1
Siphonaria japonica	0	0	0	0	0	0	2	0
*Perna viridis**	0%	0%	0%	0%	0%	0.33%	0%	0%
*Saccostrea cucullata**	10%	18.33%	36.67%	13.75%	0%	46.67%	38.33%	6%
*Capitulum mitella**	0%	0.33%	0.67%	0%	0%	3.33%	0.33%	0.20%
*Balanus amphitrite**	0%	0%	6.67%	0%	0%	0%	0%	0.20%
*Tetraclita japonica**	0%	0%	0.33%	7.50%	5.25%	0%	0%	0%
Ralfsia expansa	0%	0%	0%	0%	0%	0%	3.33%	0%
*Hildenbrandia rubra**	20%	0%	0%	0%	0%	0%	0%	38%
*Hildenbrandia occidentalis**	0%	0%	0%	2.50%	3.75%	0%	0%	0%
*Pseudulvella applanata**	0%	0%	0%	10%	0%	0%	0%	6%
*Ulva spp.**	0%	3.33%	0%	0%	22.5%	0%	0%	0%
*Porphyra suborbiculata**	0%	0%	0%	0%	17.5%	0%	0%	2%
Haliplanella lineata	0	0	1	0	0	2	1	0
Hemigrapsus sanguineus	0	3	10	0	0	0	0	2
Ligia exotica	23	26	0	0	0	0	2	0
Total Abundance*	**46**	**33**	**21**	**3**	**15**	**15**	**34**	**106**
Taxa	**6**	**6**	**9**	**5**	**7**	**6**	**10**	**5**
Average Density (individuals /m^2)	**46**	**44**	**28**	**3**	**15**	**20**	**45.3**	**84.8**

Note: * Species which was expressed as average percentage cover was not included in calculation.

Table 8.17 Composition and Abundance of Intertidal Biota in Tai Ho Wan During 2008/09

Species	Wet Season					Dry Season					
	Date 11-Aug-08		Date 25-Oct-08			Date 11-Feb-09			Date 23-Apr-09		
	Transect										
	1	2	1	2	3	1	2	3	1	2	3
	-	-	1.5 (mCD)	1.0 (mCD)	0.7 (mCD)	1.5 (mCD)	1.0 (mCD)	0.7 (mCD)	1.5 (mCD)	1 (mCD)	0.7 (mCD)
	No of Quadrat										
	7	7	10	10	10	10	10	10	10	10	10
	Abundance										
Crustacea											
Balanus sp.	11	9	5	5	1	2	17	15	9	18	8
Capitulum mitella	2	5	0	0	0	0	0	0	0	0	0
Sesarma bidens	1	1	0	0	0	0	0	0	0	0	0
Siphonaria spp.	0	3	0	0	0	0	0	0	0	0	0
uca spp.	0	0	0	0	0	0	0	0	29	18	0
Uca crassipes	1	1	0	0	0	0	0	0	0	0	0
Hermit crab	4	8	0	0	0	16	9	14	20	22	6
Hemigrapsus sanguineus	0	0	0	0	0	0	0	0	1	0	0
Helice sp.	0	0	0	0	0	1	0	0	2	1	0
Mollusk											
Batillaria zonalis	0	0	0	0	0	4	1	5	83	41	16
Batillaria spp.	4	4	13	3	6	840	145	132	1,179	397	184
Cerithidea djadjariensis	74	43	10	30	35	186	231	66	121	205	86
Cerithidea microptera	0	0	0	0	0	4	0	1	4	0	1
Cerithidea rhizophorarum	0	0	0	0	0	2	0	1	2	0	0
Cerithidea sp.	0	0	0	0	0	0	0	0	0	0	0
Clithon sp.	3	3	5	0	3	2	1	2	7	5	0
Littoraria articulata	5	1	0	0	0	0	0	0	2	0	0
Monodonta labio	2	3	0	0	0	1	1	0	1	3	0
Nerita lineata	1	1	0	0	0	0	0	0	0	0	0
Nerita polita	8	7	0	0	0	1	1	1	3	7	4
Saccostrea cucullata	2.43%*	2.43%*	2	3	1	1	1	2	22	23	14
Terebralia sulcata	0	0	3	4	0	9	0	0	5	0	0
Nassarius sp.	0	0	0	0	0	0	0	0	1	0	0
Sipuncula											
Sipunculus nudus	1	0	0	0	0	0	0	0	0	0	0
Total Abundance*	**117**	**89**	**33**	**38**	**45**	**1,068**	**406**	**237**	**1491**	**740**	**319**
Taxa	**13**	**14**	**6**	**5**	**5**	**13**	**9**	**10**	**17**	**11**	**8**
Average Density (individuals /m^2)	**66.86**	**50.86**	**13.20**	**15.20**	**18.00**	**427.20**	**162.40**	**94.80**	**596.40**	**296.00**	**127.60**

Note: * Species which was expressed as average percentage cover was not included in calculation.

Table 8.18 Species Recorded during 2008/09 Qualitative Intertidal Survey

Species	Survey Date		
	11 Aug 2008	11 Feb 2009	22 Apr 2009
	Ocurrance		
Crustacea			
Helice sp.		+	+
Hemigrapsus sanguineus		+	+
Alpheus spp.		+	+
Balanus reticulatus	+	+	+
Balanus sp.	+	+	+
Capitulum mitella	+	+	+
Clibanarius spp.		+	+
Hermit crab	+	++	++
Ligia exotica	+	+	+
Scylla serrata	+	+	
Sesarma bidens	+	+	+
Sesarma spp.		+	+
Tetraclita sp.			+
Uca crassipes	++	++	++
Uca spp.		++	++
Mollusk			
Batillaria spp.	+	+++	+++
Batillaria zonalis		+	+
Brachidontes sp.		+	
Cellana testudinaria		+	+
Cellana sp.		+	
Cerithidea djadjariensis		+++	+++
Cerithidea microptera		+	+
Cerithidea rhizophorarum		+	+
Cerithidea sp.	++	++	++
Chlorostoma argyrostoma			+
Clithon oualaniensis		+	+
Clithon sp.	+	+	+
Clypeomorus monififerum		+	+
Echinolittorina spp.			++
Ellobium chinensis		+	+
Fulvia sp.		+	
Geloina erosa		+	+
Isognomon isognomum			+
Littoraria articulata	+	+	+
Littoraria melanostoma		+	+
Littoraria sp.		+	+
Lunella coronata granulata		+	+
Monodonta labio	++	+	++
Nassarius sp.		+	+
Nerita albicilla			+
Nerita lineata	+	+	+
Nerita polita	+	+	+
Nerita sp.		+	+
Nodilittorina spp.			+
Patelloida saccharina			+
Perna viridis			+
Planaxis sulcatus		+	+
Saccostrea cucullata	++	+++	+++
Saccostrea sp.			+

Species	Survey Date		
	11 Aug 2008	11 Feb 2009	22 Apr 2009
	Ocurrance		
Septifer sp.			+
Serpulorbis inbricatus			+
Siphonaria spp.	+	+	+
Terebralia sulcata			
Thais clavigera			+
Trapezium liratum		+	+
Turbo articulatus		+	+
Sipuncula			
Sipunculus nudus	+	+	+
Fish			
Periophthalmus cantonensis		+	+
Number of Species	**18**	**45**	**53**

Note: + few; ++ common; +++ abundant

<u>Mangroves</u>

8.9.3.11 The previous HZMB field surveys for mangroves were conducted between September 2003 and May 2004, with major stands being found at Tai Ho Wan and San Tau to Tung Chung Bay. The raw data of the field surveys under the project are presented in **Appendix E20**.

San Tau Mangrove Habitats

8.9.3.12 The mangrove habitat at San Tau is considered to be of particular ecological importance and this habitat is dominated by the mangroves *Aeigceras corniculatum*, *Kandelia candel* and the restricted *Bruguiera gymnorrhiza*. Other mangroves *Avicennia marina* and *Acanthus ilicifolius* are also well represented. Apart from the restricted mangrove species *Bruguiera gymnorrhiza*, some locally restricted species were also recorded in the vicinity of the habitats and these included *Thespesia populnea*, *Stenoloma biflorum* and *Ipomoea imperati*.

Tai Ho Mangrove Habitats

8.9.3.13 The number of floral species recorded in Tai Ho was fairly high. There were six true mangrove species including *Lumnitzera racemosa*, *Kandelia candel*, *Bruguiera gymnorrhiza*, *Avicennia marina*, *Aegiceras corniculatum* and *Acanthus ilicifolius*. In addition to these true mangrove species, a number of mangal associated flora, such as *Limonium sinense*, *Clerodendrum inerme* and *Acrostichum aureum* were also recorded within the mangrove habitat. Other common species recorded within the coastal or mangrove communities included *Zoysia sinica*, *Suaeda maritime* and *Vitex rotundifolia*.

8.9.3.14 Recent field surveys in Tai Ho and Pak Mong of North Lantau have also been conducted during 2008-2009 under the TM-CLKL study. The raw data of the surveys are presented in **Appendix E22**.

8.9.3.15 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.

There were four true mangrove species including Kandelia (*Kandelia candel*), Many-petaled Mangrove (*Bruguiera gymnorrhiza*), River Mangrove (*Aegiceras corniculatum*) and Spiny Bears Breech *(Acanthus ilicifolius).* It should be noted that beside the four recorded species, true mangrove species Lumnitzera (*Lumnitzera racemosa)* and Black Mangrove *(Avicennia marina)* were also surveyed during 2003/04. In addition to these true mangrove species, mangal associated flora such as *Acrostichum aureum* and *Thespesia populnea* was also recorded within the mangrove habitat.

8.9.3.16 Among the true mangrove species recorded, Many-petaled Mangrove (*Bruguiera gymnorrhiza*) is considered to have a restricted distribution in Hong Kong (Xing *et al.*, 2000). This species has established a relatively large population in Tai Ho and it is known to adapt to hardened and stiff mud.

Seagrass

San Tau Seagrass Bed

8.9.3.17 The HZMB field surveys for seagrass beds were undertaken during 2003-2004. The results confirmed that two seagrass beds were present in the Study Area. The seagrass bed at Tung Chung Bay, where the San Tau Beach SSSI is located, were found to support two seagrass species, *Halophila ovalis* and *Zostera japonica* which are of ecological importance. During the April 2004 survey, the seagrass *Halophila beccarii* habitat was found during the low tide at Tai Ho Wan, supporting more than 20 colonies within a size of about 30cm×30 cm. It should be noted that the seagrass bed at San Tau has been subject to impacts associated with the reclamation works for the airport at Chek Lap Kok (HKU, 1998). The seagrass has, however, successfully recovered since the works were completed.

8.9.3.18 During the 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 $0.1m^2$ to $16m^2$. It is noted that the number of patches and patch sizes increased during the survey. Three patches of *Halophila minor* with size of $0.2m^2$ to $1.5m^2$ were recorded in January 2009 and found in association with the *Zostera japonica* patches.

8.9.3.19 The seagrass species *Zostera japonica* and *Halophila ovalis* are considered rare locally (Xing *et al.*, 2000). *Zostera japonica* has been recorded in Lai Chi Wo, San Tau, Sheung Sze Wan, Siu Tan and So Lo Pun (AFCD, 2005). Another locally restricted seagrass species, *Halophila ovalis,* is considered to be of special scientific interest because it is one of the few marine flowering plants in Hong Kong (AFCD, 2003). Apart from San Tau, *Haplophila ovalis* has been previously recorded in Ham Tin, Ho Chung, Hoi Ha, Kai Kuk Shue Ha, Nam Chung Yeung Uk, Nim Shue Wan, Sheung Pak Nai, Sheung Sze Wan, Siu Tan, To Kwa Peng, Tsam Chuk Wan and Yam O (AFCD, 2005). *Zostera japonica* and *Halophila ovalis* are usually found co-habiting the seaward margins of mangrove stands (AFCD, 2003). Yip & Lai (2006) reported *Halophila minor* as a new record of *Halophila* species in Hong Kong, in addition to the two known species *H. ovalis* and *H. beccarii*. It also represents the first locality of the species in continental China besides the reported sightings in Hainan and Nansha Islands. This species was previously unknown in Hong Kong although the examination of herbarium specimen deposits indicate their presence in early times. This species was recently discovered at To Kwa Peng, Sai Kung by staff of AFCD (Kowk et al, 2005) in 2005 and was later recorded in Ho Chung, Tsam Chuk Wan and Siu Tan.

Tai Ho Seagrass Bed

8.9.3.20 The HZMB field surveys for seagrass beds, undertaken during 2003-2004, also surveyed the seagrass bed at Tai Ho. The seagrass *Halophila beccarii* is also locally rare (Xing *et al*., 2000) and was previously found at Tai Ho Wan (Mott, 1998; Mouchel, 2000). This species have been recorded in Nam Chung Yeung Uk, Sha Kong Tsuen and Sheung Pak Nai (AFCD, 2005).

8.9.3.21 The TM-CLKL field surveys for seagrass beds were undertaken concurrently with the intertidal surveys during 2008-2009. However, no seagrass was observed in San Tau on 30 July 2008 and at Tai Ho Wan on 30 July, 11 August 2008 and 11 February 2009. The data are presented in **Appendix F6**.

Horseshoe Crabs and Mudflat

8.9.3.22 The HZMB horseshoe crab survey was undertaken during 2003 and 2004. The raw data for the horseshoe crab surveys under the HZMB study are presented in **Appendix F9**.

8.9.3.23 Ten *Tachypleus tridentatus* and one *Carcinoscorpius rotundicauda* were recorded at San Tau mudflat in November 2003. During a survey in May 2004, twenty-six individuals of this species were also recorded between Tung Chung and San Tau. In addition, fourteen live and three molts of *Carcinoscorpius rotundicauda* were recorded at Tai Ho Wan. Survey results showed that the areas of importance for the horseshoe crab include mudflat at San Tau, Tung Chung Bay and Tai Ho Wan.

8.9.3.24 During the 2008-09 TM-CLKL survey, two *Tachypleus tridentatus* and three *Carcinoscorpius rotundicauda* were recorded at San Tau in July 2008. In addition, two *Carcinoscorpius rotundicauda* were recorded at Tung Chung Bay. No horseshoe crabs or trails were found at Pak Mong on 30 July 2008 and Tai Ho Wan on 30 July, 11 August 2008 and 11 February 2009. The raw data for the horseshoe crab surveys under the TM-CLKL study are presented in **Appendix F10**.

8.9.3.25 The results of the present surveys together with historical records of the horseshoe crabs in the vicinity of the study area are summarised below in **Table 8.19**

Table 8.19 Horseshoe Crab Sightings and Landings in the Study Area between June 2003 and February 2009

Location	Species (Gender / life stage)	Date	Number of Individuals
Nim Wan	Unknown (juveniles)	May, 1995	8
Tuen Mun	*Tachypleus tridentatus* (adult, dead)	Jun, 1995	1
The Brothers	Unknown (juvenile)	Apr, 1995	1
	Tachypleus gigas	Jun, 1996	5
	Tachypleus sp.	May, 2001	1
San Tau	Unknown	May, 1995	~ 13
	Tachypleus tridentatus and *Carcinoscorpius rotundicauda* (juveniles)	Oct, 1997 – Jun, 1998	~ 15
	Tachypleus tridentatus (5 males, 6 females)	Apr, 1997	11
	Tachypleus tridentatus (juveniles)	Jun, 2002	57
	Carcinoscorpius rotundicauda (juvenile)	Nov, 2003	1
	Tachypleus tridentatus (juveniles)	Nov, 2003	10
	Tachypleus tridentatus	May, 2004	11
	Carcinoscorpius rotundicauda	Jul, 2008	3
	Tachypleus tridentatus	Jul, 2008	2
Tung Chung Wan	*Tachypleus tridentatus* (18 males, 14 females)	Apr, 1997 – Oct, 1997	32
	Carcinoscorpius rotundicauda	Apr, 1997	1
	Carcinoscorpius rotundicauda (juveniles)	Jun, 2002	2
	Tachypleus tridentatus	May, 2004	15
	Tachypleus tridentatus (13 males, 8 females)	Oct, 1997	21
	Carcinoscorpius rotundicauda	Jul, 2008	2
Tai Ho Wan	Unknown (juvenile)	Sep, 1998	1
	Carcinoscorpius rotundicauda	Jun, 1999	10
	Tachypleus tridentatus (juveniles)	Jun, 1999	2
	Carcinoscorpius rotundicauda (juveniles)	Dec, 2003	20
	Carcinoscorpius rotundicauda	May, 2004	14 and 3 molts

Note: Although *Tachypleus gigas* has been reported in the wider study area, it may have been misidentified as Chiu and Morton (1999) only recorded the similar *Tachypleus tridentatus* during extensive surveys of the North-western waters. Adapted from ERM (1997), Chiu and Morton (1999); Fong (1999); Huang (1997); Mott Connell Ltd (2003); Mouchel (2002a; 2004; 2005b).

8.9.4 Corals and Other Subtidal Macrobenthos

Corals

8.9.4.1 A coral survey under the HZMB project was conducted along the coastline of East Chek Lap Kok Channel and East Tung Chung on 15 October 2003. The locations of stations surveyed are shown in **Figure 8.4b**. The findings are, also, summarised in **Table 8.20** below and the detailed coral survey report is included in **Appendix F11**.

8.9.4.2 In Sham Wat/San Shek Wan, ten spot dives (S1-10) were conducted and only one hard ahermatypic coral, *Balanophyllia spp.*, and one soft coral *Echinomuricea spp.*, were found on hard substrate. However, the abundance and overall percentage cover of the coral was low (<5%).

8.9.4.3 At the West of Chek Lap Kok where eight dives were conducted (S11-18) and at the East of Chek Lap Kok where four dives were conducted (S19-22), no hard or soft corals were found.

8.9.4.4 At East of Tung Chung, four spot dives (S23-27) were conducted with only one soft coral *Echinomuricea spp*. being recorded. The soft coral was patchily distributed and the overall percentage cover of the coral was low (<5%). A summary of the species noted in these surveys is provided in **Table 8.20** below.

8.9.4.5 Generally, ubiquitous taxa were the green mussel *Perna viridis*, barnacles and oysters at North Lantau. Despite the presence of the ahermatypic cup coral, *Balanophyllia spp*. and the gorgonian soft coral, *Echinomuricea spp*. in certain areas, abundance of these corals were low (cover <5%) and, in particular, the *Echinomuricea spp*. had suffered high levels of partial mortality. Results of these coral surveys indicated that the few corals present were of low abundance and in poor condition and, therefore, of low ecological importance (which is typical of the North-western waters). As such, higher tier assessments nor further coral surveys were considered necessary.

8.9.4.6 Spot dive surveys under the TM-CLKL project were conducted on 6 March 2009. The locations of the spot dive stations surveyed are shown in **Figure 8.5b**. Stations C1-2 and C6-7 are located at the northern landfall and the southern landing point of the marine viaduct of TM-CLKL, respectively, while Stations C3-5 are located around the Tai Mo To. Stations B1-8 are located along the proposed alignment. In addition to these TM-CLKL alignment specific dives, further dives were conducted in the general study area where corals would be expected. Stations C01-C08 are located all around the Tai Mo To islands while Stations E1-10 are located at the area around the proposed southern landing of the TM-CLKL marine viaduct. The findings are summarised in **Table 8.21** below and **Figure 8.9.** The detailed coral survey report is included in **Appendix F12**.

8.9.4.7 At station C1, populations of the gorgonian (cf. *Guaiagorgia* sp.) (~1 colony per $2m^2$) and the ahermatypic coral *Paracyathus rotundatus* (~5 colonies per $1m^2$) were recorded on exposed surfaces of the vertical and sloping seawalls. At stations C2 and C3, no hard or soft corals were found on soft mud seabed. At station C4, gorgonian (cf. *Guaiagorgia* sp.) was recorded but in substantially lower populations levels (~1 colony per $20m^2$). At station C5, a reasonable population of the gorgonian (cf. *Guaiagorgia* sp.) (~1 colony per $2m^2$) was recorded and the ahermatypic coral *Paracyathus rotundatus* was also present in reasonable numbers (~1 colony per $1m^2$). At stations C6 and C7, there were populations of the gorgonian (cf. *Guaiagorgia* sp.) (~1 colony per $2m^2$) and the ahermatypic coral *Paracyathus rotundatus* (~1 colony per $1m^2$) found along the rock wall.

8.9.4.8 Surveys at the other stations revealed the following results. The findings are also summarised in **Table 8.21** below.

- at Station C01, a reasonable population of the gorgonian (cf. *Guaiagorgia* sp.) (~1 colony per $2m^2$) was recorded and the ahermatypic coral *Paracyathus rotundatus* was, also, present in reasonable numbers (~1 colony per $1m^2$);

- at Station C02, a dense population of the gorgonian (cf. *Guaiagorgia* sp.) (~1 colony per $2m^2$) were recorded and the ahermatypic coral *Paracyathus rotundatus* was, also, present in reasonable numbers (~1 colony per $1m^2$);
- at Station C03, the highest coverage of the gorgonian (cf. *Guaiagorgia* sp.) (~3 colonies per $1m^2$) was surveyed among the areas investigated. There was also a correspondingly high population of the ahermatypic coral *Paracyathus rotundatus* (~2 colonies per $1m^2$);
- at Station C04, the gorgonian (cf. *Guaiagorgia* sp.) was recorded (~1 colony per $100m^2$) but not the ahermatypic coral *Paracyathus rotundatus*. Colonies were smaller than other areas with most being less than 15cm;
- at Station C05, very low number of the gorgonian (cf. *Guaiagorgia* sp.) was recorded (~1 colony per $100m^2$). Colonies were smaller than other areas with most being less than 15cm. The ahermatypic coral *Paracyathus rotundatus* was also not recorded on this dive;
- at Station C06, a more dense population of the gorgonian (cf. *Guaiagorgia* sp.) (~1 colony per $4m^2$) than the previous two stations (C04 & C05) was recorded. The ahermatypic coral *Paracyathus rotundatus* was recorded in densities of (~1 colony per $5m^2$);
- at Station C07, the area recorded a reasonable population of the gorgonian (cf. *Guaiagorgia* sp.) (~1 colony per $5m^2$) and the ahermatypic coral *Paracyathus rotundatus* was also present in reasonable numbers (~1 colony per $5m^2$);
- at Station C08, a dense population of the gorgonian (cf. *Guaiagorgia* sp.) (~1 colony per $2m^2$) was recorded and the ahermatypic coral *Paracyathus rotundatus* was, also, present in reasonable numbers (~1colony per $1m^2$); and
- there were no corals recorded at Stations B1-4, B8 and E1-10 while Stations B5-7 were not dived for safety reasons.

8.9.4.9 There was only one species of hard coral recorded: the ahermatypic coral *Paracyathus rotundatus*. It seems to have a slightly wider distribution in that it has been recorded all around Lantau Island. It is usually associated with the gorgonian species such as *Echinomuricea* sp. and/or *Guaiagorgia* sp.

Table 8.20 Coral Survey Results for 2003

Station	Depth (m)	Hard Coral* Recorded	Soft Coral* Recorded	Coral Coverage (%)
S01	1.1-3.1	Y	Y	<5
S02	1-3.4	Y	Y	<5
S03	0.9-3.2	Y	Y	<5
S04	1-4.6	Y	Y	<5
S05	1.1-3.2	Y	Y	<5
S06	1.2-3.4	N	Y	<1
S07	0.8-3.6	Y	Y	<1
S08	0.4-3.8	Y	Y	<1
S09	1.1-4.2	Y	Y	<1
S10	0.9-3.1	N	Y	<1
S11	0.8-3.1	N	N	0
S12	0.8-2.9	N	N	0
S13	1-2.4	N	N	0
S14	1.2-5.6	N	N	0
S15	1-3.1	N	N	0
S16	0.9-3.4	N	N	0
S17	0.8-5.8	N	N	0
S18	0.6-3.2	N	N	0
S19	0.8-5.2	N	N	0
S20	0.9-5.6	N	N	0
S21	0.6-5.8	N	N	0
S22	0.7-6.1	Y	Y	<5
S23	0.9-5.4	N	Y	<1
S24	0.6-6.2	N	Y	<1
S25	0.4-4.2	N	Y	<1
S26	0.9-6.1	N	Y	<1
S27	1.1-6.8	N	Y	<1

Note: Y = Coral Recorded; N = No Coral Recorded. *Soft Coral referred to in the table is gorgonian Echinomuricea spp. and the hard coral is Balanophyllia spp.

Table 8.21 Coral Survey Results for 2009

Station	Depth (m)	Hard Coral* Recorded	Octocoral* Recorded	Remark
C1	1.8-3.6	~5 colonies per m^2	~1 colonies per 2 m^2	-
C2	12.5	None	None	-
C3	5.9	None	None	-
C4	2.0	None	~1 colonies per 20 m^2	-
C5	1.8-3.6	~1 colonies per m^2	~1 colonies per $2m^2$	-
C6	1.8-3.6	~1 colonies per $2m^2$	~1 colonies per $2m^2$	-
C7	1.8-3.6	~1 colonies per m^2	~1 colonies per $2m^2$	-
C01	1.8-4.0	~1 colonies per m^2	~1 colonies per $2m^2$	-
C02	1.8-4.0	~1 colonies per m^2	~1 colonies per $2m^2$	-
C03	1.8-4.0	~2 colonies per m^2	~3 colonies per m^2	-
C04	1.8-2.0	None	~1 colonies per $100m^2$	-
C05	1.8-2.0	None	~1 colonies per $100m^2$	-
C06	1.8-4.0	~1 colonies per $5m^2$	~1 colonies per $4m^2$	-
C07	1.8-4.0	~1 colonies per $5m^2$	~1 colonies per $5m^2$	-
C08	1.8-4.0	~1 colonies per m^2	~1 colonies per $2m^2$	-
B1	4.2	None	None	-
B2	4.3	None	None	-
B3	4.5	None	None	-
B4	4.5	None	None	-
B5	-	-	-	Not dived for safety reasons
B6	-	-	-	Not dived for safety reasons
B7	-	-	-	Not dived for safety reasons
B8	12.1	None	None	-
E1	3.9	None	None	-
E2	3.8	None	None	-
E3	3.9	None	None	-
E4	4.0	None	None	-
E5	4.2	None	None	-
E6	3.9	None	None	-
E7	4.5	None	None	-
E8	4.5	None	None	-
E9	4.4	None	None	-
E10	4.5	None	None	-

Note: **-** = n/a. *Octocoral referred to in the table is the gorgonian (cf. *Guaiagorgia* sp.) and the hard coral is *Paracyathus rotundatus*.

8.9.4.10 Four Rapid Ecological Assessment (REA) Surveys were carried out following the TM-CLKL spot dive surveys, one at the Northern Landing Point (REA 1), one at the Southern Landing Point (REA 4) and two around Tai Mo To Island (REA 2 and REA 3) (**Figure 8.5b**). Based on the spot dive records of coral populations at both landing points, REA 1 and 4 were carried out. Due to the fact that REA 3 is deemed to be typical of the whole island and REA 2 had the highest recorded density of the gorgonian (cf. *Guaiagorgia* sp.) coral colonies, REA Survey at these stations around Tai Mo To Island were also conducted. A summary of the Tier I and Tier II results are presented in **Tables 8.22-8.23** below and the detailed coral survey report is included in **Appendix F12**.

8.9.4.11 Both landing points had a similar population of the gorgonian (cf. *Guaiagorgia* sp.) with the northern landing colonies being in a slightly better condition (~10% partial mortality) than those at the southern area (~20% partial mortality). The populations of the gorgonian (cf. *Guaiagorgia* sp.) recorded at REA 3 (a typical area at Tai Mo To Island) were approximately the same as both landing areas (REA 1 and REA 4) while the highest populations were recorded at REA 2. All four REA (REA 1-4) had a lower recorded population of ahermatypic coral *Paracyathus rotundatus*.

Table 8.22 Summary of the Tier I Coral Survey Results

Parameter / Station	REA 1 Northern Landfall	REA 2 Tai Mo To North	REA 3 Tai Mo To East	REA 4 Southern Viaduct Landing Point
Average Depth (m)	2.15	1.95	2.2	2.4
Exposure (1~4)	1	4	2	3
Sediment (0~3)	1	1	2	2
% cover soft corals (live)	<10	<30	<10	<10
% cover hard corals (live)	<5	<5	<5	<5
Hard Substrate (% of total)	100	60	40	100
Bed rock (% of HS)	50	10	0	0
Large boulders (% of HS)	50	90	100	100
Soft Substrate (% of total)	0	0	0	0
Sand (% of SS)	0	0	0	0
Silt/mud (% of SS)	0	0	0	0
Mud (% of SS)	0	0	0	0
Slope (flat = 0, vertical = 4)	4	0	0	2
Visibility (m)	2	3	3	2
Salinity (ppt)	32	31	31	29
Temp (°C)	20	22	22	21

Table 8.23 Summary of the Tier II Coral Survey Results

Taxa / Station	REA 1 Northern Landfall	REA 2 Tai Mo To North	REA 3 Tai Mo To East	REA 4 Southern Viaduct Landing Point
Bryazoa				
Brown/orange encrusting	1	2	1	1
Red encrusting	1	1	1	0
Bugula sp.	1	2	1	2
Actiniaria (sea anemonies)				
Anthopleura dixoniana	1	0	0	0
Anemone	0	0	0	0
Sand anemone	0	0	1	0
Gorgonacea				
Guaiagorgia sp.	4	5	4	4
Scleractinia				
Paracyathus rotundatus	4	4	3	3
Molusca				
Phenacovolva brevitostris	2	1	1	1
Perna viridis	3	3	2	2
Oysters small	1	1	0	2
Oysters large	0	2	2	0

Taxa / Station	REA 1	REA 2	REA 3	REA 4
	Northern Landfall	Tai Mo To North	Tai Mo To East	Southern Viaduct Landing Point
Porifere (sponge)				
Orange encrusting	1	1	1	1
Encrusting	1	1	1	1
Golf ball	0	0	0	0
Crustacea				
Cirripedea	2	2	2	2
Echinodermata				
Diadema setosum	1	1	1	1
Parasalenia gratiosa	0	0	0	0
Echinothrix calamaris	0	1	1	0
Holothuria leucospilota	0	1	1	0
Misc.				
Coralline algae	3	2	1	2
Cyanobacteria l mats	1	1	1	1
Tunicata	0	1	0	1

Other Subtidal Macrobenthos

8.9.4.12 During HZMB survey, the most ubiquitous taxa were the green mussel *Perna viridis*, barnacles and oysters recorded in Sham Wat/San Shek Wan (S1-10), at the West (S11-18) and East (S19-22) of Chek Lap Kok and at East of Tung Chung (S23-27) and they are common and widespread in Hong Kong.

8.9.4.13 During TM-CLKL spot dive survey, other organisms recorded were common in Hong Kong, with sponges, branacles, oysters, coralline algae especially *Schzoporella errata* being recorded in nearly all areas with corals.

8.9.4.14 In TM-CLKL REA survey, other sessile organisms consisted of coralline algae, mainly *Schizoporella errata*, and similar unidentified red algae, Bivalve *Perna viridis* and sponges were also sighted in these areas (**Table 8.23**). No species of conservation importance were recorded in the survey sites.

8.10 Impact Assessment Methodology

8.10.1 Species Evaluation

8.10.1.1 The marine species of conservation interest recorded within the potential impacted areas comprise the Chinese White Dolphin, corals, horseshoe crab and seagrass. The evaluation of ecological values of these species has been undertaken in accordance with EIAO Annex 8, Table 3 and are presented in **Table 8.24**.

8.10.1.2 The northern and western waters of Lantau are considered as one of the major sighting habitats for Chinese White Dolphins (Jefferson 2005 and Hung 2006), with calves observed near the Sha Chau and Lung Kwu Chau Marine Park. Combined with on-effort CWD sightings from 2005-09 AFCD monitoring surveys with the present TM-CLKL study, distribution patterns showed that CWD groups were frequently sighted in the central region of North Lantau waters, with concentrations of sightings occurred at the northeast corner of Chek Lap Kok Airport Island, the waters between and around the Brothers, waters around the Sha Chau and Lung Kwu Chau Marine Park, and near Sham Shui Kok.

8.10.1.3 The scattered coral colonies of Gorgonacea and Scleratinia associated with the hard substratum were recorded in the areas surveyed. Stony corals (in order Scleractinia) are protected under Protection of Endangered Species of Animals and Plants Ordinance (Cap. 586).

8.10.1.4 The Horseshoe crab is not a protected species in Hong Kong, but is locally rare and of conservation interest. Juvenile and adults horseshoe crabs were recorded in North-western WCZ such as Sham Wat Wan, San Tau, Hak Hok Wan, Tung Chung Wan and Tai Ho Wan.

8.10.1.5 Seagrass is, also, not a protected species in Hong Kong, but is locally rare and of conservation interest. Seagrass was recorded in the North-western WCZ with *Halophila ovalis*, *Halophila minor* and *Zostera japonica* recorded in San Tau mudflat, and *Halophila beccarii* recorded in Tai Ho Wan.

8.10.1.6 The Indo-Pacific Tropical Sand Goby *Favonigobius reichei*, Walking Goby *Scartelaos histophorus*, Flat-headed Goby *Luciogobius guttatus*, Snowy Puffer *Takifugu niphobles*, Predaceous Chub *Parazacco spilurus*, Sea Cucumber *Holothuria leucospilota* and Greasyback Shrimp *Metapenaeus ensis* were recored at soft shores along North Lantau and of conservation interest or potential conservation interest.

Table 8.24 Ecological Value of Marine Species within North-western WCZ

Species	Protection Status	Distribution	Rarity
Chinese White Dolphin	Protected under local regulation (Cap. 170 and Cap. 586). CWD is listed in CITES Appendix 1 and protected in the People Republic of China.	Local population mainly distributed in estuarine habitat in Pearl River Delta and North-western WCZ within the Study Area.	Some 103-193 individuals inhabit Hong Kong waters at various time of the year.
Corals	Stony corals (in order Scleractinia) are protected under local regulation (Cap. 586). All corals in Marine Parks are protected under Marine Park Ordinance (Cap. 476).	Solitary corals were recorded from the region around the Sha Chau and Lung Kwu Chau Marine Park and further to the east at Sham Tseng and Tsing Lung Tau.	The hard coral species recorded in the North-western waters are generally common in local waters.
Horseshoe Crab	No statutory protection status in Hong Kong and Mainland China.	Local population mainly distributed in estuarine habitat mainly in Deep Bay WCZ and North-western WCZ within the Study Area. Two, *Tachypleus tridentatus* and *Carcinoscorpius rotundicauda*, have been recorded within the Study Area.	Relatively local rare species of a taxonomically distinct and ancient class.

Species	Protection Status	Distribution	Rarity
Halophila minor	No statutory protection status in Hong Kong and Mainland China.	Seagrass beds were recorded in San Tau. Other recent records include To Kwa Peng, Ho Chung, Tsam Chuk Wan and Siu Tan.	Locally rare
Halophila beccarii	No statutory protection status in Hong Kong and Mainland China.	Seagrass beds were recorded in Ngau Hom Shek, Sha Kwong Tsuen, Sheung Pak Nai and Nam Chung Yeung UK and Tai Ho Wan. Only Tai Ho Wan within North-western WCZ supports this seagrass beds.	Locally rare
Halophila ovalis	No statutory protection status in Hong Kong and Mainland China.	Seagrass beds were recorded in eastern waters in Hong Kong (AFCD, 2005) including Hoi Ha, Ham Tin and also distributed in eastern waters such as Sheung Pak Nai, San Tau, Yam O and Nim Yue Wan. Only San Tau and Yam O within North-western WCZ supports this seagrass beds.	Locally rare
Zostera japonica	No statutory protection status in Hong Kong and Mainland China.	Seagrass beds were recorded in Lam Chung Yeung Uk, San Tau, Sheung Pak Nai, Sha Kwong Tsuen, and San Tau. Only San Tau within North-western WCZ supports this seagrass beds.	Locally rare
Indo-Pacific Tropical Sand Goby *Favonigobius reichei*	Lower Risk / Near Threatened by IUCN (2008).	Soft shores at Sham Wat, San Shek Wan, Sha Lo Wan, Hau Hok Wan, San Tau and Tung Chung Bay.	Common and widespread (Lee et al., 2004, Nip 2005)
Walking Goby *Scartelaos histophorus*	No statutory protection status in Hong Kong.	Soft shores at San Shek Wan, Sha Lo Wan and Hau Hok Wan.	Uncommon in Hong Kong
Flat-headed Goby *Luciogobius guttatus*	No statutory protection status in Hong Kong.	Soft shores at San Shek Wan.	Uncommon in Hong Kong
Snowy Puffer *Takifugu niphobles*	IUCN “Data Deficient”	Soft shores atHau Hok Wan and San Tau.	Common in Hong Kong (AFCD 2008).
Predaceous Chub *Parazacco spilurus*	“Vulnerable” in China Red Data Book	Soft shores at San Shek Wan.	Common andn widespread (Lee et al., 2004)
Sea Cucumber *Holothuria leucospilota*	Endangered in Mainland China due to over-exploitation (CSIS 2008)	Soft shores at Sham Wat.	Common in Hong Kong (Lai et al., 2006)

Species	Protection Status	Distribution	Rarity
Greasyback Shrimp ***Metapenaeus ensis***	"Vulnerable" in China Red Data Book	Soft shores at Sham Wat, San Shek Wan, Hau Hok Wan and San Tau.	Found on sandy-mud or muddy bottoms. Major species cultivated at Mai Po Marshes Nature Reserve (AFCD 2004).

8.10.2 Habitat Evaluation

8.10.2.1 With reference to the detailed description above, the ecological values of habitats identified within the North-western waters study area have been assessed using criteria in *EIAO TM Annex 8*, and the results presented in **Tables 8.25a – 8.25h**.

Marine Waters

8.10.2.2 The Chinese White Dolphin *Sousa chinensis*, and the Finless Porpoise *Neophocaena phocaenoides*, are the only species of marine mammals regularly sighted in Hong Kong marine waters (Jefferson and Hung 2007). As sightings of the Finless Porpoise have mainly been in southern and eastern waters of Hong Kong (Jefferson et al. 2002; AFCD 2005) and no records have been reported within or close to the Study Area, this species is not under threat from impacts due to the proposed Projects. The population of Chinese White Dolphin is reported to be centred around the Pearl River Estuary, and the western waters of Hong Kong are thought to represent the eastern portion of the population range (Jefferson 2000; Jefferson and Hung 2004). North and West Lantau represent the major area of distribution of dolphins in Hong Kong waters, and are the only places in Hong Kong where dolphins are seen year round. Estimates of density and abundance of dolphins in Northeast Lantau was considered low to moderate, and they used this area seasonally, with more dolphins in summer/autumn months and fewer in winter/spring months (Jefferson 2007). East Lantau was rarely used by the dolphins, and the area can be considered a marginal habitat for dolphins (Jefferson 2007).

Table 8.25a Ecological Value of Marine Waters within North-western WCZ

Criteria	NWWCZ Marine Waters (within project site)	NWWCZ Marine Waters (except project site)
Naturalness	Disturbed as a result of extensive infrastructure development, commercial fishing activities, and busy shipping lanes.	Disturbed as a result of extensive infrastructure development, commercial fishing activities, and busy shipping lanes.
Size	Relatively small	Large
Diversity	Low to moderate dolphin densities (SPSE: <10 and DPSE: <40) were recorded within Study area (Hung, 2009). No Finless Porpoise *(Neophocaena phocaenoides)* have been sighted in this area (Hung, 2009).	Very high dolphin densities (SPSE: >20 and DPSE: >80) were recorded in West Lantau and around Lung kwu Chau in Northwest Lantau during 2002-08 (Hung, 2009). No Finless Porpoise *(Neophocaena phocaenoides)* have been sighted in this area (Hung, 2009).
Rarity	*Sousa chinensis* is a species of conservation importance and is protected under Hong Kong law.	*Sousa chinensis* is a species of conservation importance and is protected under Hong Kong law.
Re-creatability	This habitat cannot be easily recreated.	This habitat cannot be easily recreated.

Criteria	NWWCZ Marine Waters (within project site)	NWWCZ Marine Waters (except project site)
Fragmentation	Marine waters are not fragmented, although the continued reclamation in the northern Lantau area threaten to do so.	Marine waters are not fragmented, although the continued reclamation in the northern Lantau area threaten to do so.
Ecological linkage	Linked to the area of high ecological value around the Brothers Islands.	Linked to core marine waters at Sha Chau and Lung Kwu Chau Marine Park, and along the west coast of Lantau Island (around Tai O).
Potential value	High, as moderate dolphin density were recorded around the Brothers Islands during 2002-08 (Hung, 2009).	High, as the most heavily utilized habitats by CWD (SPSE: >20; DPSE: >80) were located at the east of Lung Kwu Chau and along the west coast of Lantau during 2008-2009 (Hung, 2009).
Nursery/ breeding area	During 2008-09, calves have been occasionally recorded in the area indicating that it is used for calving and nursing by reproductive females (Hung, 2009).	From 2002-08, high densities of young calves can be found around Lung Kwu Chau, near Tai O Peninsula, Kai Kung Shan, Fan Lau and Kau Ling Chung. All these areas can be considered important nursery areas (Hung, 2009).
Age	Not applicable	Not applicable
Abundance/ Richness of wildlife	The project site overlaps with part of the Northwest and Northeast Lantau areas. The encounter rates were 7.2 sightings per 100 km in Northwest Lantau and 2.2 sightings per 100 km in Northeast Lantau respectively.	The encounter rate in West Lantau was 17.9 sightings per 100 km which was the highest amongst all survey areas whereas the combined encounter rate of survey areas around Lantau was 7.2 sightings per 100 km (Hung 2009)
Ecological Value	**Moderate**	**Low to High** High at major hot-spots: e.g., Sha Chau and Lung Kwu Chau Marine Park and west Lantau; Moderate at localised hot-spots: e.g., The Brothers and Sham Shui Kok; and Low at coastal fringe with high background disturbance: e.g., Tung Chung, Aiport Channel and Tuen Mun.

Note: DPSE = number of dolphins per 100 units of survey effort; SPSE = number of on-effort dolphinsightings per 100 units of survey effort.

Soft Substrate Benthic Habitats

8.10.2.3 Various benthic studies have been undertaken at locations within or close to the Study Area. The marine benthic habitats present in north-western waters of Hong Kong are generally characterized by soft-bottom material composed of silts and clay (HyD 2004). Based on the criteria set in Annex 8 of TM-EIAO, ecological values of the soft bottom benthic habitat are listed below.

Table 8.25b Ecological Value of Soft Substrate Benthic Habitat within North-western WCZ

Criteria	Soft Substrate Benthic Habitat
Naturalness	Habitats have been subject to high degree of disturbance from Pearl River discharges, high marine traffic and moderate high trawling pressure for fisheries resources.
Size	Relatively large as the majority of marine benthic habitats are composed of soft-bottom silt-clay material.
Diversity	Low abundance of common and widespread species dominated by polychaetes. The assemblages are of similar diversity to the majority of other areas in Hong Kong.
Rarity	No organism was found that are considered as rare or of conservation interest.
Re-creatability	The habitat can be expected to recreate naturally within a relatively short timeframe through sediment deposition.
Fragmentation	Not fragmented. The surrounding environment contains many other areas of soft substrate.
Ecological linkage	The benthic infauna acts as food source for epi-benthic organisms.
Potential value	Unlikely that the site can develop conservation interest.
Nursery/ breeding area	No significant record
Age	Unknown
Abundance/ Richness of wildlife	Abundance of infauna are comparable to the majority of other areas in Hong Kong
Ecological Value	**Low**

Marine Hard Substrate Benthic Habitats

8.10.2.4 Consistent with the results of other surveys carried out in nearby areas (Oceanway 2002a; 2002b; 2004c), relatively low coverage of both soft coral gorgonian and ahermatypic coral were recorded in the study areas hard substratum within the area surveyed. The result showed that only scattered colonies of *Gorgonacea/Scleractini* on hard substratum and the species diversity is low.

Table 8.25c Ecological Value of Hard Substrate Benthic Habitat within North-western WCZ

Criteria	Hard Substrate Benthic Habitat
Naturalness	Habitats are largely natural, which may be affected by deterioration of water quality.
Size	The hard-substrates is relatively small in area compared to soft bottom sediment. The coverage of corals in this region is very low (less than 5%, and usually <1%, the lowest compared with other regions in Hong Kong). The subtidal section of artifical seawall (including approximately 390m of sloping seawall and 210m of vertical seawall), rocks and boulders occasionally found in the soft-bottom seabed are likely to be directly impacted. There is, however, potential for indirect impacts related to alterations in water quality.
Diversity	Low species diversity as only 2 coral species were recorded within the study area and most hard substrates are dominated by barnacles, mussels and rock oysters.
Rarity	No rare species recorded although protected hard corals reported in the area surveyed.
Re-creatability	Corals may recolonise subtidal hard substrate given favourable environmental conditions.
Fragmentation	Naturally fragmented from adjacent homogeneous soft-bottom seabed
Ecological linkage	Connected to overlying water column and soft-bottom seabed
Potential value	Moderate given that the corals are of conservation interest.
Nursery/ breeding area	Possible but none documented.
Age	Unknown
Abundance/ Richness of wildlife	Scattered colonies of Gorgonacea/Scleractini with hard substratum.
Ecological Value	**With corals: Low – Moderate** **Without corals: Low**

<u>Soft Shores</u>

8.10.2.5 Soft shores (such as sandy shore and mudflats) are often buffered by mangrove and their associates and provide nursery habitats for Horseshoe Crabs and many fishes and invertebrate species. The mudflats at Tung Chung Bay and San Tau are known to support seagrass beds. The HZMB Study (HyD, 2004) found more than 50 Horseshoe Crab individuals, consisting of two species (*Carcinoscorpius rotundicauda* and *T. tridentatus*) at Tung Chung Bay, San Tau, Hau Hok Wan and Sham Wan. Findings in 2003-04 from the HZMB study have revealed Horseshoe Crabs at Sham Wat, San Tau and Tung Chung Bay, indicating that these areas are still favourable habitat for this species.

8.10.2.6 Local people from Tung Chung have been frequently observed collecting clams at Tung Chung Bay and San Tau. This process can be potentially destructive to seagrass beds and horeseshoe crabs habitat.

8.10.2.7 Based on the above observations and the criteria set in Annex 8 of TM-EIAO, ecological values of the soft shores are listed below.

Table 8.25d Ecological Value of Soft Shore Habitats within North-western WCZ

Criteria	Soft Shore - Tung Chung Bay (TCB), San Tau (ST)	Soft Shore - Hau Kok Wan (HKW), Sha Lo Wan (SLW), Sham Wat (SW) and Tai Ho Wan (THW)	Soft Shore - San Shek Wan (SSW) and Butterfly Beach (BB)
Naturalness	Natural Sandy mudflat.	Natural sandy mudflat.	SSW: Natural sandy shore with numerous boulders present. BB: Gazetted beach with certain human disturbance.
Size	TCB: Large ST: Medium	Medium	Medium to large
Diversity	Moderate	HKW, SLW and SW: Moderate THW: 17 species found in mangrove and 58 intertidal species recorded. Horseshoe crab and seagrass are supported.	SSW: Moderate BB: No intertidal fauna was recorded from Sandy Beach during TMWB study.
Rarity	TCB: Presence of Horseshoe crab, seagrass and mangrove. ST: Presence of Horseshoe crab, seagrass and mangrove.	HKW, SLW and SW: Presence of Horseshoe crab and mangrove. THW: Locally rare Seagrass (*Halophila ovalis)* and locally restricted mangrove species Many-petaled Mangrove (*Bruguiera gymnorrhiza*) and Lumnitzera (*Lumnitzera racemosa*) were present in Tai Ho. Two species of horseshoe crabs have been identified utilising these mudflat.	SSW: Presence of Indo-Pacific Tropical Sand Goby. BB: No rare species recorded.
Re-creatability	Not readily re-creatable.	Not readily re-creatable the habitat. (Mangrove is re-creatable but may not be return to it original status. Seagrass bed is difficult to recreate.)	SSW: Not readily be recreated. BB: readily be recreated.
Fragmentation	Not fragmented.	Not fragmented.	Not fragmented.
Ecological Linkage	Linked to terrestrial and marine areas.	Linked to terrestrial and marine areas.	Linked to terrestrial and marine areas.
Potential Value	High	Medium to high	Low as the nature of boulder shore in SSW and sand in BB.
Nursery/ Breeding Ground	Nursery and/or breeding ground for horseshoe crabs, fishes, crustaceans and other intertidal fauna.	Nursery and/or breeding ground for fishes, crustaceans and common intertidal fauna. Potential (HHK and SLW) breeding ground or breeding ground (SW and THW) for horseshoe crabs.	SSW: Nursery and/or breeding ground for common intertidal fauna. BB: No significant nursery or breeding ground.
Age	Not Known.	Not Known.	Not Known.

Criteria	Soft Shore - Tung Chung Bay (TCB), San Tau (ST)	Soft Shore - Hau Kok Wan (HKW), Sha Lo Wan (SLW), Sham Wat (SW) and Tai Ho Wan (THW)	Soft Shore - San Shek Wan (SSW) and Butterfly Beach (BB)
Abundance/ Richness of Wildlife	Moderate.	Low-Moderate. THW: 41 species (no species of conservation interest) recorded during HZMB and 11 avifauna species (4 species of conservation interest) recorded during TM-CLKL study.	SSW: Low-moderate. BB: Low species richness with 2 avifauna, 1 dragonfly and 2 butterfly species was recorded during TMWB study. No intertidal fauna was recorded.
Ecological Value	**High**	**Moderate**	**SSW: Low to Moderate** **BB: Low**

Hard Shores

8.10.2.8 The intertidal rocky shores surveyed in this study are not considered to be of particular conservation concern. The coastline of Hong Kong is rich in rocky shore habitats (Williams 2003, Lai et al. 2006). Rocky shore habitats are commoner than mangrove, sandy beach and mudflat coastal habitats in Hong Kong. At present, a portion of the rocky coastline has been transformed into artificial hard-bottom area (i.e. seawall). The artificial habitat would be less diverse than natural shores. However, most typical species inhabiting natural rocky shore would readily colonize artificial hard-bottom embankment (Morton and Morton 1983) and natural rocky shore habitats are, thus, considered to be recreatable in general.

8.10.2.9 Based on the above observations and the criteria set in Annex 8 of TM-EIAO, ecological values of the hard shores are listed below.

Table 8.25e Ecological Value of Natural and Artificial Hard Shore Habitats within North-western WCZ

Criteria	Natural Hard Shore - San Shek Wan West (SSWW) and East (SSWE), Sha Lo Wan Pier (SLWP)	Artificial Hard Shores - Airport Island East (AIE) and South (AIS), Tai Ho seawall (TH) and Tuen Mun seawall (TM)
Naturalness	Natural rocky shore	Artificial. Habitats have been subject to certain degree of human disturbance.
Size	Approximately 5.5km	Approximately 15.6km
Diversity	Low	Low. TM: Diversity ranged from 3-46 individuals per m^2 according to TMWB survey.
Rarity	Common habitat in Hong Kong. No rare species recorded.	The species recorded are common in Hong Kong. No rare species recorded.
Re-creatability	The habitats can readily be recreated.	The habitats can readily be recreated.
Fragmentation	Not fragmented.	Not fragmented.
Ecological Linkage	Linked to marine areas.	Not functionally linked to any highly valued habitat in close proximity.
Potential Value	Low.	Low due to high degree of human disturbance.
Nursery/ Breeding Ground	Nursery and/or breeding ground for common rocky shore species.	Nursery and/or breeding ground for common rocky shore species.
Age	Not known.	Not known.
Abundance/ Richness of Wildlife	High	Moderate-High. TM: 6 avifauna and 25 intertidal species recorded. Among the avifauna, 1 species are of conservation interest.
Ecological Value	**Low-Moderate**	**Low**

Artificial Reefs

8.10.2.10 Winthin the study area, artificial reefs have been deployed at the Sha Chau and Lung Kwu Chau Marine Park and the Chek Lap Kok Marine Exclusion Zone. Although it can enhance and protect these marine areas for the benefit of the CWD and general marine resources, the ecological value of this habitat is low due to its recreability and artificial nature.

8.10.2.11 Based on the above observations and the criteria set in Annex 8 of TM-EIAO, ecological values of these areas mentioned above are listed below.

Table 8.25f Ecological Value of Artificial Reefs Habitats within North-western WCZ

Criteria	Artificial Reefs at Airport East Exclusion Zone and Sha Chau
Naturalness	Low as the artificial reefs are man-made and artificially deployed.
Size	Small
Diversity	Species richness of fish is expected to be moderate within the artificial reef areas.
Rarity	No rare species was documented.
Re-creatability	High
Fragmentation	The habitats are not fragmented.
Ecological linkage	Link to the marine habitat for Chinese white dolphin and possibly enhance its food availability.
Potential value	Moderate as it have been deployed for approximately 9 years in areas with fishing restriction.
Nursery/ breeding area	Possible but none documented.
Age	n/a
Abundance/ Richness of wildlife	Moderate
Ecological Value	**Moderate**

Marine Park

8.10.2.12 There is one designated Marine Park located within the wider study area which is the Sha Chau and Lung Kwu Chau Marine Park. It is one of the important habitats in the western waters for the CWD. The habitat serves as a nursery ground for many estuarine and pelagic fishes and shellfish species as well as CWD. Thus, the ecological value of this marine park is considered high. Based on the above observations and the criteria set in Annex 8 of TM-EIAO, ecological values of these areas mentioned above are listed below.

Table 8.25g Ecological Value of Sha Chau and Lung Kwu Chau Marine Park Habitats within North-western WCZ

Criteria	Sha Chau and Lung Kwu Chau Marine Park
Naturalness	High as highly conserved.
Size	Modaerate as a total sea area of about 1,200 hectares.
Diversity	High species diversity.
Rarity	The Marine Park is extensively utilised by *Sousa chinensis* and birds
Re-creatability	The Marine Park would be expected to be difficult to recreate within a short timeframe.
Fragmentation	The habitats are not fragmented.
Ecological linkage	Link to the marine habitat for Chinese white dolphin and possibly enhance its food availability.
Potential value	High as of conservation interest.
Nursery/ breeding area	Nursery grounds for many coastal and oceanic fish and shellfish species as well as *Sousa chinensis*.
Age	n/a
Abundance/ Richness of wildlife	Due to its protected status, the Marine Park would be expected to support high abundances of organisms in comparison to other habitats.
Ecological Value	**High**

SSSIs

8.10.2.13 There are two recognised sites of conservation importance located within the study area, namely the San Tau Beach SSSI and Tai Ho Stream SSSI. There are important mangrove stands and seagrass beds found within these areas. The habitat serves as a nursery, forageing and roosting ground of many faunal species and the ecological value of this type of habitat is considered high.

8.10.2.14 Based on the above observations and the criteria set in Annex 8 of TM-EIAO, ecological values of these areas mentioned above are listed below.

Table 8.25h Ecological Value of SSSI Habitats within North-western WCZ

Criteria	San Tau Beach SSSI	Tai Ho Stream SSSI
Naturalness	Coastal mangrove with associates, a result of natural colonization but under stress from human disturbance. The seagrass bed at San Tau has been subject to impacts associated with the reclamation works for the airport at Chek Lap Kok (HKU, 1998). The seagrass has, however, successfully recovered since the works were completed.	Natural but under stress from people disturbance. The hydrological system of stream, estuary and bay within Tai Ho Stream SSSI remains intact and little modified by human activity.
Size	2.7ha	5ha
Diversity	Low species diversity dominated by common mangrove apecies (*Aegiceras corniculatum*, *Avicennia marina*, *bruguiera gymnorrhiza*, *Kandelia abovata*), herbs and associated mangrove species (HKLR, 2009)	Reported to support the greatest diversity of fresh water and brackish-water fish in Hong Kong.
Rarity	Two species of Horsecrab crab have been identified as using these mudflat as well as two species of seagrass.	The only known location for the migratory fish Ayu (*Plecoglossus altivelis*). There are mangroves and small patches of seagrass *Halophila beccarii* located close to the southern end of the stream.
Re-creatability	The SSSI would be expected to be difficult to recreate within a short timeframe.	The SSSI would be expected to be difficult to recreate within a short timeframe.
Fragmentation	The SSSI is relatively unfragmented	The SSSI is relatively unfragmented
Ecological linkage	There are diverse ecological habitats nearby, i.e. mangrove, mudflat and seagrass bed.	There are diverse ecological habitats nearby, i.e. mangrove, mudflat and seagrass bed.
Potential value	Ecological value is high as the site is of conservation interest.	Ecological value is high as the site is of conservation interest.
Nursery/ breeding area	The SSSI act as a nursery ground for numerous species, including 2 species of horsecrab crabs.	Tai Ho is the only sprawing ground in the territory for the local rare fish Ayu. The Halophila beccarii seagrass bed in Tai Ho Wan was identified as a nursery and feeding ground for horseshoe crabs (Fong 1999).
Age	Not Known.	Not Known.
Abundance/ Richness of wildlife	Moderate	High
Ecological Value	**High**	**High**

8.10.2.15 The habitats present within the study area have been ranked according to their overall ecological value and summarised in **Table 8.26**. The marine waters within study area is the most ecological valuable habitat. The marine water within site boubdary, soft shore at Tung Chung Bay and San Tau, Sha Chau and Lung Kwu Chau Marine Park, San Tau Beach and Tai Ho Wan SSSIs are considered to be of high ecological value. Most of the soft shores along North Lantau such as Hau Kok Wan, Sha Lo Wan and Sham Wat and Tai Ho Wan are ranked as moderate ecological value while the soft shores at San Shek Wan and the hard substrate habitat with coral communities within study area are ranked as low to moderate ecological value. The natural and artificial hard shores, soft shore at Tuen Mun Butterfly Beach, artificial reefs at Airport East Exclusion Zone and Sha Chau, soft substrate benthic habitat are of the lowest ecological value.

Table 8.26 Summary of the Ecological Value of Habitats within the Study Area

Habitat	Ecological Value
NWWCZ Marine waters (except project site)	Low-High
Sha Chau and Lung Kwu Chau Marine Park	High
San Tau Beach SSSI	High
Tai Ho Stream SSSI	High
Soft Shore (Tung Chung Bay, San Tau)	High
NWWCZ Marine waters (within project site)	Moderate
Soft Shore (Hau Kok Wan, Sha Lo Wan, Sham Wat, Tai Ho Wan)	Moderate
Artificial Reefs at Airport East Exclusion Zone and Sha Chau	Moderate
Soft Shore (San Shek Wan)	Low-Moderate
Hard Substrate Benthic Habitat (with Corals)	Low-Moderate
Intertidal Habitat on Natural Hard Shore (San Shek Wan West and East, Sha Lo Wan Pier)	Low-Moderate
Hard Substrate Benthic Habitat (without Corals)	Low
Intertidal Habitat on Artificial Hard Shore (Airport Island East and South, Tai Ho seawall and Tuen Mun Seawall)	Low
Soft Shore (Tuen Mun Butterfly Beach)	Low
Soft Substrate Benthic Habitat	Low

8.10.3 Assessment Methodology

Background

8.10.3.1 The objective of the marine ecological assessment is to predict the direct and indirect, primary and secondary, on-site and off-site impacts of the project on the marine environmental and ecological resources and habitats. The significance of any predicted ecological impacts have been evaluated based on the criteria stipulated in Table 1, Annex 8 of the TM using the following criteria:

- habitat quality;
- species affected;
- size/abundance of habitats affected;
- duration of impacts;

- reversibility of impacts; and
- magnitude of environmental changes.

8.10.3.2 Impacts are ranked as "minor", "moderate" or "severe", although in a few cases, "insignificant" (less than "minor") or "extremely severe" may also be given. The ranking of a given impact will vary based on the criteria listed above. For example, an impact might be ranked as "minor" if it affected only common species and habitats, or if it affected only small numbers of individuals or small areas, whereas it might be ranked as "severe" if it affected rare species or habitats, large numbers of individuals or large areas. The major factors giving rise to a ranking of "moderate" or "severe" are spelled out in the text as far as possible. As noted in Annex 16 of the TM, a degree of professional judgment is involved in the evaluation of impacts.

8.10.3.3 If ecological impacts are found to be significant (i.e., moderate to severe) mitigation needs to be carried out in accordance with the TM. Mitigation measures are not required for insignificant impacts although precautionary and /or enhacement measures may be recommended if desirable. The policy for mitigating significant impacts on habitats and wildlife is to seek to achieve impact avoidance, impact minimisation and impact compensation in that order of priority. Impact avoidance typically consists of modifications to the project design, but may in extreme cases require abandonment of the project (the "no-go" alternative). Impact minimisation includes any means of reducing the scope or severity of a given impact, e.g., through timing of construction works, modification in design, or ecological restoration of disturbed areas following the completion of works. Impact compensation assumes that an irreversible impact will occur upon a given habitat or species and attempts to compensate for it elsewhere, for example, by enhancement or creation of suitable habitat. Compensation may take place on-site or off-site.

<u>Cumulative Impacts</u>

8.10.3.4 In order to assess the potential ecological impacts from other activities in the study area, cumulative impacts have also been examined. There are numerous other operations in the overall study area that could potentially lead to cumulative impacts and these include disposal of contaminated dredged material in the East Sha Chau CMPs and The Brothers MBA and neighbouring works that may result in cumulative ecological impacts. There is also the potential for impacts due to dredging of the HKBCF, HKLR, a new contaminated mud pit facility at Airport East or East of Sha Chau, Lantau Logisitcs Park and maintenance dredging for the Tonggu Waterway and Kwai Chung Terminal. Details of the concurrent projects are provided in Section 3 and **Appendix A2**. Impacts from marine pollution, fishing and shipping activity, also, require consideration. The cumulative impacts are, therefore, wider in scope than the potential impacts attributable to the project and are discussed in Section 8.16 below.

8.11 Prediction and Evaluation of Construction Phase Impacts

8.11.1 Potential Ecological Impacts

8.11.1.1 Construction related impacts are mainly related to dredging and filling activities associated with reclamation works for the southern and northern tunnel landfall areas, and bored piling for the southern marine viaduct.

8.11.1.2 In general, there will be no direct impacts to the marine ecology during the constructional phase as the tunnel section will be formed by TBM and, as such, will not require any dredging or seabed disturbance and therefore, construction phase impacts are not expected.

8.11.1.3 Potential indirect impacts are mostly associated with the construction of the reclamations and the viaduct piers. Details of the construction works for the TM-CLKL are provided in Section 3 and, also, in the Water Quality chapter, Section 6.

8.11.1.4 The key potential indirect impacts of these works could include:

- Elevation in suspended solids concentrations during the dredging and filling for the reclamation works (as to a much lesser extent the viaduct pier works) which may cause smothering of corals and other sessile benthos;
- Reduction of dissolved oxygen due to suspended solids which, combined with other factors, could reduced the dissolved oxygen concentration in the water columns;
- Possible release of contaminants (from sediments) during dredging;
- Increased acoustic disturbance to marine life due to bored piling works for the viaduct piers, dredging and reclamation works; and
- Injury/mortality or disturbance from construction phase vessel traffic to marine life, specifically the CWDs.

8.11.1.5 It is anticipated that construction for the TM-CLKL will commence in late 2011. The marine works of TM-CLKL will be undertaken from late 2011 to early 2014, for a total of about 2.5 years. The southern most portion (Portion N-c) of the northern reclamation must be formed first to allow for the TBM tunnel launching pit to be built and subsequently tunnel boring to commence southward from that end. The viaduct connection and slip roads of the Northern Section are planned to commence in early 2014 after the completion of the northern reclamation. Construction of the southern landfall reclamation and viaduct will commence in late 2011 and be scheduled for completion in 2013, to match the reclamation programme of the HKBCF interim opening in 2014. Thus, indirect impacts would be short term in nature. It should be noted, that as described in Seciton 3, an alternatve programme with an interim opening of 2015 is, also, being proposed for the HKBCF but as the year of 2014 would require more intensive construction it is considered the worst case and has been adopted for the purposes of a conservative assessment in the EIA report.

8.11.2 Alternation of Hydrodynamics and Water Quality

8.11.2.1 The major potential water quality impacts that may arise during the construction phase of the Project include seawall dredging and filling, reclamation filling behind seawall and pier site dredging.

8.11.2.2 During the construction phase, dredging and backfilling at the reclamation sites will lead to increases in suspended solid concentrations in the water column, particulary in close vicinity to the works area. Suspended solids from the dredged spoils, also, contain organic matter and consequently also have an oxygen demand. Elevated suspended solids, therefore, have the potential to cause limited oxygen depletion of the water column although it should be noted that no reduction in ambient dissolved oxygen in Northwestern waters has been recorded even at high suspended solids concentrations (100 mg l^{-1}; Mouchel, 2001c). Suspended solids can also smother the benthos and corals when they settle-out. Impacts related to elevated suspended solids are mostly observed in benthic sessile organisms that are unable to migrate from the affected habitat. Increased suspended solids can clog the gills of filter-feeding sessile organisms such as bivalves and fish leading to suffocation. High suspended solids, also, reduce incident solar radiation from reaching the benthos which can impair photosynthesis. It should be noted, however, that owing to seasonal inputs from the Pearl River, suspended solids in the North-western region of Hong Kong vary over a wide range and it is likely that the organisms present are adapted to short-term elevated suspended solid inputs (Greiner-Maunsell, 1991).

8.11.2.3 Dredging work for the TM-CLKL study would be mainly conducted at seawall locations prior the the filling process. Where possible, the seawall formation would be completed (leaving for a small marine access of 50-100m only) before any filling activities would commence. A full depth silt curtain will, also, be used to surround the access. The seawall, thus, formed would be a very effective means to reduce the dispersion of the sediment during the dredging process. As demonstrated in other reclamation projects such as Penny’s Bay, by adopting this approach (the seawalls to be constructed prior to the filling works), the potential water quality impacts associated with reclamation could be significantly reduced. Section 6 (Water Quality Asssessment) has a full account of the potential sediment loss from the project related to dredging and filling works, integrated measures to reduce and mitigated sediment plumes and, also, the quantitative water quality modelling of the fate and dispersion of the sediment plumes from the project. The potential for sediment resuspension is predicted to be confined to a short distance within the works sites and significant adverse offsite impacts not predicted.

8.11.2.4 The TM-CLKL alignment will pass through natural seabed where limited dredging and bored piling would be required for construction of piers. There would be about 50 pier sites in the sea from the HKBCF island to the viaduct landing at Tai Ho Wan. However, the piers would be constructed in sequence rather than all at the same time. Due to other environmental considerations (such as water quality protection and marine access), the minimum distance between two pilecap construction sites would be about 50m and the maximum number of pier sites simultaneously under construction would be limited to about 15 sites. The water quality impact is, thus, controlled. Furthermore, the pier locations would be enclosed by cofferdams during constuction.

8.11.2.5 In summary, impacts due to elevated SS from the reclamation works during construction phase would be reduced by using a range of integrated construction methods such as construction of leading edges of seawall where possible and completion of as much of the seawall as possible before commencing reclamation dredging and backfilling. These measures are combined with other mitigation including cage silt curtains for the grab dreadgers and silt curtains around the works (see Section 6) to reduce impacts to acceptable levels. Thus, significant adverse water quality impacts are not predicted.

8.11.3 Disturbance to Soft Substrate Benthic Habitats associated with Suspended Solids

8.11.3.1 The seabed nearby the reclaimed areas and at each pier would be disturbed during construction. There is potential for the suspension of sediment particles due to dredging and backfilling activities for the reclamation works leading to impacts associated with suspended solids as described in the preceding section on alterations to water quality. This could adversely affect benthic fauna at these locations. It should be noted that the North-western waters is constantly subjected to dredging disturbance (for example, dredging activity associated with maintaining access channels to the existing AFRF at Sha Chau and Castle Peak Power Station) and intense trawling pressures (which also disturbs the seabed) and the species present are either tolerant of these activities and/or have rapid recolonisation potential. For example, recolonisation of defaunated sediment has been shown to be rapid and peaks in macroinvertebrate abundance are reached after only three months (Lu and Wu, 1998). Similarly, recolonisation of the clean material used to cap the exhausted borrow pits at East Sha Chau has also been shown to be rapid (Mouchel, 2001a). The water quality assessment has noted that, with appropriate mitigation, the construction related suspended solids can be controlled to within the water quality objectives except for some small areas in close proximity or within the actual works sites. Based upon this, only those fauna directly adjacent to the dredging activity are likely to be affected. Because benthic communities are capable of rapid recovery (Mouchel, 1996; 2001a; Meinhardt, 2006a) after physical distrubance, this potential impact is considered minor.

8.11.4 Disturbance to Hard Substrate Benthic Habitats associated with Suspended Solids

8.11.4.1 Dredging and filling works are required for reclamation works. As discussed in Section 6, the major water quality issues in the construction period are those associated with elevated suspended solids as a result of dredging and backfilling for the land formation. Potential impacts on corals nearby the construction works associated with the elevated suspended solids levels have been discussed below.

8.11.4.2 During the TM-CLKL coral survey, there were populations of the gorgonian and the ahermatypic coral *Paracyathus rotundatus* found around Tai Mo Island (Station C4-5 and C01-08) and at the southern viaduct landing area (Station C6-7).

8.11.4.3 The HZMB survey indicated that the hard ahermatypic coral *Balanophyllia spp*. were found on hard substrate in Sham Wat Wan and Sha Lo Wan. However, the abundance and overall percentage cover of the coral was low (<5%). Soft coral *Echinomuricea spp*. were also found in Sham Wat Wan, San Shek Wan, Sha Lo Wan as well as at East of Tung Chung. However, the soft coral was patchily distributed and the overall percentage cover of the coral was low (<5%).

8.11.4.4 The HKLR verification and supplementary surveys indicated that the gorgonian *Echinomuricea* sp. were found in the waters at the south-eastern side of the Airport. The cover of *Echinomuricea* sp. was ranged from <1-10% and they were in fair condition. As an additional precautionary and enhancement measure, a pre-contruction dive survey would be conducted to identify any coral colonies suitable for translocation before construction of the HKLR or TM-CLKL begin.

8.11.4.5 Records of hard/stony corals in the wide study area are less extensive although there are hard corals (Faviidae) present subtidally near to Sha Chau (ERM, 1995) and Lung Kwu Chau (Maunsell, 2002) and isolated hard corals were also recorded more recently (June 2001) in the broader study area at Tsing Lung Tau and Sham Tseng (Mouchel, 2001b). Previous surveys have also revealed the soft coral (such as sea pens and gorgonians) appear to be distributed throughout the North-western waters (e.g., Greiner-Maunsell, 1991; ERM, 1996; Mouchel, 2001a; 2001b; Maunsell, 2002). Sea pens such as *Pteroides esperi* has been previously recorded throughout the soft-bottom seabed of wider study area (ERM, 1996; Mouchel, 2001a, 2001b, 2005b).

8.11.4.6 The soft gorgonian coral *Ellisella gracilis* has, also, been recorded in the northeast of Sha Chau (ERM, 1996). These soft corals are not particularly susceptible to high suspended solid loadings as they do not possess symbiotic zooxanthellae. Gorgonians are typically branching corals that are probably less susceptible than other forms to sedimentation (Brown and Howard, 1985).

8.11.4.7 In order to determine whether water quality alterations with respect to suspended solids would have an impact on coral colonies around the known coral sites, the water quality modelling has included specific modelling points around representative sensitive sites. While as discussed above, the natural level and variation of suspended solids in the North-western waters are high, the general water quality objective of a 30% elevation from the ambient has been assumed as the assessment criteria. For corals, the daily sedimentation rate could also be a concern and a protective tolerant limit of 200 $g/m^2/day$ is commonly adopted in EIA studies in the western waters and is also proposed. The water quality modelling (Section 6), therefore also included the sedimentation parameter in its analysis. Details of the predicted water quality impact have been assessed in Section 6 and a summary of results relelvant to the corals colonies are presented below.

8.11.4.8 The WSRs relevant to the nearby identified corals colonies are WSR46 near Tai Mo To, WSR48 at the west end of airport channel, WSR22c adjacent to Tai Ho Wan and WSR 47b at Tuen Mun. Under the unmitigated scenarios (See **Tables 6.21**, **6.23** and **6.25**), marginal WQO exeedances are predicted at WSR 46 during the construction phase but at very low frequency (generally less than 3% of the time) and no exceedances are predicted at WSR 22c. Higher levels and frequency of WQO exceedances, however, are predicted at Tuen Mun during the 2013 scenario when the works for the northern landfall reclamation are closer to the shallow shore (**Table 6.25**). For the coral patches near Tai Ho (WSR 22c) or at the west end of the airport channel (WSR 48), no WQO exceedances are predicted at all. With respect to the daily sedimentation rate, the predicted rates at the coral sites (**Table 6.27**) are generally below the 200 g/m^2/day criteria, except for the 2013 scenairo at Tuen Mun (WSR 47b) where the maximum rate is predicted to be about 263.1 g/m^2/day. Based on these predicted impacts, it is concluded that the elevations in suspended solids would be relatively localised to the works areas even without mitigation measures applied and minor impacts are anticipated.

8.11.4.9 As some WQO exceedances are prediced at some sensitive receivers including those relevant to ecology under the unmitigated scenarios, mitigation measures in the form of an extensive perpherial silt curtain system has been proposed and such scenarios have been also modelled. With the application of this silt curtain system, WQO exceedances at corals sites are not predicted, except at Tuen Mun, again during the 2013 scenario only (**Tables 6.22**, **6.24** and **6.26**) when low level (SS elevation of 5.9 mg/L) WQO exceedances is still predicted for about 11 % of the wet season period but not during the dry season. With the mitigation measures, the sedimentation rate at all coral sites are all predicted to be below the tolerance criteria of 200 g/m^2/day (**Table 6.27**). While there are still some predicted WQO exceedances at Tuen Mun coral site, both the magnitude and frequency is low and it is only predicted during the later period (2013) of the construction programme.

8.11.4.10 Sedimentation impacts on hard corals are well documented and toxicity and mortality are dependent on whether the deposited material is toxic (sediments in the study area are considered to be comparatively non-contaminated as detailed in Section 6), the duration of smothering and the species of coral present as platelike forms appear more sensitive although they have not been recorded in the study area. Therefore, the overall impacts are still considered as minor. Nonetheless, as discussed above, the octo-corals at Tuen Mun are proposed to be translocated as far as reasonably practicable as an additional precautionary and enhancement measures only.

8.11.5 Disturbance to Intertidal Habitats associated with Suspended Solids

<u>Soft Shores</u>

8.11.5.1 Although the sandy shore at Tuen Mun (Butterfly Beach) will not be directly affected by this project, there is potential for indirect impacts related to alterations in water quality from elevated SS levels that may arise from reclamation works. However, this site is about 1km from the works area and the water quality assessment has predicted that, even without mitigation, no excedances of the WQO are predicted for this site (see WSR 12; see **Tables 6.21** to **6.26**)

8.11.5.2 In addition, natural soft shore habitats which of moderate to high ecological value at Tung Chung Bay, San Tau, Hau Hok Wan, Sha Lo Wan, Sham Wat and Tai Ho Wan at North Lantau were found to be habitats for horseshoe crabs, seagrass and/or mangroves. Although these natural intertidal habitats are not directly affected by this project, there is potential for indirect impacts related to alterations in water quality from elevated SS levels that may arise from reclamation and viaduct pier works. This could result in decreasing photosynthesis rates of primary producers and, thus, reduce food supply to the numerous herbivores on shores. However, as the piers for the marine viaduct will be constructed within metal caissons, the amount of suspended solids lost to suspection will be negligible. The water quality modelling has included all these interitidal habitats in the model. The modelling results (**Tables 6.21** to **6.26**) indicated that, even without mitigation, the water quality objective in these areas will not be exceed and the potential impact is, thus, considered to be insignificant.

Natural Hard Shores

8.11.5.3 Although the natural hard shore habitats at Sha Lo Wan Pier and San Shek Wan (West and East) at North Lantau are not directly affected by this project, there is potential for indirect impacts related to alterations in water quality from elevated SS levels that may arise from reclamation and viaduct pier works. All the intertidal species recorded are common and characteristic of intertidal habitats throughout Hong Kong. As noted above, the water quality modelling results at WSR30 at Sha Lo Wan (**Tables 6.21, 6.23** and **6.25**) show that, even without mitigation, the water quality objective in these areas will not exceed the relevant criteria. Therefore, as the ecological value of this habitat is generally considered as low-moderate, no significant impact is anticipated.

8.11.6 Disturbance to Artificial Reefs

8.11.6.1 The proposed alignment of TM-CLKL is located approximately about 1km away (at the nearest point) from the artificial reefs (ARs) at the Airport East Exclusion Zone (WSR 41) and 7.5km from the AR in the Sha Chau and Lung Kwu Chau Marine Park (WSR 42).

8.11.6.2 The AR (with an overall volume of approximately 5,580m^3) located in the Sha Chau and Lung Kwu Chau Marine Park habitats will not be directly affected by this project. There is, however, potential for indirect impacts related to alterations in water quality. The water quality modelling (based on suspensions of sediment attributable to worst-case dredging and backfilling operations) described in Section 6 predicted that there will be virtually no project related SS elevation in the Marine Park (WSR 10) and the AR inside (WSR 42), even without mitigation measures (**Table 6.21. 6.23 and 6.25**).

8.11.6.3 The closest AR at Airport East Exclusion Zone (WSR 41) would be largely impacted by the reclamation work of the artificial island HKBCF, which is only a few hundreded meters away. This AR was implemented in 2000 and has a footprint of 1,200m^2 and an overall volume of approximately 3600m^3. Under the unmitigated scenarios, the results of the water quality assessment show that comparatively high levels (10.0–29.9 mg/L) and frequency (9–39%) of WQO exceedances are predicted for WSR 41 and the situation is more severe in the 2011 sceario than the other years.

8.11.6.4 With the application of extensive silt curtain mitigation measures, the WQO exceedances at this AR is largerly controlled to within the WQO, except during the wet season of 2011 when low levels of WQO exceedances are still predicted albeit for only 4% of the wet season period, but no exceedances wil occur in the dry season (**Table 6.22**). The maximum mitigated SS elevations are predicted to be 6.1 mg/L in the wet season, about 2.4 mg/L above the relevant WQO. It should be noted that the highest background SS level measured among nearby EPD monitoring stations (NM1, NM2 and NM3) during 2006 was 21.3mg/L at NM2 which is 14.9 mg/L above its station mean of 6.4 mg/L. Hence, the maximum mitigated SS elevations are not predicted to be higher than natural variations. While the artificial reef is man-made, artificially deployed and of relatively small in size, as the reefs serve as a refuge for fish and other marine life, the potential impacts to the AR is considered minor-moderate, requiring mitigation as described in the Water Quality Assesment (Section 6) and the re-provision of the AR.

8.11.6.5 It is jointly proposed by the TM-CLKL and HKBCF projects that this AR will be reprovisioned to mitigate against the predicted impacts from the reclamation works.

8.11.7 Disturbance to Marine Park

8.11.7.1 Although the Sha Chau and Lung Kwu Chau Marine Park is located over 6km away from the proposed alignment, there are several sensitive receivers known to inhabit the park, including the Chinese White Dolphin, horseshoe crabs and coral communities. The Marine Park comprises 1,200ha of estuarine waters around the islands of Sha Chau and Lung Kwu Chau and was designated marine park status on 22 November 1996. The marine park was specifically designated due to the importance of the habitat for the Chinese White Dolphin.

8.11.7.2 Construction phase impacts described in the sections on impacts to the benthos and corals detailed above, are also applicable to the Sha Chau and Lung Kwu Chau Marine Park. The species-based ecological impact assessment to the Chinese White Dolphin should, also, be consulted as the predicted impacts will apply to individuals inhabiting the Marine Park.

8.11.7.3 Although there will not be any loss of habitat in the Marine Park due to TM-CLKL, water quality alterations with respect to suspended solids could have an impact on sensitive receivers inhabitating the marine park. Water quality modelling has been conducted as described in detail in Section 6 of this report. The water quality modelling (based on suspensions of sediment attributable to worst-case dredging and backfilling operations) described in Section 6 predicted that there will be minimal (<0.5 mg/L in the unmitigated case, see WSR10 in **Table 6.21. 6.23 and 6.25**) project related elevations in suspended solids at the

Marine Park which is some distance from the works.

8.11.8 Disturbance to San Tau Beach SSSI and Tai Ho Stream SSSI

8.11.8.1 Although the San Tau Beach SSSI, Tai Ho Wan and Tai Ho Stream SSSI are, respectively, located 4.7km and 0.5km away from the proposed marine viaduct alignment, there are important species known to inhabit these areas, including the horseshoe crabs, seagrass and mangrove stands. While no direct impacts are predicted, construction phase impacts described in the sections on intertidal habitats above, are also applicable to the San Tau Beach SSSI, Tai Ho Wan and Tai Ho Stream SSSI. The results of the water quality modelling during construction have shown that, even without mitigation, elevations in SS at the Tai Ho culvert outlet (WSR22a), within Tai Ho Wan itself close to Tai Ho Stream SSSI (WSR22b) and at the San Tau Beach SSSI (WSR27), would not exceed the WQO (**Tables 6.21, 6.23** and **6.25**) and, therefore, significant adverse impacts are not expected.

8.11.9 Disturbance to Chinese White Dolphins

Background

8.11.9.1 There is increasing pressure being placed on the north-western waters, due to numerous infrastructural developments in this location. As the area, also, contains the majority of Hong Kong's Chinese White Dolphins (CWD) (and these are part of the Hong Kong-Pearl River Estuary population), it is important to ensure suitable protection of this species. The species is protected in Hong Kong, although the survival of the local population is being affected adversely by pollution, fishing pressures, habitat loss and an increase in marine traffic (Liu and Hills, 1997; Jefferson, 1998; 2000, 2007; Jefferson and Hung, 2004). Although extirpation of the local population is considered unlikely and the Chinese White Dolphins remain reasonably abundant, there is nevertheless a clear need for effective protection of this species to ensure its long-term survival in Hong Kong waters (Jefferson, 1998, 2000, 2007; Jefferson and Hung, 2004). It is, therefore, important that any project within the Chinese White Dolphins' habitat is carefully evaluated to ensure the long-term conservation requirements of this species are not compromised. The sections below provide a species-based ecological impact assessment for the Chinese White Dolphins (CWD) and discuss the likely impacts attributable to the construction-phase activities associated with the TMCLKL to the local dolphin population.

Blocking of Dolphin Travel Corridors

8.11.9.2 Hung (2008) demonstrated the importance of travel corridors to the CWD population in Hong Kong. This analysis indicated that areas can be important to Chinese White Dolphins, even if a high density of Chinese White Dolphins is not recorded. For instance, dolphin density is high in the area near the Tuen Mun/Lung Kwu Chau area and, also, around the Brothers Islands/Sham Shui Kok but the area in between these two regions do not show particularly high densities in the grid analysis (Hung 2008). However, it is known to be used a travel corridor for Chinese White Dolphins moving between these two high-density areas. As such, such areas represent important dolphin habitat, and should not be degraded to the point where Chinese White Dolphins no longer use them as, in this case, it would affect the Chinese White Dolphins use of the Brothers Islands/Sham Shui Kok area as well.

8.11.9.3 There will not be a complete physical blockage of the travelling corridors between north-west and north-east Lantau in this project and Chinese White Dolphins will still be able to move through the area. In addition, the use of the TBM for tunnel construction to minimise impacts. However, the reclamation and potential noise associated with the construction of the TM-CLKL may have some impacts in terms of reducing dolphin use of these corridors. While this potential impact has not be widely studied, investigation in the form of pre, during and post-construction monitoring of Chinese White Dolphins, as part of environmental monitoring and audit (EM&A), will be required to monitor this effect.

Acoustic Disturbance from Construction Works

8.11.9.4 No underwater blasting is proposed and as such, impacts from this activity will not occur. In addition, as detailed in Section 2, percussive piling will not be used during any part of the project and bored piling as been selected for the construction of the piers for the southern marine viaduct.

8.11.9.5 Bored piling is significantly less-noisy than percussive piling and does not generate shock waves as is the case for percussive piling, although it can still be quite loud and can take longer to complete, thereby lengthening the overall time period of impact. The viaduct for this project will require about 50 piers, each with 12 piles and the piling for the viaduct pier foundations is anticipated to take approximately 14 months. In addition to the bored piling, a temporary sheet piled wall will, also, be required. During the construction of the Phase 2 of the HKBCF and northern portion of the TM-CLKL southern landfall, as the tidal flows in this part of the works site are higher than further south, the temporary sheet piled wall is proposed to protect the works areas from the higher flows and allow the silt curtain to work effectively. The sheet piles would be driven into the sediment layer to about 20m by vibratory tools but would not require to be driven into the rock level for support. The sheet piled wall would be a joint requirement of both the HKBCF and TM-CLKL but would take only about 3 months to install.

8.11.9.6 There is limited research on the effects of both bored and sheet piling on Chinese White Dolphins or porpoises, but it is reasonable to assume that they may cause some behavioural disturbance in the same way as percussive piling, but the effects are expected to be much less severe than for percussive piling. Indeed, the only really noisy aspect of the bored piling works will be when the metal caisson is bored into the rock layer, with activities of pushinghte caisson through soft mud and extracting sediment, not being expected to yield significant underwater noise levels that would affect the CWDs. Sheet piling is also expected to be even less intrusive than bored piling as the the piles will be contained with the sediment and not be driven into rock.

8.11.9.7 Little is, also, known about the effects of dredging or reclamation work on cetaceans. The few studies that have been done appear mostly to have been conducted on large whales and involve dredging. Richardson et al. (1990) conducted sound playback experiments with bowhead whales (Balaena mysticetus) in the Arctic, and used sounds recorded from active dredgers. The whales showed some behavioral responses, changing their vocalization patterns, feeding and diving behaviour when the noise corresponded to that of dredgers at about 3-11 km distance.

8.11.9.8 However, reactions of Chinese White Dolphins may differ and, in general, the increased use of high frequency sound by Chinese White Dolphins may make them less vulnerable to the effects of dredgers, which generally produce very low frequency sounds (less than a few kHz - see Greene 1987). Also, stationary dredgers appear to have less effect than more transitory sound sources (Richardson & Würsig 1997). The only small toothed whale for which there is some quantitative data on reaction to dredgers is the beluga whale (Delphinapterus leucas). In general, the reactions of belugas to dredgers were of a low level, and whales tended to occur well within the ensonified areas, suggesting that they did not find the noise to be highly disturbing (Richardson & Würsig 1997). Similarly, Thomas et al. (1990) conducted studies of the behavioral responses of captive belugas to recorded playbacks of oil drilling operations (which in some ways are similar to those of dredging operations). No discernable behavioral responses were found and, also, the study found no evidence of stress from examination of blood catecholamines.

8.11.9.9 Jefferson (pers. obs.) has observed Chinese White Dolphins in Hong Kong moving very close to grab dredging operations near the Sha Chau area and the Chinese White Dolphins appeared to be attracted to the disturbance of the sea bottom as the work could make the prey more accessible. This is probably indicative that the level of disturbance is not major. Though it might also increase the chances of a dolphin being struck by equipment or vessels involved in the operations.

8.11.9.10 Recently, significant downward trends have been demonstrated in small-scale dolphin usage of areas at Tuen Muen Area 38 (an area of recent coastal reclamation) and near the East Sha Chau Contaminated Mud Pits (an area of extensive dredge and fill operations of many years), Hung 2008. These results provide an indication of the ability of dredge/fill activities and coastal reclamation to have important negative population-level impacts on Chinese White Dolphins in Hong Kong. As such, it is important that effective mitigation measures be taken to ensure that there are no significant negative impacts of the current project on Chinese White Dolphins resulting from these activities.

8.11.9.11 While there is no possibility of severe damage to Chinese White Dolphins from this acoustic disturbance and the frequencies are probably of a level not heavily used by Chinese White Dolphins, the bored piling, sheet piling and other dredging works may result in at least temporary abandonment of habitat (see Jefferson 2000), forcing animals to spend time in lower-quality habitats, which in turn, may result in lowered fitness, reduced reproductive output, or reduced survival. As such, a minor to moderate impact for each is predicted and appropriate mitigation measures will be needed.

8.11.9.12 For all dredging and backfilling works, mitigation should include acoustic decoupling of noisy equipment from the vessels to prevent transfer of noise into the marine environment, together with the use of dolphin exclusion zones during the works.

8.11.9.13 For the sheet piling, while this is expected to be much less intrusive than bored piling, as little is known about the potential impacts, the use of a dolphin exclusion zone during the piling is recommended.

8.11.9.14 For the bored piling works, it is recommended that a monitoring programme, including underwater noise measurements and tracking of dolphin movement on land, is conducted as part of EM&A in order to study the impact of bored piling. The monitoring programme will be undertaken before, during and after the bored piling works. In addition to the bored piling monitoring programme, the use of a dolphin exclusion zone during the bored piling is recommended, together with avoidance of driving the metal case into the sediment or bedrock during peak dolphin calving months of May and June.

Impact from Suspended Solids and Bio-accumulation due to Dredging and Backfilling

8.11.9.15 During dredging and backfilling operations, increases in suspended solid concentrations can be expected. Any increase may potentially influence the CWD's prey and affect the Chinese White Dolphins indirectly by the loss of food supply, due to disturbance of the seabed and increased sedimentation and, therefore, result in reduced use of the area by Chinese White Dolphins (Hung 2008).

8.11.9.16 Moreover, during dredging operations, contaminants such as heavy metals and organochlorines (OCs) may be stirred up, desorbed from the sediment substrate and redistributed into the water column. This resuspension of environmental contaminants may increase the bioaccumulation in Chinese White Dolphins and porpoises through the intake of prey items in the vicinity of the work area. The main class of pollutants of concern are the organochlorines (also referred to as persistent organic pollutants (POPs)), although some heavy metals and organotins may also be an issue (Jefferson et al. (2006)).

8.11.9.17 Organochlorines have been reported to interfere with reproductive capacity, cause immunosuppression (lowered resistance to disease) and may have carcinogenic (cancer-causing) and teratogenic (development) effects (Tanabe & Tatsukawa, 1991; Busbee *et al*., 1999). Exposure during early development can affect the endocrine, reproductive, immune, and nervous systems, sometimes not expressing their effects until adulthood. For instance, it has been found that high concentrations of PCBs and DDE were correlated with lowered testosterone levels in the blood of Dall's porpoises (*Phocoenoides dalli*) in the North Pacific (Subramanian *et al*., 1987). In another study, Martineau *et al*. (1988) found that industrial contaminants were associated with lesions and cancer-like tumours in beluga whales in the St. Lawrence Estuary. Many of these were implicated in the animals' deaths. Clear evidence showed that high levels of OCs suppressed the immune response of bottlenose dolphins in the southeastern USA (Lahvis *et al*., 1995). Cockcroft (1989) suggested that OC concentrations in South Africa may be high enough to impair reproductive function of male humpback dolphins, and to prove fatal to neonates of primiparous females. Finally, high concentrations of OCs are suspected to have been a causal factor in the die-offs of dolphins in the Mediterranean Sea and northeastern USA in recent years (see Kannan *et al*., 1993; Reijnders 1996; Aguilar, 2000). While the link between OCs and marine mammal die-offs has not yet been clearly and unequivocally proven, there is good reason to be concerned about such factors (Kennedy, 1999).

8.11.9.18 In addition, in some situations dredging operations can give rise to concerns about possible release of nutrients or organically rich material which could result in water column oxygen depletion. There is no available information on the effects of oxygen depletion in the water on CWDs but as dolphins are air breathing mammals and do not obtain oxygen from the water itself and are, also, tolerant of natural variations in the study area, there is no reason to believe that there would be any significant effects.

8.11.9.19 Notwithstanding the above, it is noted that the water quality assessment has concluded that, with the application of recommended mitigation measures, no excessive exceedances of the WQO for SS are predicted except in the immediate vicinity or within the works areas. The potential water quality impacts to CWD are detailed in Section 6.9.6 including a review of the natual SS levels and fluctuations the CWD would experience in its natual home range in the Pearl River Estuary. It is notable that CWD would encouter substantially higher levels of SS elevations (potentially greater than 10,000 mg/L) and that the derived SS WQO for general water quality protection is considered extremely conservative for the CWD. An alternative criterion of 50mg/L SS which is, also, conservative for the protection of fishes, which, is the main preys for CWD, has been suggested. Based on this alternative criteria, it can be concluded that SS elevation that could potentially affect the CWD prey would be mainly limited to within 500m of the the work site with the application of the recommended (1+1) silt curtain mitigation measures.

8.11.9.20 The predicted maximum extent of sediment plumes and the potential maximum elevations are shown together with the 2002-2008 long-term CWD density grid DPSE (which indicates relatively density of dolphins within a grid) in **Figures 6.14** to **6.25** for each of the modelling scenario times with and without (1+1) silt curtain mitigation. It should be noted that the maximum plume envelope only indicates the potentially highest level at any one place without any indication of the time or frequency that such a maximum elevation would occur. The frequency of the SS levels exceeding the WQO criteria (generally below 10 mg/L), and the even more conservative criteria for CWD, are tabulated in **Tables 6.21** to **6.26** at representative CWD hot-spots, including the Sha Chau and Lung Kwu Chau Marine Park (WSR 10), Sham Shui Kok (WSR 45c), the Tai Mo To (WSRs 46 and 49) and shall be referenced for the more exact value of predicted maximum

SS elevations and frequency of WQO exceedances. It is clear from these tables that the predicted maximum SS elevation at these points are well below the 50 mg/L criteria even without mitigation.

8.11.9.21 With reference to **Figures 6.14** to **6.25** and the CWD DPSE density grid and sediment plumes, it is clear that the prime CWD habitats are to the west of Lantau and, also, at the Sha Chau and Lung Kwu Chau Marine Park (left panel of the figures) but no project related sediment plumes are predicted in these prime CWD habitats despite the fact that there could be small sediment losses from bored piling along the HKLR alignment at west of Lantau. The project related sediment plumes are mainly confined to the more sheltered East Tung Chung Bay and often the majority of the plumes are confined to within the project site (right panel of the figures). While plumes can extend outside the project site, the maximum levels are generally constrained to less than 50 mg/L within 500m of the works site, also taking into account that high levels of elevations are not frequently predicted. Without mitigation, plumes reaching the Brothers/Sham Shui Kok area are generally below 10 mg/L, although a higher levels of less than 30 mg/L could be present in the bottom level.

8.11.9.22 **Figures 6.14** to **6.25** also demonstrate that, with the implementation of the extensive (1+1) silt curtain system which effectively encloses the entire project sites, the SS elevation band at around 500m of the site are largely reduced to <30 mg/L. This is well within the CWD tolerable range and establishing a SS mixing zone for CWD is not considered as being warranted. Notwithstanding the above, there will be a 250m CWD exclusion zone to protect the CWD from underwater noise disturbance during all dredging and reclamation works and this exclusion zone would, also, offer protection against water quality deterioration in the immediate vicinity of the works site, as has been predicted. It is known that dolphins become entangled in fishing nets mainly in two situations: 1) in which they are surrounded by the net and they get entangled in the process of being released or trying to escape; or 2) in which the nets are made of very fine monofilament mesh with large openings. In the latter case, they apparently do not detect the nets in some cases and blunder into them, getting entangled. Since the structure and operation of the proposed silt curtains is very different, and thus should not cause a significant entanglement risk. Furthermore, the silt curtain system will be within the dolphin exclusion zone and any dolphin present in this zone would be closely monitored to ensure this prediction is correct.

8.11.9.23 All the mitigation measure would be properly implemented and a comprehensive monitoring programme during the whole construction phase will be implemented to ensure the predicted effectiveness of the recommended mitigation measures are achieved or if not additional mitigation measures be implemented. In addition, as detailed in Section 6, historical data and the project specific sediment testing have concluded that the sediment is, overall, uncontaminated. The site-specific sediment quality characteristics has been reviewed in Section 6.3.5.14 to 6.3.5.19 and with detailed results presented in **Appendix D1**.

8.11.9.24 In terms of dissolved oxygen depletion, there is very extensive experience of dredging operations for construction works similar to those intended for this project within the marine waters of Hong Kong. Nutrient enrichment or oxygen depletion has never been reported as a major concern for marine dredging works in Hong Kong previously and there is no reason to believe that these processes would be of concern in the well flushed North-western Waters. Notwithstanding, in the water quality assessment in Section 6, the maximum potential instant dissolved oxygen (DO) depletion has been estimated using the estimated maximum potential increase in suspended solids. The estimated potential DO depletion at representative ecological sites, including Sham Shui Kok (WSR 45c) and Tai Mo To (WSR 46 and WSR 49) where the CWD may frequent, is included in **Table 6.28.** As indicated in **Table 6.28**, significant DO depletion is generally not expected as the predicted depletion levels are generally predicted to be between 0.0 to 0.4 mg/L. The DO level of the North-western waters is generally high and on average ranges between 5.7 - 6.8 mg/L and, hence, a small potential reduction of 0.4 mg/L would not be of significance.

8.11.9.25 Overall, the water quality assessment suggested that for this project the pollutant of concern would be the suspended solids *per se* and it has predicted that the unmitigated impacts to CWD, interms of SS elevation or contamiant release, are expected to be minor. Furthermore, based upon the fact that the sediment is classed as uncontaminated overall and that water quality impacts can be effectivelly mitigated to within acceptable levels overall, the potential impact from suspended solids and contaminants on the CWD would be expected to be adequately mitigated with application of the water quality mitigation measures.

<u>Injury/Mortality or Disturbance from Vessel Traffic</u>

8.11.9.26 Increased vessel traffic will undoubtedly occur in this project during construction, and this will potentially increase the chance of Chinese White Dolphins or porpoises being killed or injured by vessel collisions. In fact, several stranded Chinese White Dolphins and porpoises in Hong Kong presented wounds that were consistent with blunt traumatic injury, probably caused by boat collisions (Parsons and Jefferson 2000). A significant number of Chinese White Dolphins in the photo-identification catalogue of known animals from the Pearl River Estuary, also, bear injury marks, apparently caused by propellers or vessel hulls (Jefferson 2000; Parsons and Jefferson 2000). This provides further evidence of the potential for harm to Chinese White Dolphins from vessels.

8.11.9.27 Vessel traffic can also result in acoustic disturbance to Chinese White Dolphins and porpoises. Small cetaceans are acoustically-sensitive, and noise from vessel traffic could cause behavioural disturbance to them (Würsig and Richardson 2002). Since Chinese White Dolphins and porpoises rely on their echolocation to navigate their surroundings, detect and capture prey, avoid predators and communicate with one another, sound is vital to their survival (especially for mother-calf pairs). In fact, a land-based study on Hong Kong's CWD showed changes in their diving behaviour in response to heavy vessel traffic (Ng and Leung 2003). CWD mainly produce lower-frequency, broad-band clicks in the range of 8 kHz to >22 kHz during foraging (Van Parijs and Corkeron 2001), while finless porpoises generally exhibit narrowband, high-frequency ultrasonic pulses with peak energy of 142 kHz (Goold and Jefferson 2002).

8.11.9.28 Some studies seem to have been conducted on large whales. Although no detailed quantitative studies of effects were done, dredgers working in the North Atlantic whale (*Eubalaena glacialis*) calving habitat off the south-eastern United States were required to reduce speed to 5 knots to avoid potential collisions with whales (Slay et al. 1993). Richardson et al. (1990), also, conducted sound playback experiments with bowhead whales (*Balaena mysticetus*) in the Arctic, and used sounds recorded from active dredgers. The whales showed some behavioural responses, changing their vocalization patterns, feeding and diving behaviour when the noise corresponded to that of dredgers at a distance of about 3-11 km.

8.11.9.29 However, reactions of Chinese White Dolphins may differ and in general the increased use of high-frequency sound by Chinese White Dolphins may make them less vulnerable to the effects of dredgers, which generally produce very low frequency noise (less than a few kilohertz (Greene 1987, Richardson et al. 1995)). Also, stationary dredgers appear to have less effect than more transitory sound sources (Richardson & Würsig 1997). Therefore, the expected acoustic disturbance from large vessels is well below the primary acoustic range for CWD and finless porpoises. The only small toothed whale for which there is some quantitative data on reaction to dredgers appears to be the beluga whale (*Delphinapterus leucas*). In general, the reactions of belugas to dredgers were of a low level and the whales tended to habitate well within the ensonified areas, suggesting that they did not find the noise to be highly disturbing (Richardson & Würsig 1997).

8.11.9.30 Notwithstanding the above, the CWD may still need to alter their diving and surfacing patterns to avoid collisions with marine vessels. This could result in some short-term behavioural disturbance to the Chinese White Dolphins and porpoises, or if severe enough, they may even be displaced from their preferred habitats.

8.11.9.31 Overall, much more is known about the effects of vessel traffic on Chinese White Dolphins. The literature on this topic highlights three concerns as detailed below:

- high-speed vessels (generally those over 20-25 knots) travelling through dolphin/porpoise habitat can cause impacts because small cetaceans are not always able to get out of their way. High-speed vessels may strike and injure, or kill, small cetaceans;
- even if not physically hit by vessels, there is evidence that dolphin usage in shipping lanes is lower than usage near the lanes, which suggests that Chinese White Dolphins probably reduce the time they spend in the path of vessels (Hung 2008); and
- vessels that are deliberately approaching and following groups of Chinese White Dolphins (see Ng and Leung 2003); if not conducted properly, these activities may harass and seriously 'disturb' small cetaceans. Such stress can reduce fitness, and hamper critical activities such as rest, feeding, socializing, and reproduction.

8.11.9.32 Fortunately, the vessels that will be involved in construction activities for this project, including transportation of dredged sediments, will be largely restricted to slow-moving barges, dredgers and crew boats. Since, they will not be engaged in dolphin-watching activities, these vessels would not be expected to have a serious impact on dolphin behaviour. Nevertheless, given the large numbers of project related vessels and traffic, disruption to the dolphin travel and diving could occur. Depending upon the speed of marine vessels travelling through the construction area, the impact would be of minor to moderate and, therefore, some mitigation measures will be required to minimise the level of impact.

Conclusions

8.11.9.33 The ecological survey conducted for this project (see Section 8.9) clearly highlights that the study area for the TM-CLKL project is heavily used by Chinese White Dolphins and that the nearby Brothers Islands/Sham Shui Kok area are critical dolphin habitats (see Jefferson 2000; Hung 2008). As such, impacts on the CWD are predicted and must be adequately addressed with suitable and sufficient mitigation.

8.11.9.34 The primary issues of concern related to impacts on Hong Kong's CWD from the TM-CLKL contruction and requiring mitigation are:

- blocking of dolphin travelling corridors that span between important parts of their habitat;
- potential acoustic disturbance from bored piling, sheet piling, reclamation and dredging works; and
- injury/mortality or disturbance from construction phase vessel traffic.

8.12 Prediction and Evaluation of Operational Phase Impact

8.12.1 Background

8.12.1.1 During the operational phase, potential direct impacts on marine ecology due to reclamation would result from the permanent loss of approximately 600m of existing seawall (390m of sloping seawall and 210m vertical seawall) at Tuen Mun and about 46.7ha of mostly soft-bottom seabed for the construction of the northern and southern tunnel landfalls (25.4ha adjacent to the HKBCF and about 21.1ha near Tuen Mun) and 0.2ha associated with the southern marine viaduct bridge piers.

8.12.1.2 In addition, indirectly, any changes to the water quality in the area as a result of changes to the water flows due to the presence of the new landforms will need to be taken into account as these could cause secondary impacts to the marine ecology.

8.12.1.3 It should be noted that the TM-CLKL, HKBCF and HKLR will be constructed concurrently and the completed reclamations and road connections associated with each development could impact on local and large scale tidal flows with adverse impacts on marine water quality and the marine environment. Therefore, an assessment of impacts to the marine environment of any one of these projects individually would not be relevant and would not reflect the potential impacts that could occur from their concurrent implementation. As such, in order to fully assess the impacts from the three projects, this water quality assessment has comprised a tidal hydraulic and marine water quality study during the operational phases for all three project combined (TM-CLKL+HKBCF+HKLR).

8.12.1.4 Potential changes to the hydrodynamics, water quality and sedimentation has been modelled and assessed in the Water Quality Assessment (Section 6). The modelling results indicated that the proposed reclamation works and associated facilities will not cause significant large scale regional changes in hydrodynamic or water quality although some localised changes are predicted. With respect to the key ecology habitats, the predicted physio-chemical parameters such as temperature and salinity are of particular concern but the modelling results indicated that any predicted changes attributable to the project works will be generally small (often less than 5% of changes), complied with the relevant WQOs and within the range of natural variations (**Tables 6.18** and **6.19**).

8.12.1.5 The modelling, also, predicted annual sedimentation patterns (Section 6.3.8). With respect to changes at representative ecology / fisheries sensitive sites such as the Sha Chau and Lung Kwu Chau Marine Park (WSR 10), San Tau Beach SSSI and Airport Channel (WSRs 27, 28, 29 and 30), Tai Ho Wan (WSRs 22b and 22c), Tai Mo To (WSR 49), the artificial reef at the NE of the airport (WSR 41) and Ma Wan FCZ, the predicted changes are very small and range between -0.09mm/year to +0.10mm/year. These small changes indicate that the inter-tidal habitats at these soft-shores will not be impacted. With the project implemented (2026), the predicted annual deposition rates at these sites ranged between +0.50 mm/year to +2.28 mm/year. The positive results shows that the project is not expected to lead to a net erosion at the soft-shores habitats along the north Lantau coast. Overall, the results of the water quality modelling undertaken has shown that significant impacts on water quality as a result of the project are not expected and, therefore, no significant impacts to ecological resources in the operational phase from changes to tidal flows with adverse impacts on marine water quality are predicted.

8.12.1.6 There is potential for marine water quality degradation by surface runoff into the surrounding waters from the reclamation sites as well as the bridge. Road surfaces runoffs could contain harmful materials and chemicals (fuel residues containing heavy metals, rubber residues, gasoline, and diesel fuel). However, the amounts of these chemicals and materials would be limited, and this is not anticipated to be a severe issue. Furthermore, silt-grease traps could prevent a direct input of surface runoff to the marine waters. The impact is ranked as insignificant.

8.12.1.7 However, there is the potential risk to the marine ecology due to the chemical or oil spillages arising from a vehicle accident during operation of the project as discussed below.

8.12.2 Habitat Loss from Land Reclamation

Soft Substrate Benthic Habitats

8.12.2.1 The TM-CLKL in the marine environment will comprise either newly reclaimed area or elevated piers. The total size of the reclamation required for the TM-CLKL is about 46.5ha (21.1ha of the northern landfall reclamation and 25.4ha of the southern landfall reclamation). The section of TM-CLKL from HKBCF to North Lantau will be a viaduct supported by piers. Some permanent physical loss (0.2ha) of marine habitat will result from construction works at each location where piers are installed to support the bridge deck.

8.12.2.2 Impacts to benthic organisms are dependent upon the location of the assemblages in relation to the reclaimed areas and pier loactions. Within these areas, primary impacts will be the removal and/or burial of organisms which are present there. These impacts will necessarily occur during dredging and filling operations associated with the reclamation works as well as installation of piers. There will be a permanent loss of benthic communities resulting from the landfall reclamations for the tunnel portals and construction of the piers for the marine viaduct. A series of options have been reviewed as detailed in Section 2 and the selected scheme comprises a southern landfall for the tunnel of the TM-CLKL alignment located on reclaimed land, attached to the HKBCF. This option has the advantage over the previous proposal with a separate island also at Tai Mo To, as it reduces the overall land formation area and, therefore, minimizes the loss of benthic habitat. The total size of the reclamation and piers required for the TM-CLKL is about 46.7ha and this area of benthic habitat will be permanently lost.

8.12.2.3 It is important to determine whether the reclamation sites and pier locations contains unique or otherwise noteworthy benthic assemblages which will be lost as a result of their construction. The available data for the wider study area has shown that the macro-infaunal and epifaunal species composition mostly comprises filter-feeding and deposit-feeding representatives including polychaetes, molluscs, crustaceans and echinoderms. These representatives typically account for 95% of the benthic assemblage present (ERM, 1997) and are characteristic of soft-bottom benthic communities throughout Hong Kong (Shin and Thompson, 1982; Shin, 1989; CCPC, 2002). The historical data have indicated that no rare infaunal or epifaunal macro-invertebrate species are present in the study area. Therefore, it is unlikely that the species abundance and diversity will be reduced.

8.12.2.4 In addition to the permanent loss of the seabed and water column, works areas in the reclamation areas and at each piers will cause temporary loss of seabed and the water column habitat. The affected seabed would not be disturbed at the same time as piers would be constructed in sequence. It should be noted that the area to be temporarily lost by the project is minimised as the tunnel alignment will not be dredged but constructed using TBM.

8.12.2.5 Because of the absence of biota of conservation importance that is strictly dependent upon the seabed habitat, the subtidal soft benthic habitats at the areas to be reclaimed were regarded as being of low ecological value. Although the proposed reclamation will result in the loss of approximately 46.7 hectares of subtidal soft benthic habitats, the severity of the impact is anticipated to be minor.

Hard Substrate Benthic Habitat

8.12.2.6 For the TM-CLKL project, land reclamation of about 46.7ha in total, including 21.1ha in the Tuen Mun (North) and 25.4ha in the HKBCF (South) landfalls and about 0.2ha in North Lantau is required for the tunnel and construction of the piers for the marine viaduct.

8.12.2.7 No impacts would be anticipated as a result of the southern reclamation as no corals were recorded in this location (Station B2 and B3). In addition, although there are populations of gorgonian and the ahermatypic coral *Paracyathus rotundatus* recorded on the rock wall in the sourthern landing area at Tai Ho Wan, no reclamation work would be undertaken in the area and, thus, the coral habitat on the seawall is not expected to be lost. The construction of piers would also not affect the corals as they are far away (>10m) from either side of the viaduct piers. Therefore, no direct impact on corals would be anticipated in location of the southern viaduct landing area.

8.12.2.8 It is expected that direct loss of coral would result due to the proposed reclamation work at the northern landfall area as corals recorded in this area are located in a thin veneer on hard substratum all along the coast. Approximately 390m of sloping seawall and 210m of vertical seawall at Tuen Mun would be affected from the reclamation which would result in the permanent loss of subtidal habitat of approximately 8,580m^2 (0.8ha) and any associated coral communities. The TM-CLKL coral survey recorded populations of two species, the gorgonian and the ahermatypic coral on the seawall in the area of proposed northern landfall reclamation (Station C1 and REA 1). Although the diversity is low with the only 2 species being recorded, results of REA survey revealed that dense population of the gorgonian (approximately 1 colony per 2m^2) were recorded on the seawall attributing to <10% of the total cover while the ahermatypic coral was recorded with the density of approximately 5 colonies per m^2 was recorded forming <5% of the total surface area. As such, the subtidal hard substrate habitat has been ranked as being of low to moderate ecological value.

8.12.2.9 Based upon the comprehensive options assessment, as detailed in Section 2, the current TM-CLKL alignment have been selected as being the preferred option, both environmentally and from other engineering and operational perspectives. Other alignment options have been considered for evaluation under the current Investigation Assignment, including one with a reclamation area located away from the existing seawall towards the eastern side. Comparing with the current adopted option, however, this alternative option had a number of disadvantages, as follows:

- it would have creates an embayed area in between the existing seawall and shoreline and the new reclamation as a potential area of deteriorating water quality;

- it would have required a relatively larger area of reclamation, being necessary to accommodate a toll plaza which, under this alignment, would not be possible to be positioned in Tuen Mun;
- the alignment would have been closer to Butterfly Beach, and will become a potential source of water quality impact, visual impact and other impacts; and
- the alignment would have encroached into a zone heavily underlain with submarine utility cables, the resolution of the conflict with which will have serious programme implications on the project.

8.12.2.10 As the location of the northern reclamation is integral to the remainder of the alignment it cannot be changed without affecting other elements. As noted above, the size of the northern reclamation has been reduced as much as possible (for example, by moving the toll plaza onto land) and the current reclaimed land allocation is the minimum required for the tunnel landing and portal. In addition, it appears that the species of corals recorded in this area are located in a thin veneer on all hard substratum all along the coast in this area, from areas right up to Ka Loon at Tsuen Wan. As a result, even if viable, shifting the northern reclamation would only result in other corals being affected.

8.12.2.11 In summary, based on the above, it is not possible to remove the reclamation all together and shifting the reclamation would, also, result in the loss of coral communities. Minor impact on the subtidal hard substrate habitat would be expected on Tuen Mun beacasue the reclamation area are consist of constructed seawall.

8.12.2.12 Notwithstanding, more hard substrate habitat will be provided by new artificial seawalls at the future northern and southern reclamation of TM-CLKL. At the northern landing area, a total of 574m sloping seawall would be constructed after reclamation and will be an enhancement measure for the predicted coral habitat loss. Construction of the new seawall will be longer than the existing 390m of seawall to be lost so the new seawall provides additional suitable artificial habitat for coral recolonization and recovery. In addition, for the southern landfall reclamation adjacent to the artificial island for the HKBCF, a further 1,565m of sloping seawall would be created. In total, after the reclamation, 3.4ha of sub-tidal habitats on sloping seawalls will be provided. As a result, the total length of new seawall in both areas would be notably longer than the existing seawall to be affected and would be an enhancement for the habitat loss.

8.12.2.13 It has been demonstrated that marine organisms have recolonised sloping rubble mound seawalls after construction (CED, 1996, 1997). It is anticipated that assemblages of hard corals will settle on and recolonise the newly constructed seawalls as environmental conditions of that area would be similar to existing conditions that have allowed the growth of ahermatypic coral and gorgonian recorded in the field surveys of this Study. The potential habitat provided by the total surface area of the new sloping seawalls on the northern and southern reclamations is expected to mitigate for the loss of low-moderate ecological value assemblages of hard corals on the existing Pillar Point seawall (approximately

0.8ha). In addition, as discussed below, a new artifical reef (AR) is proposed to be deployed, as an additional habitat enhancement measure and to reprovision the AR affect at the aiport exclusion zone. ARs act as fish aggregation devices and provide hard bottom, high profile in areas without natural cover. Colonisation of ARs occurs through settlement of the spores and larvae of algae, corals and other benthic organisms. The area of new AR would be approximately three times larger than the existing AR at Airport East Exclusion Zone. As a result, a further 3,600m^2 of new AR would be deployed in order to provide more suitable area for the recruitment of more corals. In addition, the AR deployment would be an enhancement measure for the disturbance to corals.

8.12.2.14 With this large increase in created habitat, both the newly formed seawalls and also the purposely built new AR, which would also act as compensatory and enhancement new AR, which would also act as an enhancement measure for the corals affected, the ecological impacts caused by TM-CLKL reclamation are reduced and not predicted to be significant. Therefore, no further specific mitigation for the corals should be required. Thus, while this soft coral species is not a protected species in Hong Kong, given the potentially large patches to be directly impacted and/or indirectly affected via construction sediment plumes, which are predicted to occasionally exceed the relevant WQO criteria even with silt curtain protection system in place (see WSR 47b, **Table 6.26**), and the fact that the species were recorded to be in good health and condition, translocation of the gorgonian corals colonies at this site is recommended as an additional precautionary and enhancement measure, although this would be subject to the findings of pre-construction baseline survey and further discussions with the relevant authoriteis (for example, AFCD and EPD) on the technical feasibility and details.

8.12.2.15 While the ahermatypic corals are protected in Hong Kong, there is currently no feasible method of relocating this species available as the species recorded will break up when removed from the substratum. Therefore, this does not allow for substratum removal methods to be used and, thus, only those colonies on small separate pieces of substratum may be relocated. However, current technology does allow for the substratum removal relocation of the gorgonian corals. It is considered that it could be possible to relocate between 80-90% of the gorgonian corals and have a high success rate (>70%) (Oceanway, 2005; HKECL, 2001; ERM, 2001). However, the exact number of corals to be relocated, the species name and the relocation method will be confirmed following the pre-translocation survey.

Artifical Hard Shores

8.12.2.16 Due to the northern reclamation, intertidal habitat bordering the northern landfall area of 600m, mainly vertical cement boat landing and sloping large boulder seawall, will be lost. The inter-tidal habitat in this areas borders reclaimed land adjacent to the Tuen Mun special industrial area where the coastal line has been highly modified due to past activities. Therefore, the ecological value of this habitat is generally considered as low.

8.12.2.17 The location of the southern landfall reclamation, integrated with the artificial island for the HKBCF, avoids direct impacts on all inter-tidal areas, including that of the Brothers where horseshoe crabs have been recorded previously. Similarly, the area near the southern landing of the marine viaduct is largely artificial seawall, installed during the construction of the North Lantau Highway. Thus, the ecological value of this man-made habitat in the study area is generally considered as low. Notwithstanding, there will be no reclamation work carried out in this areas and the seawall will not be directly affected by the construciotn of the elevanted viaduct which will pass over the seawall without touching it.

8.12.2.18 Thus, a total length of about 600m of the low ecological valued artificial seawall along the Tuen Mun shores, including approximately 390m of sloping seawall and 210m of vertical seawall, will be lost as a result of reclamation activities in the northern landfall. The results from field surveys indicated that the intertidal assemblages recorded are common and characteristic of intertidal habitats throughout Hong Kong. None of the recorded fauna and flora was rare and they were with low conservation interest. These intertidal habitats will be replaced by a total of 2,100m of ecologically more favourable (compare to the vertical seawall) sloping artificial seawalls at both the northern and southern landfall reclamation areas, resulting in a net gain in sloping seawalls of 1,500m. The new artificial seawalls can be expected, over time, support similar assemblages of intertidal fauna and flora. Organisms present on intertidal shores in Hong Kong rely on larval settlement for recruitment. Assuming that there is a regular supply of larvae brought to the area, recolonization of new seawalls resulting from the reclamation will occur. The design of the seawall will be critical in determining the extent to which the community re-establishes post reclamation. The more heterogeneous the seawall, as can be expected in the slopping seawall with the rock armour, the more diverse a community the habitat can potentially be supportted. Although the reclamation works will result in the loss of 600m of intertidal habitats, the severity of the impact can be to some extend be reduced by the provision of ecologically favourable sloping seawalls and mininal impact would be expected. No further mitigation is required for the loss of low value intertidal habitat.

Marine Waters: Chinese White Dolphin Habitat

8.12.2.19 Seabed ‘reclamation’ involves creating land areas from shallow coastal marine areas by dumping and filling of rock and sediment. There will be reclamation for this project of about 46.7ha (46.5ha of land reclamation and 0.2ha of viaduct piers) in total.

8.12.2.20 The filling in of marine habitats to produce land has the effect of eliminating dolphin and porpoise habitat. This is irreversible and while the effects of construction work are temporary and can often be mitigated, it is virtually impossible to mitigate against the effects of complete and total loss of habitat, especially if this area represents important cetacean habitat. However, it should be noted, that the impact of the footprint of the reclamation works will not result in the loss of any natural coastline habitat or indented bays and, therefore, impacts can be expected to be less than would be the case if such habitats were lost. In addition, the CWD groups were found to be more concentrated near Lung Kwu

Chau and the waters between Lung Kwu Chau and Black Point, indicating that the waters in the western end of North Lantau (especially the area around Sha Chau and Lung Kwu Chau Marine Park) are more important dolphin habitats than the central and eastern regions of North Lantau, where the proposed TM-CLKL will be constructed. Therefore, while there will be some loss of dolphin habitat from reclamation, any damage to nursery grounds of prey species should not be significant (Hung 2008).

8.12.2.21 Although there has been much general literature, only limited quantitative study on the effects of habitat loss from reclamation and other construction activities that physically remove potential habitat for Chinese White Dolphins or porpoises has been undertaken (Kemp 1996). Notwithstanding, Hung (2008) has provided evidence that there has been a significant decline in dolphin usage of the area around the recent reclamation at Tuen Mun Area 38. It should be noted that the low number of dolphin sightings at Castle Peak may, also, be related to other factors including its frequent by marine traffic and the fact that numerous boats anchor in that area. However, after the project at Tuen Mun Area 38, dolphin densities significantly decreased between 1996-2005 at and near the reclamation area, and as such some habitat loss and degradation in the marine area due to the reclamation works is considered to be a key factor to this trend (Hung, pers comm).

8.12.2.22 The area around Pillar Point is moderately used by Chinese White Dolphins, with average or above-average habitat ratings of 11-22 (Hung 2008). There are, also, areas of important dolphin habitat nearby, such as the areas off Tap Shek Kok and Sham Shui Kok, both with high dolphin habitat scores of 30-40 (Hung 2008). In addition, the deeper waters of the Urmston Road shipping channel are frequently used by Chinese White Dolphins for feeding and foraging (see Jefferson 2000; Hung 2008). Reclamation in and near these important dolphin habitat areas will result in some permanent loss of dolphin habitat, as the animals will no longer be able to use most of these areas for feeding or other activities. However, the areas involved are not very large, at 46.7ha for the TM-CLKL in total, as compared with the predicted losses for other concurrent projects, specifically the 138ha for the HKBCF, as discussed further below. In addition, the submarine tunnel is proposed to be constructed using a TBM in order to avoid disturbance to the seabed and minimize the amount of dredged material to be removed. This proposed design would, also, minimise marine habitat loss and ecological impacts on the Chinese White Dolphins. However, given that some loss would occur, a minor impact would be predicted from the TM-CLKL alone and as such, some residual impacts would remain for habitat loss.

Ecological Resources

8.12.2.23 Major habitats to be lost due to reclamation will be approximately 600m of existing seawalls (390m of sloping seawall and 210m vertical seawall) at northern landing area of Tuen Mun and about 46.7ha of mostly soft-bottom seabed for the construction of the northern and southern tunnel landfalls (25.4ha adjacent to the HKBCF and about 21.1ha near Tuen Mun) and 0.2ha associated with the southern marine viaduct bridge piers. The artificial seawall habitats are common along the reclamation areas and the more prominent one include the Tuen Mun coast between the typhoon shelter and Butterfly Beach, the airport and north Lantau along the North Lantau Highway. New artifical seawalls will also be created as part of the new reclamations. While the affected soft-bottom seabed habitat will not be re-created, this is the dominant sub-tidal habitat in throughout Hong Kong (and the wider PRE) waters and the project related loss only represent a tiny fraction of similar habitat in Hong Kong. Thus, it is not anticipated that project works would significantly affect the overall species diversity or the carrying capacity of these habitats in Hong Kong.

8.12.2.24 While some gorgonian and the ahermatypic coral at the northern landing will be directly affected, they were also recorded at other suitable haibtats within the study area including the Brothers and the Tai Ho Wan. The proposed northern reclamation area is, thus, not of unique importance for the directly affected corals. Furthermore, colonies of suitable condition will be translocated before the works and some hard-substrate artificial seawall where some of these colonies were recoreded will be re-created to enable recolonisation by the corals. It is, therefore, not anticipated that the species abundance and diversity of corals in the North Lantau waters would be affected in a significant way.

8.12.2.25 Although intertidal habitats for horseshoe crabs, seagrasses and mangroves are found along coastline of north Lantau and Tuen Mun, no horseshoe crabs, seagrasses or mangroves were recorded in both the northern and southern reclamation areas. Hence, no intertidal habitats for seagrasses and mangroves or feeding grounds of horseshoe crabs would be diectly lost due to reclamation of TM-CLKL.

8.12.2.26 Apart from Chinese White Dolphin (CWD), no other marine species of conservation importance were recorded inside or in the vincinity of the both northern and southern reclamation areas. While the sea areas to be occupied are also habitat for CWD and their prey, the major food items of CWD would be estuarine fish. The fish production in the sea areas to be lost would be an indication of the food supply for CWD. Port Survey conducted AFCD provides information of the fisheries production in different areas in Hong Kong waters. In accordance with the results from Port Survey 2006, the sea area to be lost from the reclamations of the Project are not of high fisheries production. The fisheries production in these areas ranged from very low to moderate, when considering the fisheries production distribution in Hong Kong. The project footprint also would aviod most key areas of fish fry production or fisheries species spawning/nursery ground. There would not be any impact on the sustainability of the fish resources, i.e. the food supply to CWD, in North Lantau waters. The use of a tunnel Boring Machine (TBM) as the selected method for construction of the sub-sea tunnel would minimise disturbance to the seabed and the amount of dredged material to be removed (see Section 3). It is not anticipated that the carrying capacity of the North Lantau waters for CWD would be affected.

8.12.3 Accidental Spillage

8.12.3.1 There is the potential risk to the marine ecology due to the chemical or oil spillages arising from a vehicle accident during operation of the project. While

Dangerous Goods (DG) vehicles of Categories 1, 2 and 5 are prohibited from using the tunnel, tankers (DG Cat 5) will be allowed to use the southern marine viaduct and in the event of an accident with such a tanker, there is the possibility for the spillage of oil or chemicals. In this case, the integrated permanent road drainage system discharge any spilt materials into the marine environment, although the 0.8m profile barrier, which has been proposed along the marine viaduct, will prevent vehicles from leaving the road. The majority of Hong Kong road tanker transport will be of fuels, such as petrol, diesel and possibly LPG and LNG, together with some liquid chemicals.

8.12.3.2 By far the most serious environmental consequences of a major fuel spill would occur in the early stages when the split material may form extensive slicks on the sea surface. Direct contact with the oil or chemicals may affect many types of marine organisms.

8.12.3.3 Sessile and immobile fauna such as bivalve molluscs are more susceptible to direct contact than free swimming species. Exposure to aviation fuel could potentially cause smothering and clogging of gill filaments. Molluscs are able to avoid polluted ambient conditions for long periods through closure of the shell. Nevertheless these species remain vulnerable on account of their limited ability to metabolise and excrete fuel compounds (owing to relatively inefficient enzyme systems involved in petroleum hydrocarbon metabolism; Moore et al., 1987) and, thus, they may accumulate hydrocarbons from the water column to high concentrations (e.g., Goldberg et al., 1978).

8.12.3.4 Marine mammals have the ability to detect hydrocarbon spills and can take evasive action although the available evidence is not conclusive. Studies on captive bottlenose dolphins (*Tursiops truncates*), a species that is related to, and shares many ecological characteristics with the CWDs, showed that the dolphins can detect and avoid crude oil and mineral oil slicks (Smith et al., 1983; Geraci and St. Aubin, 1987). There is some data to suggest that dolphins cannot detect lightly coloured or refined oil or possibly chemical products that disperse into thin films (Geraci et al., 1983). However, field observations following incidents involving large crude oil tankers, also, suggested that the spills apparently did not cause significant damage to them. Ritchie and O'Sullivan (1994) reported negligible effects on otters, seals and dolphins following the wreck of the crude oil tanker the Braer off the Shetland Isles, UK. A review of another incident involving a major crude oil spill from the Sea Empress off the coast of Wales, UK found that whilst some seals caught up in the spill were oiled there were no mammal deaths caused by the spill (SEEC 1996). After the 1989 Exxon Valdez oil spill in Prince William Sound, Alaska, most cetaceans observed during monitoring surveys appeared to be behaving normally, although one Dall's porpoise (Phocoenoides dalli) was seen covered in oil and appeared stressed, with laboured breathing. Its fate is unknown (Harvey and Dahlheim 1994). A more recent assessment of the effects of the oil spill of the Erika, off the French Atlantic coast, however, did not observe any measurable effect on dolphins or seals (Ridoux et al., 2004). It shall be noted that, however, all these spills were primarily related to heavy oils such as crude oil, occurred on open coasts or involved more oceanic species that have more wide-ranging movements than do

Hong Kong CWDs. Dolphins in coastal areas, and especially those that inhabit bays and estuaries, are potentially more vulnerable to oil spill effects than are more oceanic species (Geraci 1990; Wursig 1990).

8.12.3.5 The most detailed observations of dolphins' responses to spills and oil spills in particular, and those most pertinent to the Hong Kong situation, are those of Smultea and Wursig (1992,1995) after the Mega Borg oil spill in 1990 in nearshore waters off Galveston Bay, in the Gulf of Mexico. Bottlenose dolphins were observed for several days from aircraft in the area around the oil spill. Dolphins consistently detected and avoided mousse oil, although group structure appeared to break down as dolphins moved around it. Slick oil appeared to be detectable to dolphins, but they were observed to swim through it. Of more direct relevance to the study area, previous reviewers have concluded that it is unlikely that a population of dolphins would be disabled by a spill at sea. Dolphins directly observed from reconnaissance aircraft and surface vessels following two oil spills in Texas, USA were also seen to move under or around thick oil slicks (from ERM review, 1995).

8.12.3.6 Behavioural studies of local CWD suggests that the normal swimming speed of the dolphins is about 1-2 m/s although as high as 4-6 m/s has been reported. The mean diving time is about 29 seconds although as long as 270 seconds has been recorded (Jefferson, 2000). In this situation, oil and chemical spillages would occur only under rare accidental events. A typical oil or chemical tanker capacity is between 10-12m^3 and in the event of an accident, the emergency call-out procedure in case oil/chemical spillage on the road would be rapidly implemented to clean-up and contain any spill. Assuming all the spill did enter the marine waters, as the fuels all have a specific gravity of less than 1 (water), they would all float on water. In respect of any petrol and diesel, the natural process of the spill spreading would reduce its thickness and allow the process of wind and wave action in breaking up the spill to increase as well as evaporation and dissolution. Dispersion of any spill will occur more rapidly in high energy waters which occur along the majority of the viaduct length. Both LPG/LNG have very low boiling points and would rapidly vapourise. Inorganic chemicals such as acids and alkalis, may not evaporate as quickly but would rapidly be diluted. The possible quantity of material is very small and the dilution and dispersion factors of the receiving waters so large (the tidal discharges across north of airport island between Tuen Mun and Chek Lap Kok are predicted to be in the range of 41,498 – 45,927 m^3/s, **Table 6.17**) in comparison.

8.12.3.7 Given the rapid dispersion/dilution and small quantity of material involved, it would, thus, appear that a dolphin could easily swim away from a spill without difficulty even if a spill did occur in its vicinity. Overall, it would appear that, there is evidence to suggest that dolphins are able to detect oil and outrun a spill without difficulties, although they may not necessary avoid them, especially a light sheen. It must be noted also that the probability of a dolphin actually coming into a contact with a spill in the first instance would be very low, notwithstanding the fact that the spill would dissipate very rapidly (within a few hours at any one location and within a few days overall as discussed below) and the fact that the dolphins stay below water most of the time whereas most fuel and chemicals, being lighter than water, would form a thin layer on the surface of the water before evaporating. As such, the likelihood of any actual exposure would be very small and of short duration.

8.12.3.8 In addition, biomagnification of spilled hydrocarbons through the marine food chain is unlikely to be a particular concern for CWDs. The principal food species of the CWDs are estuarine fish although squid and crustaceans (shrimp) may be occasionally preyed upon (Jefferson, 1998; 2000). Both fish and crustaceans are able to metabolise petroleum hydrocarbons (Capuzzo and Lancaster, 1981; Whipple et al., 1981; Brzorad and Burger, 1994) relatively efficiently although there may be some risk from species including molluscs (e.g. squid that may form part of the dolphins' diet) which may store hydrocarbon pollutants. In terms of the potential to affect the food chains and accumulation in dolphins, it should be noted that the vast majority of the spilled hydrocarbons (HCs), in the case of an oil spill, will be lost through evaporation and other weathering processes in a very short time (i.e., 2-3 days even for a large spill) and the amount remaining in the marine environment will be extremely low thereafter. Thus, the remaining amount of HCs which would ultimately become bio-available will be very small. As noted above, fish and crustaceans have the capability to metabolise/detoxify/excrete the petroleum hydrocarbons, and, for example, during the 5 years EM&A programme for the contaminated mud disposal site at East of Sha Chau (Meinhardt under preparation) between 2001-2005, 2680 fisheries samples (including fish, prawn and shrimps, crabs and squids) were analysed for contaminants including PCBs and PAHs. The result indicated that PCBs and PAHs were below analytical detection limits and the average detection frequency was only 1.7% indicating these contaminants were generally not bio-accumulated.

8.12.3.9 Post-spill studies of the Exxon Valdez (see API 2001 and the references cited) oil spill in 1989 did not show any evidence of biomagnification. In addition, demersal fish species swim predominantly under the surface and are very unlikely to come into direct contact with oil should a spill occur (with the fuel floating on the surface once spilt and evaporating rapidly). The chance of contaminated fish being subsequently eaten by a dolphin is very minimal. Dolphins do not lick themselves to clean fur, as some other marine mammals do, and are, thus, not likely to ingest enough oil for acute effects. While long term impacts from ingestion of small amounts of oil over time are possible (Geraci and St. Aubin 1980), this would not be an issue in this case as any spilled material would be in extremely small quantities and would not persist in the environment to cause any long term impacts. Based upon this and the very low probability of the spill occurring in the fist place, the likelihood of dolphins getting enough toxic chemicals into their systems through the food chain to do serious harm is small (Jefferson, pers comm.).

8.12.3.10 Furthermore, dolphins themselves are able to metabolise and excrete hydrocarbons and, thus, elevated accumulation within dolphin tissue is most unlikely. There is evidence to suggest both pinnipeds and cetaceans can metabolise petroleum hydrocarbons to polar metabolites because of the mixed-function oxidase system in their kidneys/ liver. Because polar metabolites are soluble, these can then be excreted (Haebler, 1994 and the references cited).

Long-term exposure to organic contaminants (such as DDTs, PCBs, HCHs, and PAHs), however, can cause reproductive compromise in dolphins (Geraci and St. Aubin 1987), and studies in Hong Kong are beginning to show some evidence for this in the local population of CWDs (Jefferson, 2005; Jefferson et al. in press). Cetaceans are known to have a very limited ability to metabolise organic contaminants, such as DDTs, PCBs, etc., and these substances appear to bioaccumulate in their tissues (Jefferson et al. in press). Hong Kong sediments have been found to contain significant quantities of PAHs and other petroleum hydrocarbons, which suggest that dolphins may be exposed to certain levels of these contaminants at low background levels (Zheng and Richardson 1999).

8.12.3.11 Fuel spills could also be a concern where they could potentially impact on slow growing coral species. The destruction of coral stands could take years to recover. Impacts on mangroves could also persist for many years if spilled fuel became entrained within the complex ecosystems in which any attempts at clean up are likely to be very problematic. Mangrove trees could defoliate on contact with fuel. Direct contact with an influx of fuel could be devastating for juvenile fish, molluscs and crustaceans and other fauna inhabiting the diverse mangrove habitat.

8.12.3.12 It should, however, be noted that crude oils and products differ widely in toxicity and environmental impacts. Crude oils is a natural mixture of hydrocarbons and other compounds which tends to be more persistent and could cause impacts both due to toxicity and physical effect such as smothering. Light oils, on the other hand, are highly volatile and non-persistent and, thus, are less environmental damaging. As the majority of the available data is associated with major crude oil spills, for the purposes of this assessment it is assumed that spilled fuel would be similarly damaging although it should noted that spills of light refined products (e.g., kerosene which is the major component of jet fuel) may evaporate completely within a few hours (ITOPF, 2002) and they would, thus, cause far less environmental damage compared to their heavier counterparts.

8.12.3.13 As the fuels/chemicals being transported and with the potential to be split are not the heavy crude oil but are generally, lighter materials that would float on the water surface and more rapidly disperse (light refined products like kerosene) may evaporate completely within a few hours (ITOPF, 2002), corals are not expected to be greatly affected by a spill and the depth of the water in the North-western waters is a sufficient buffer between the surface and sublittoral corals. Although major oil spills have been reported to cause substantial mortality in coral reef systems (GESAMP, 1993) it is notable that spill of 4000 tonnes of heavy marine diesel from Ap Lei Chau did not have any noticeable impacts on the coral reef fauna found subtidally at Lamma Island (Spooner, 1977). It would appear that intertidal corals are more vulnerable to oil than those found subtidally (GESAMP, 1993) presumably because oils are washed ashore and trapped in intertidal coral reefs. Oil pollution, also, appears to be most harmful to corals over prolonged (chronic) exposures (GESAMP, 1993). The coral data from the study area indicate that the species present are mostly subtidal and a surface spill is not considered to pose a significant threat.

8.12.3.14 Accidentally spilled fuels are known to be particularly damaging in low-energy shallow coastal waters that are often inhabited by important flora such as mangroves and seagrasses. The mangrove stands or seagrass communities in the immediate vicinity of the TM-CLKL are present at Tai Ho Wan, Tung Chung, San Tau and Sham Wat on the Northwest coast of Lantau (Tam and Wong, 2000). These areas have also been identified as horseshoe crab nursery grounds.

8.12.3.15 Accumulated heavy oils in low-energy habitats such as mangrove stands are known to be persistent and have the potential for long-term impacts. However, heavy oils are not predicted and the duration of impacts attributable to any spillage would be not expected to be persistent and chronic (long-term) exposures appear to be more damaging to biological communities. As noted above, a typical oil or chemical tanker capacity is between 10-12m^3 and in the unlikely event of an accident, the emergency call-out procedure in case oil/chemical spillage on the road would be rapidly implemented to clean-up and contain any spill. If some of the spill did enter the marine waters, the natural process of the spill spreading would reduce its thickness and allows the process of wind and wave action in breaking up the spill to increase as well as evaporation and dissolution. Dispersion of any spill will occur more rapidly in high energy waters which occur along the majority of the viaduct length. Notwithstanding, it is likely that a spill would disperse in a matter of days at most without any long term effects on water quality (ERM 1995). Notwithstanding, even based upon the worst case assumption that all of the contents of a tanker did find its way into the marine environment, the quantity is so small and the dilution and dispersion factors of the receiving waters so large (the tidal discharges across north of airport island between Tuen Mun and Chek Lap Kok are predicted to be in the range of 41,498 – 45,927 m^3/s, **Table 6.17**) in comparison, that significant impacts to water quality or any marine life would not be expected.

8.13 Summary of Impacts Evaluation

8.13.1.1 The potential ecological impacts to marine habitats and key sensitive receivers in the study area resulting from the project have been evaluated according to Table 1 of Annex 8 of the TM-EIAO and are presented in **Tables 8.27a-8.27g** below.

Table 8.27a Overall Impact Evaluation of Marine Waters

Evaluation Criteria	Marine Waters (Within Site Boundary)	Marine Waters (Outside Site Boundary)
Predicted Impact	Construction impact: Acoustic disturbance from construction work Operation impact: Habitat lost; Change of hydrodynamics and water quality; Marine fragmentation; Accidental chemical spillage	Construction impact: Alternation of hydrodynamics and water quality; Blocking of dolphin travel corridors, Acoustic disturbance from construction work; Injury/mortality or disturbance from vessel traffic; Disturbance to CWD from suspended solid and bio-accumulation Operation impact: Change of hydrodynamics and water quality
Habitat quality	The ecological value of this habitat is moderate as reflected by the moderate sighting density around the Brothers Islands.	The ecological value of this habitat is low to high depending on the location and the associated sighting density in north Lantau waters .
Species	The Chinese White Dolphin is regularly sighted in North Lantau waters, including the project site, year round.	The Chinese White Dolphin is regularly sighted in North Lantau waters year round.
Size/Abundance	The project site overlaps with part of the Northwest and Northeast Lantau areas. The encounter rates were 7.2 sightings per 100 km in Northwest Lantau and 2.2 sightings per 100 km in Northeast Lantau respectively. Low abundance.	The encounter rate in West Lantau was 17.9 sightings per 100 km which was the highest amongst all survey areas whereas the combined encounter rate of survey areas around Lantau was 7.2 sightings per 100 km (Hung 2009. Low to high abundance in different locations.
Duration	The habitat will be lost permanently (approximately 47ha). Operation impact of marine fragmentation and change of hydrodynamics and water quality will be long term.	The exact duration of temporary disturbance during construction phase is estimated to be 2.5 years. Operation impact of change of hydrodynamics and water quality will be long term.
Reversibility	Temporary disturbance to CWD during construction phase is reversible. Operation impact of marine fragmentation and change of hydrodynamics and water quality is irreversible. Permanent habitat loss is irreversible.	Temporary disturbance to CWD during construction phase is reversible. Operation impact of change of hydrodynamics and water quality is irreversible.
Magnitude	Small to Medium	Small to Medium
Overall impact conclusion	**Construction impact: Minor-moderate** **Operation impact: Insignificant to Minor**	**Construction impact: Insignificant to Minor-moderate** **Operation impact: Insignificant**

Table 8.27b Overall Impact Evaluation of Soft Substrate Benthic Habitat

Evaluation Criteria	Soft Substrate Benthic Habitat
Predicted Impact	Construction impact: Disturbance associated with suspended solid. Operation impact: Habitat loss.
Habitat quality	The ecological value of benthic habitats is low.
Species	No direct impact to species of conservation interest.
Size/Abundance	Permanent loss: approximately 47ha for northern and southern reclamation and pier construction
Duration	Direct loss will be permanent. The exact duration of temporary disturbance is estimated to be 2.5 years.
Reversibility	Permanent habitat loss is irreversible.
Magnitude	Small
Overall impact conclusion	**Construction impact: Minor** **Operation impact: Minor**

Table 8.27c Overall Impact Evaluation of Hard Substrate Habitat

Evaluation Criteria	Hard Substrate Habitat
Predicted Imapct	Construction impact: Disturbance associated with suspended solid. Operation impact: Habitat loss
Habitat quality	The scattered coral colonies associated with the hard substratum is considered to be of low-moderate ecological vaue. Coral colonies to be lost are located in the northern landfall at Tuen Mun.
Species	Solitary coral species Scletactinia and Gorgonacea were recorded at northern landfall. Stony corals (in order Scleractinia) are protected under Protection of Endangered Species of Animals and Plants Ordinance (Cap. 586).
Size/Abundance	Approximately 390m of sloping seawall and 210m of vertical seawall at Tuen Mun would be affected from the reclamation. There will be a permanent loss of subtidal habitat (approximately 8,580m^2 (0.8ha)) with any associated coral communities resulting from the landfall reclamations. The coral communities affected are common species with low coverage.
Duration	Direct loss will be permanent. The exact duration of temporary disturbance is estimated to be 2.5 years.
Reversibility	Although permanent habitat loss is irreversible, new sloping seawall totalling 34,303m^2 (3.4ha) subtidal area will be created at the both northern (Tuen Mun) and southern (HKBCF) reclamation area to replace the affected area.
Magnitude	Small to medium
Overall impact conclusion	**Construction impact: Minor** **Operation impact: Minor**

Table 8.27d Overall Impact Evaluation of Coastal Intertidal Habitats

Evaluation Criteria	Soft Shore	Natural Hard Shore	Artificial Hard Shore
Predicted Impact	Construction impact: Disturbance associated with suspended solid. Operation impact: n/a	Construction impact: Disturbance associated with suspended solid. Operation impact: n/a	Construction impact: Disturbance associated with suspended solid. Operation impact: Habitat loss
Habitat quality	The habitat quality is low to high.	The habitat quality is low-moderate.	The habitat quality is low
Species	No rare or protected plant species will be directly impacted.	No rare or protected plant species will be directly impacted.	No rare or protected plant species will be directly impacted.
Size/Abundance	Soft shores are located on the coastline along the North-western waters. The size of intertidal habitats is large.	Hard shores are located on the coastline along the North-western waters. Low species abundance.	Approximately 600m of coast line in Tuen Mun, including approximately 390m of sloping seawall and 210m of vertical seawall, will be directly lost as a result of reclamation activities in the northern landfall but it is mostly artificial seawall.
Duration	Intertidal habitats are not directly affected by this project. There is, however, potential for indirect impacts related to alterations in water quality. Distrubance associated with water quality alteration will be temporary.	Intertidal habitats are not directly affected by this project. There is, however, potential for indirect impacts related to alterations in water quality. Distrubance associated with water quality alteration will be temporary.	Direct loss will be permanent. Distrubance associated with water quality alteration will be temporary.
Reversibility	Temporary disturbance is reversible.	Temporary disturbance is reversible.	Although there is direct habitat loss due to construction work and the impact is irreversible, a total of about 2,100m of new ecologically enhancing sloping artificial seawalls will be created including 574m sloping seawall with 1,952m^2 (0.19ha) intertidal area at the northern reclamation area and 1565m sloping seawall with 5,321m^2 (0.53ha) intertidal area at the southern reclamation area. Temporary disturbance is reversible.
Magnitude	Small	Small	Small
Overall impact conclusion	**Construction impact: Insignificant Operation impact: n/a**	**Construction impact: Insignificant Operation impact: n/a**	**Construction impact: Insignificant Operation impact: Insignificant**

Table 8.27e Overall Impact Evaluation of Artificial Reef

Evaluation Criteria	Artifical Reef at Airport East Exclusion Zone and Sha Chau
Predicted Impact	Construction impact: Disturbance associated with suspended solid. Operation impact: n/a
Habitat quality	Moderate ecological value
Species	No rare species documented.
Size/Abundance	Species richness of fish is moderate within the artificial reef areas but the size of AR is small.
Duration	Direct loss will be permanent while the disturbance associated with water quality alteration will be temporary.
Reversibility	The temporary disturbance is reversible. In addition, new artificial reef will be deployed and replace the affected area
Magnitude	Airport East Exclusion Zone : Large given the close distance Sha Chau: Small
Overall impact conclusion	**Construction impact: Insignificant to Minor –moderate** **Operation impact: n/a**

Table 8.27f Overall Impact Evaluation of Marine Park

Evaluation Criteria	Sha Chau and Lung Kwu Chau Marine Park
Predicted Impact	Construction impact: Disturbance associated with suspended solid. Operation impact: n/a
Habitat quality	The habitat quality is high.
Species	Several sensitive receivers known to inhabit the park, including the Indo-Pacific Humpback dolphin, horseshoe crabs and coral communities.
Size/Abundance	The Marine Park comprises 1200 ha of estuarine waters around the islands of Sha Chau and Lung Kwu Chau
Duration	Marine park is not directly affected by this project. There is, however, potential for indirect impacts related to alterations in water quality. Distrubance associated with water quality alteration will be temporary.
Reversibility	The temporary disturbance is reversible.
Magnitude	Small
Overall impact conclusion	**Construction impact: Insignificant** **Operation impact: n/a**

Table 8.27g Overall Impact Evaluation of San Tau Beach and Tai Ho Stream SSSI

Evaluation Criteria	San Tau Beach and Tai Ho Stream SSSI
Predicted Impact	Construction impact: Disturbance associated with suspended solid. Operation impact: n/a
Habitat quality	The habitat quality is high
Species	Several rare species were found including mangrove, seagrass and horseshoe crabs.
Size/Abundance	The size of mangrove habitats is 2.7ha at San Tau Beach SSSI and 1.9ha at Tai Ho Stream SSSI. The area of seagrass bed is about 2 ha at San Tau and 0.05ha at Tai Ho.
Duration	Distrubance associated with water quality alteration will be temporary.
Reversibility	The temporary disturbance is reversible.
Magnitude	Small
Overall impact conclusion	**Construction impact: Insignificant** **Operation impact: n/a**

8.13.1.2 Mitigation measures are required to address the significant impacts predicted above. All the potential ecological impacts to marine habitats and key sensitive receivers in the study area resulting from the project together with the suggested mitigation or/and enhancement measures are summarised in **Tables 8.28 and 8.29** below. Details of the recommended mitigation and enhancement measures are provided in Section 8.14 below.

Table 8.28 Overall Construction Stage Impact and Mitigation/Enhancement

Potential Impact	Source	Receiver	Nature of Impact						Severity	Further Mitigation / Enhancement required
			Habitat Quality	Species affected	Size / abundance	Duration	Reversibility	Magnitude		
Construction Stage										
Alternation of hydro-dynamics and water quality (e.g. decrease DO, increase in nutrient)	Dredging and filling associated with reclamation works	Marine waters	Moderate – high for CWD; Low to moderate for corals; Low for benthos	Marine fauna in nearby waters such as CWD, corals and benthos	Localized area	Temporary	Reversible	Small	Insignificant	No but there would be water quality mitigation measures
Disturbance to soft substrate seabed associated with suspended solid	Dredging and backfilling associated with reclamation works and pier construction	Benthic Habitat	Low	Common infauna and epifauna in benthic community	Localized area	Temporary	Reversible	Small	Minor	No but there would be water quality mitigation measures
Disturbance to hard substrate seabed associated with suspended solid	Dredging and backfilling associated with reclamation works	Corals	Low to moderate	Various hard and soft corals in nearby waters	Localized area	Temporary	Reversible	Small	Minor	No but WQ mitigation would be provided.

Potential Impact	Source	Receiver	Nature of Impact						Severity	Further Mitigation / Enhancement required
			Habitat Quality	Species affected	Size / abundance	Duration	Reversibility	Magnitude		
Disturbance to soft shore associated with suspended solid	Dredging and backfilling associated with reclamation works	Intertidal habitat	High for TCB, ST; Moderate for HKW, SLW, SW and THW; Low-moderate for SSW and low for BB (Table 8.25d)	Horseshoe crab, seagrass and mangrove	Localized area	Temporary	Reversible	Small	Insignificant	No but WQ mitigation would be provided
Disturbance to hard shore associated with suspended solid	Dredging and backfilling associated with reclamation works	Intertidal habitat	Low	Common intertidal species	Localized area	Temporary	Reversible	Small	Insignificant	No but WQ mitigation would be provided
Disturbance to Artificial Reef in Sha Chau and Lung Chu Chau Marine Park associated with suspended solid	Dredging and backfilling associated with reclamation works	Artificial Reef	Moderate	Epifauna and fish	$5,580m^3$	Temporary	Reversible	Small	Insignificant	No

Potential Impact	Source	Receiver	Nature of Impact						Severity	Further Mitigation / Enhancement required
			Habitat Quality	Species affected	Size / abundance	Duration	Reversibility	Magnitude		
Disturbance to Artificial Reef in Airport East Exclusion Zone associated with suspended solid	Dredging and backfilling associated with reclamation works	Artificial Reef	Moderate	Epifauna and fish	$3600m^3$	Temporary	Reversible	Large given the close distance	Minor to moderate	Re-provision of artificial reef
Disturbance to Sha Chau and Lung Kwu Chau Marine Park associated with suspended solid	Reclamation	Marine Park	High	CWD, Horseshoe crab and corals	1,200ha	Temporary	Reversible	Small	Insignificant	No but there would be water quality mitigation measures
Disturbance to SSSI associated with suspended solid	Reclamation	SSSI	High	Horseshoe crabs, mangrove and seagrass	2.7ha for San Tau SSSI and 5ha for Tai Ho Stream SSSI	Temporary	Reversible	Small	Insignificant	No but there would be water quality mitigation measures
Blocking of dolphin travel corridors	All marine works	Marine Waters	Moderate to high	CWD	Area in between Tuen Mun/Lung Kwu Chau area and the Brothers Islands/Sham Shui Kok; Low – moderate abundance.	Temporary	Reversible	Small given no complete physical blockage of the travelling corridors	Minor	No, but comprehensive EM&A, including pre-, during and post-construction monitoring would be carried out.

Potential Impact	Source	Receiver	Nature of Impact						Severity	Further Mitigation / Enhancement required
			Habitat Quality	Species affected	Size / abundance	Duration	Reversibility	Magnitude		
Acoustic disturbance from construction work	Reclamation and dredging works	Marine Waters	Moderate to high	CWD	Low to moderate abundance	Temporary	Reversible	Medium	Minor-moderate	Acoustic decoupling of noisy equipment from the vessels Use of dolphin exclusion zone
Acoustic disturbance from construction work	Sheet piling	Marine Waters	Moderate to high	CWD	Low to moderate abundance	Temporary	Reversible	Medium	Minor-moderate	Use of dolphin exclusion zone
	Bored pilling	Marine Waters	Moderate	CWD	Low to moderate abundance	Temporary	Reversible	Medium	Minor-moderate	Avoidance of metal caisson driving during peak calving season of May and June Use of Dolphin exlusion zone throughout works Also, bored piling monitoring would be carried out as part of EM&A.

Potential Impact	Source	Receiver	Nature of Impact						Severity	Further Mitigation / Enhancement required
			Habitat Quality	Species affected	Size / abundance	Duration	Reversibility	Magnitude		
Disturbance to CWD from suspended solid and bio-accumulation	Redistribution of contaminants due to dredging and backfilling	Marine Waters	Moderate to high	CWD and their prey	Low to moderate abundance	WQ alternation is temporary but bio-accumulation is long term.	WQ alternation is reversible but bio-accumulation is irreversible.	Small	Minor	No but there would be water quality mitigation measure
Injury/ mortality or disturbance from vessel traffic	Vessel traffic associated with construction	Marine Waters	Moderate to high	CWD	Low to moderate abundance	Temporary	Reversible	Small	Minor-moderate	Vessel speed limits and restrictions Regular vessel route

Table 8.29 Overall Operation Stage Impact and Mitigation/Enhancement

Potential Impact	Source	Receiver	Nature of Impact						Severity	Further Mitigation / Enhancement required
			Habitat Quality	Species affected	Size / abundance	Duration	Reversibility	Magnitude		
Operation Stage										
Marine fragmentation	Viaduct	Marine waters	Low to High	Benthic and intertidal fauna, corals, CWD	Low to High	Long term	Irreversible	Small	Insignificant	No but comprehensive EM&A, both vessel-based and land-based monitoring would be carried out.
Change of hydro-dynamic regime and water quality	Presence of new landform and Surface Runoff	Marine waters Marine waters and various marine and coastal habitats	Moderate – high for CWD; Low to moderate for corals; Low for benthos; High – low for various soft and hard shores (Table 8.25d)	Marine and coastal organisms including CWD, horseshoe crabs and mangrove	Extensive area	Permanent but transitory for surface runoff	Irreversible	Small	Insignificant	No. Silt-grease traps in bridge and reclamation area.
Loss of soft substrate seabed	Dredging and filling associated with reclamation works and pier construction	Benthic Habitat	Low	Common infauna and epifauna in benthic community	21ha for northern reclamation; 25.4ha for southern reclamation; 0.2ha for viaduct piers	Permanent loss after completion	Irreversible	Small	Minor	No

Potential Impact	Source	Receiver	Nature of Impact						Severity	Further Mitigation / Enhancement required
			Habitat Quality	Species affected	Size / abundance	Duration	Reversibility	Magnitude		
Loss of subtidal hard substrate	Reclamation	Corals	Low to moderate	Gorgonian and ahermatypic coral recorded at Tuen Mun coastline	210m of vertical seawall; 390m of sloping seawall	Permanent loss after completion	Irreversible	Small – medium	Minor	Coral translocation is suggested as an additional enhancement and similar subtidal habitats would be provided by the new sloping seawall.
Loss of existing seawall in Tuen Mun	Reclamation	Intertidal habitat	Low	Common intertidal species	210m of vertical seawall; 390m of sloping seawall	Permanent loss after completion	Irreversible	Small	Insignificant	No but more seawall would be created after reclamation.
Loss of marine waters/habitat	Reclamation	Marine Waters	Moderate	CWD	21.1ha for northern reclamation; 25.4ha for southern reclamation; 0.2ha for viaduct piers; Low abundance	Permanent	Irreversible	Small	Minor	No
Accidental chemical spillage	Vehicle accidents involving oil or chemical tankers	Marine waters and various marine and coastal habitats	Low to High	Marine and coastal organisms such as CWD, mangrove and coral.	Extensive area	Temporary	Reversible	Small	Insignificant	No as territory emergency procedures in place

8.14 Mitigation Measures

8.14.1 Marine Ecology

8.14.1.1 As presented in Annex 16 of the TM, mitigation measures for projects in important habitat and relating to wildlife in order of priority are:

- avoidance;
- minimising; and
- compensation.

8.14.1.2 The preferred location for construction of the TM-CLKL has been assessed previously (see Section 2) and the proposed scheme has been selected in order to **avoid or minimise** impacts where possible. The selected scheme avoids major sensitive receivers including marine park, SSSIs, mangrove, seagrass beds, horseshoe crabs site and Tai Mo To. It has the following advantages, as follows:

- avoiding the coral and horseshoe crab habitats at Tai Mo To coastal areas;
- minimising impacts to prime dolphin habitat at Tai Mo To;
- avoiding large areas of dredging work and reducing impact on the seabed, benthic community and direct impacts to marine waters which are the habitat for marine mammals by using TBM instead of IMT;
- combining the TM-CLKL southern landfall reclamation with the HKBCF to minimize reclamation area and habitat loss; and
- use of non-dredge reclamation techniques are proposed where possible to avoid sediment dredging and removal.

8.14.1.3 Hydrodynamic and water quality modeling has indicated that the proposed reclamation and associated facilities will not lead to significant large scale changes during the operational phase. While localized effects are predicted, the predicted changes are small and would unlikely lead to significant adverse ecological impact in terms of both water quality and habitats stability.

8.14.1.4 The construction phase water quality assessment also indicated there shall be no significant adverse changes in water quality with the recommended mitigation for protection of water quality. It has concluded that no ecological sensitive receivers are predicted to be significantly adversely impacted. As the predicted impacts are predominantly confined to the construction phase and, hence, are short-term, project-specific impacts are not expected to result in unacceptable impacts to water quality and, hence, unacceptable secondary marine ecological impacts are similarly not anticipated. The mitigation measures (as detailed in Section 6.10), which are designed to prevent adverse impacts to water quality (for example, using silt curtains,) will also be effective in preventing impacts to the marine ecological receivers. It is, therefore, anticipated that no further specific mitigation and enhancement measures to protect marine ecological receivers, with exception of the potential impacts to artificial reef at north-east of the airport, CWD and coral colonies at Tuen Mun, are required. The proposed specific ecology mitigation and enhancement measures for the artificial reef at the NE of the airport, corals and CWD are discussed below.

8.14.2 Artificial Reef at Norht-east of Airport

8.14.2.1 It is proposed that in **compensation** for the predicted construction impacts on the AR in the airport exclusion zone from the TM-CLKL and HKBCF projects, a further AR is deployed in an area where fishing activities are prohibited. This would be a joint measure between the TM-CLKL and HKBCF projects. The existing artificial reef will be left in place and it may recover over time once the construction works have been completed, however, this is not being assumed in determining the mitigation. Thus, in order to mitigate for impacts from the TM-CLKL, HKBCF and HKLR projects, the replacement AR would be expected to be of an equivalent size as that lost, that is 1,200m^2.

8.14.2.2 The new AR which would have the double role of replacing the AR to be affected but, also, has will have some beneficial effects on fishing resources, corals and other benthos in the area. Based upon these measures, significant residual impacts are not predicted.

8.14.3 Corals

8.14.3.1 As detailed in Section 8.11.4, the water quality of the coral colonies recorded around the project sites are generally predicted to occasionally exceed the WQO and also the sedimentation rate can sometimes exceed the tolerance threshold, without appropriate water quality mitigation measures being applied. The proper implementation of the water quality mitigation measures, however, would ensure full WQO compliance at most of the known coral sites and deposition within the tolerance criteria of 200 $g/m^2/day$ at all coral sites. Hence, no significant adverse impacts are anticipated.

8.14.3.2 However, for the coral colonies at Tuen Mun, even with the application of silt curtain system, WQO exceedances predicted in about 11 % of the wet season period (but not the dry season), although the level of exceedances of SS elevation are generally of low level (max elevation of 5.9 mg/L). While there are still some predicted WQO exceedances at Tuen Mun coral site, both the magnitude and frequency is low and it is only predicted during the later period (2013) of the construction programme.

8.14.3.3 It is unlikely that either hard or soft corals outside of the dredged areas will encounter unacceptable impacts and it should be noted that the majority of species within the study area are generally ahermatypic (i.e., do not contain symbiotic zooxanthellae which require high light levels for photosynthesis). Octocorals corals that are more typical of the study area would, also be even more tolerant and there is no reason to believe that they would be impacted.

8.14.3.4 Although the low level and infrequent WQO exceedances are not expected to cause significant adverse impacts, as an enhancement measure, translocation of corals communities to be affected is recommended. Full details of the translocation specification are provided in the EM&A Manual.

8.14.4 Chinese White Dolphin

8.14.4.1 Based upon the predicted impacts to the Chinese White Dolphin from the construction of the works, a range of mitigation measures as well as ecological monitorings have been recommended as summarised below in **Table 8.30**.

Table 8.30 Summary of Mitigation and Monitoring for Chinese White Dolphins

Impact	**Significance**	**Mitigation**	**Mitigation Type**	Monitoring
Loss of Dolphin Habitat	Minor	None project specific (See cumulative impacts section)	Compensation	n/a
Blockages of travel corridor	Minor	n/a	n/a	Dolphin Monitoring
Acoustic disturbance from sheet piling	Minor to moderate	Dolphin Exclusion Zone	Minimisation	n/a
Acoustic disturbance from dredging and reclamation	Minor to moderate	Acoustic Decoupling Dolphin Exclusion Zone	Minimisation	n/a
Acoustic disturbance from bored piling	Minor to moderate	Dolphin Exclusion Zone Temporal Closure	Minimisation	Bored Piling Monitoring
Injury/Mortality or Disturbance from Vessel Traffic	Minor	Vessel Speed Limits and Restrictions	Minimisation	n/a

8.14.4.2 Further details of the mitigation measures are also provided in the sections below while details of the ecological monitoring and audit requirements are provided in the Section 8.18.

<u>Dolphin Exclusion Zones</u>

8.14.4.3 When intermittent construction activities have the potential to cause behavioural disturbance or even physical harm to small cetaceans, monitored exclusion zones can help to reduce the chances of impacts (see Jefferson 2000; Caltrans 2006). As only Chinese White Dolphins within close range of the activity of interest are at risk, therefore, the risk can be minimised and avoided by not undertaking such activities when Chinese White Dolphins are nearby. Exclusion zones are often used as mitigation measures in military and oil industry seismic surveys, but the diameter of the zone is highly variable, and there is generally little confirmation of the effectiveness of these measures (see Weir and Dolman 2007). Exclusion zones ranging from 250m to 500m in radius have been used in Hong Kong, depending on the activity. "Lower impact" activities such as dredging and cable–laying operations have used only a 250m radius, while those activities that are perceived to be more harmful (e.g., underwater blasting or percussive piling) can apply up to a 500m radius. Based upon the above, as no percussive piling will be undertaken, an exclusion zone of 250m radius would be considered appropriate (Jefferson pers. comm.).

8.14.4.4 The principles of the exclusion zone are that, during daylight hours, the area should be visually inspected for Chinese White Dolphins prior to commencement of dredging, reclamation or sheet piling works. The sheet piling works will be restricted to 12 hours a day. However, it is possible that the other marine works for the TM-CLKL, including the bored piling, would continue for 16 hours per day. As such, as the visual exclusion zone relies on the visual detection of Chinese White Dolphins, it would not suitable during evening or nighttime periods. Based upon this, an alternative method using Passive Acoustic Monitoring (PAM) would be required for any works outside the daylight hours, including the dredging and reclamation works and also bored piling works. PAM involves the use of hydrophones or cetacean detectors. The specification prepared during the detailed design should further specify the use of PAM.

8.14.4.5 The dolphin exclusion zone should be monitored by independent dolphin observers with an unobstructed, elevated view of the area. Dredging, reclamation and sheet piling works would not be allowed to begin until the observer certifies that the area is continuously clear of Chinese White Dolphins for a period of 30 minutes (see Weir and Dolman 2007) (thereby adequately spanning the approximate maximum dive time of the Chinese White Dolphins of 4 minutes). Works should, also, cease if Chinese White Dolphins move into the exclusion zone/area during these activities and works should not start again until the observer has confirmed that the area is continuously clear of Chinese White Dolphins for a period of 30 minutes.

8.14.4.6 The observers must be suitably trained in biology and should be independent of the construction contractor and should form part of the independent Environmental Team (ET) to be employed by the Contractor. An Independent Environmental Checker (IEC) would be required to audit the work of the ET. An important aspect of applying this mitigation technique effectively is that the observer should have the power to call-off construction activities to monitor the exclusion zone.

Geographical or Temporal Closures

8.14.4.7 Temporal and geographic closures can be used to to avoid unexpected impacts on critical habitat and impacts on highly-vulnerable age classes, such as newborn calves.

8.14.4.8 The most obvious way to reduce or eliminate impacts of various disturbing activities is to plan those activities to occur in places or at times when the animals of interest are not present. Area closures and avoidance of critical habitats are considered the most effective and precautionary measures available to mitigate against impacts from seismic survey work (Weir and Dolman 2007). Even when the animals are present, temporal or geographic closures that restrict the activities to lower density areas/times, or to less sensitive areas/periods, may be similarly useful. Of course, such measures require that something is known about small-scale patterns of distribution, seasonal shifts in density, diurnal patterns, and/or seasonality. When this information is available, it is often possible to use it to reduce impacts through closures. Although time and area closures have been used extensively as a mitigation measure to reduce small cetacean bycatch in various fisheries (Jefferson et al. 1994; Murray et al. 2000; Bisack and Suitnen 2006), they have been much less extensively used to protect cetaceans from the impacts of marine construction and demolition activities.

8.14.4.9 For instance, in Hong Kong, for many years it has been common practice to restrict potentially harmful activities (such as blasting and percussive piling operations) to periods outside the main calving season for both finless porpoises and CWD. The reasoning behind this procedure is that such time periods represent particularly sensitive ones for newborn calves and lactating females. As such, by simply not allowing harmful activities during these sensitive periods, the risk of injury or disturbance to more sensitive members of the population can be reduced.

8.14.4.10 Marine mammals (and Chinese White Dolphins and porpoises, in particular) are very difficult to detect in low-light or rough-weather conditions (see Jefferson and Leatherwood 1997 and Jefferson et al. 2002 for Hong Kong examples). Therefore, temporal closures for construction activities during night-time and adverse weather are generally considered important, due to the lack of alternative methods of mitigation during these conditions (see Weir and Dolman 2007).

8.14.4.11 Geographic closures are harder to implement, as most small cetaceans do not have ‘nursery areas’ in the sense that most fish do, that is, areas where only the reproductive segment of the population segregates itself to produce offspring. However, there are sometimes areas with higher densities of Chinese White Dolphins/porpoises, and even areas with higher densities of mother/calf pairs. Such areas can be viewed as particularly critical habitat, and when such areas have been identified, they are prime candidates for geographic closures. Such measures have been used on small scales in Hong Kong waters.

8.14.4.12 Given the extensive nature of the works, in addition to existing activities in the area such as marine access, geographic closures are not considered practical in this instance. However, temporal closures may be applied. According to recent dolphin data (Jefferson, 2005) the dolphin calving season is from March to August and about 76% of calves are born in this period, but with May and June being the critical months. Thus, in order to minimise disturbance to mother and calves, the installation of the metal caisson into rock during bored piling will avoid the peak months of dolphin calving (May and June).

Acoustic Decoupling of Noisy Equipment

8.14.4.13 Construction equipment can be noisy and, when such pieces of equipment are used on the water or in coastal areas, some of the sound may be transmitted into the water and affect small cetaceans as noise pollution. It is, therefore, desirable to reduce construction noise as much as possible. Construction machinery, such as compressors and generators, that are placed onto the steel hulls of barges are particular culprits. Air compressors and other noisy equipment that must be mounted on the steel piling barge should be acoustically-decoupled to the greatest extent feasible, for instance by using rubber or air-filled tyres. Specific acoustic decoupling measures shall be specified during the detailed design of the project for use during bored piling, dredging and reclamation works. This technique has been used extensively in Hong Kong since the airport construction project (see Jefferson 2000).

Vessel Speed Limits and Restrictions

8.14.4.14 As it appears that faster-moving vessels are more of a threat to Chinese White Dolphins and porpoises, a speed limit of 10 knots should be strictly observed within the works area where Chinese White Dolphins are likely to occur, namely all areas north and west of Lantau Island. This speed limit within the boundaries of the Sha Chau and Lung Kwu Chau Marine Park appears to be effective in protecting the Chinese White Dolphins from vessel collisions and acoustic disturbance. The Contractor, in conjunction with the Environmental Team, should undertake workshop(s) for all vessel captains working in the area, prior to construction, to educate them about local cetaceans, as well as guidelines for safe vessel operations in the presence of Chinese White Dolphins and porpoises. Also, vessels traversing through the work areas should also be required to use predefined and regular routes to reduce disturbance to cetaceans due to vessel movements. Specific marine routes shall be specified by the Contractor prior to construction commencing.

8.14.4.15 The temporary mitigation measures of vessel speed limits and predefined and regular routes are only proposed for construction vessels during the construction phases within the works area. Its implementation should only be enforced by the Contractor and applied to their vessels engaging in the construction works under contractual agreement. A specification for defining the Vessel Speed Limits and Restrictions should be prepared and agreed during the detailed design stage for inclusion in the contract documents.

8.15 Enhancement Measures

8.15.1 Background

8.15.1.1 Mitigation measures have been detailed above to ameliorate against specific impacts to the marine environment. However, notwithstanding, further measures to enhance the marine environment are, also, provided. While significant impacts are not predicted and mitigation not recommended required for the direct loss of gorgonian and ahermatypic corals from the seawall in Tuen Mun as a result of the northern landfall reclamation works nor the effects of the construction works on corals in the area, some enhancement measures are recommended for corals, as summarised below in **Table 8.31** and defined further in the sections below. In addition, an additional 2,400m^2 AR deployment as an **enhancement** measure is also proposed. The overall size, comprising both mitigation and enhancement measures would be on a size ratio of 1:3 to the existing one, that is a total area of 3,600m^2 and a volume of 10,800m^3.

Table 8.31 Summary of Enhancement Measures

Impact	Enhancement Measure
Loss of Artificial Reef at East of Airport Island	Reprovision of twice the size of AR
Permanent Coral Habitat Loss	Coral Translocation

8.15.2 Artificial Reef

8.15.2.1 While an AR of an equivalent size of 1,200m^2 will proposed to be deployed as a compensation for the loss of the AR at the east of the airport island from construction impacts, further enhancement of the marine environment is proposed compensation for the loss by providing an additional 2,400m^2 AR deployment as an **enhancement** measure is, also, proposed. The overall size, comprising both mitigation and enhancement measures would be on a size ratio of 1:3 to the existing one, that is a total area of 3,600m^2 and a volume of 10,800m^3.

8.15.3 Coral Translocation

8.15.3.1 A detailed translocation methodology (including pre-translocation survey, identification of receiving sites and post-translocation monitoring) should be drafted during the detailed design stage of the Project and approved by the relevant authorities. All coral identification and mapping work should be conducted by a qualified marine biologist with specialist knowledge of corals and sound experience at identifying sessile benthic taxa in the field.

8.16 Residual Impacts for TM-CLKL

8.16.1.1 The residual environmental impacts refer to the net environmental impacts after the implementation of mitigation measures, taking into account the background environmental conditions and the impacts from existing, committed and planned projects.

8.16.1.2 With mitigation measures properly implemented, there will be no residual impacts on horseshoe crabs and seagrass beds because the horseshoe crab nursery sites and seagrass habitats (soft shores along Airport Channels and Tai Ho Wan) will remain intact. Other residual impacts include the loss of subtidal benthic habitat (33.1ha of soft substrate seabed), subtidal hard substrate seabeds (about 600m along seawalls and 0.8ha of subtidal habitat) and the hard shore intertidal habitat (about 600m of artificial seawalls), and are also considered acceptable.

8.16.1.3 The application of the above mitigation measures is considered sufficient to mitigate the majority of the predicted impacts from the TM-CLKL. However, the marine viaduct piers (0.2ha), southern (25.4ha) and northern (21.1ha) reclamation of TM-CLKL will result in some loss of marine waters habitat, in particular for the Chinese White Dolphin and, thus, there will be a minor impacts associated with the loss of dolphin habitat for the TM-CLKL. While strategic measures for cumulative habitat loss can be pursued, there is limited availability for project specific compensation for the habitat loss and, as such residual impacts would occur.

8.16.1.4 **Table 8.32** below presents the assessment of residual impacts on the CWD due to habitat loss.

Table 8.32 Assessment of Residual Impacts from CWD Habitat Loss

Criteria	Assessment
Effects on public health and health of biota or risk to life.	The TMCLKL will be situated at the centre of North Lantau waters, one of the key habitats to the dolphins (Jefferson and Hung 2004; Hung 2008). There is some concern that construction and operational impacts could result in lowered fitness, reduced reproductive output or reduced survival, thereby affecting the overall health of the dolphin population in Hong Kong, especially the ones that spend a majority of their time in North Lantau waters and roam frequently between core areas around the Brothers Islands and the Sha Chau and Lung Kwu Chau Marine Park. However, for the TM-CLKL, the construction impacts will be temporary, reversible and mitigation measures have been recommended to reduce the magnitude of impacts relating to suspended solids dispersion, noise and disturbance and vessel movement that could affect dolphin feeding, behaviour and health to a minimum and are not expected to be significant. Notwithstanding there will be some permanent loss of seabed area that will reduce the overall CWD habitat by 47ha. However, the reclamations are in areas with relatively lower densities of CWD and the loss of habitat is small in comparison to their total range and would not be predicted to significantly affect their health or cause loss of life.
Magnitude of the adverse environmental impacts.	The adverse impacts from TM-CLKL construction in isolation are expected to be minor to moderate, since the habitat loss through reclamations for the southern and northern landfalls will be relatively small. Other construction phase impacts would be temporary and reversible and implementing the appropriate recommended mitigation measures would reduce these to acceptable levels. The TM-CLKL would be one of the projects contributing to cumulative impacts as there are

Criteria	Assessment
	other projects proposed to be undertaken in the study area that would contribute more significantly to the cumulative impacts in the area.Given the magnitude of the other concurrent projects proposed, the majority of the cumulative impacts would be expected to come from the HKBCF reclamation because of its large size and permanent and irreversible impacts. (138ha compared to 47ha for the TM-CLKL and about 240 dredgers and barges over the 3 year construction period for the HKBCF, compared to about 25 for the TM-CLKL). Thus, the contribution from the TM-CLKL would be small overall and in terms of seabed loss would contribute less than 10% with all concurrent projects taken into account.
Geographic extent of the adverse environmental impacts.	The geographic extent of the adverse impacts on dolphins from TM-CLKL construction will not be very large and will be limited to within a confined area within the works area in the North Lantau waters. This includes the dispersion of suspended solids during dredging and filling works for the TM-CLKL, HKBCF and HKLR projects which will be controlled to be within a short distance (less than 250m) of the works area with the implementation of water quality mitigation. In addition, it should be noted that habitat loss represents a small proportion of the available habitat in Hong Kong waters. North Lantau (~140 km^2) represents a fairly small portion of the overall CWD population's range in the Pearl River Estuary (~2,000 km^2), and dolphin abundance estimates in North Lantau (~100 dolphins) comprise a small percentage of the entire PRE population (~1,200-1,400 dolphins) (Jefferson 2007; Jefferson and Hung 2004). Notwithstanding the importance of North Lantau being magnified when it is noted that it is one of two primary areas in Hong Kong where dolphins occur in high densities year-round (Jefferson 2007), the mitigation measures proposed will confine the influence of the TM-CLKL to a small area, relatively and to areas which are of lower dolphin densities.
Duration and frequency of the adverse environmental impacts.	The construction-phase impacts of TM-CLKL construction will be of short to moderate duration and, therefore, temporary and reversible. However, the loss of habitat through reclamation in the marine habitat will be permanent. The

Criteria	Assessment
	areas involved are not very large, at 47ha for the TM-CLKL in total, as compared with the predicted losses for other concurrent projects. In addition, measures such as adopting the use of TBM for the construction of the submarine tunnel will avoid disturbance to the seabed and minimize the amount of dredged material to be removed. Notwithstanding the permanent area to be lost would be minor impact.
Likely size of the community or the environment that may be affected by the adverse impacts.	The overall geographic extent affected by the TM-CLKL will be confined to a relatively small area, and to areas which are of lower dolphin densities in North Lantau.
Degree to which the adverse environmental impacts are reversible or irreversible.	Construction-phase impacts should be reversible, but operation-phase impacts associated with habitat loss from reclamation and filling will be permanent and irreversible.
Ecological context.	The North Lantau area has been subject to significant disturbance and development over the years, including from projects such as the construction of the airport (and the associated Aviation Fuel Receiving Facility), North Lantau Transport Corridor, River Trade Terminal, Tuen Mun Areas 38 reclamation and the operation of the mud pits at East of Sha Chau and the Brothers. The area is also subject to notable marine traffic along the Urmston Road and fishing vessels throughout the area. Some impacts from these works have been noted on the marine ecosystems in the study but there is also evidence to suggest that the ecosystems have been tolerant to changes and recovered after the projects have been completed. The North-western waters are also influenced by some large seasonal variations in water quality (salinity and suspended solids) and naturally occurring marine sediment contamination to which the species present have habituated. Notwithstanding, it is still used by dolphins as a major habitat in Hong Kong (Jefferson 2000; Jefferson and Hung 2004; Hung 2008).
Degree of disruption to sites of cultural heritage.	Not applicable
International and regional importance.	According to the IUCN Red List of Threatened Species, the CWD is currently listed with the status “Near Threatened” (Reeves et al. 2008), which is close to qualifying for or is likely to qualify for a threatened category in the near future (IUCN 2008 (www.iucnredlist.org)). The Hong Kong/PRE CWD population is the likely the best-studied, most well-known, and the largest

Criteria	Assessment
	known in the world (Jefferson 2007; Reeves et al. 2008).
Likelihood and degree of uncertainty of adverse environmental impacts.	There is a small degree of uncertainty as to the exact impacts from this project. There have been no specific studies of the impacts of bored piling on dolphins, nor how much the construction of the project will affect dolphin movement corridors between the North-west and North-east Lantau. Notwithstanding, a precautionary approach has been applied to defining mitigation measures for the protection of the CWD from the project implementation.

8.16.1.5 While it is clear that the CWD is of local, regional and international importance, the study area in North Lantau is one of two primary areas in Hong Kong where dolphins occur in high densities year-round (Jefferson 2007) and there is some degree of uncertainty of the impacts, the following factors should be considered in determining the residual impacts associated with the CWD habitat loss for the TM-CLKL:

- implementation of the project is not predicted to significantly affect their health or cause loss of life;
- the magnitude of impacts relating to suspended solids dispersion, noise and disturbance and vessel movement that could affect dolphin feeding, behaviour and health are not expected to be significant;
- the majority of the predicted impacts are temporary and reversible;
- the geographic extent of the adverse impacts on dolphins from TM-CLKL construction will not be large;
- the mitigation measures proposed will confine the influence of the TM-CLKL to a small area,
- the study area has not shown itself to be fragile or undisturbed;
- the TM-CLKL itself would only be one of the projects contributing to cumulative impacts; and
- the contribution from the TM-CLKL to cumulative impacts would be small overall.

8.16.1.6 Based upon the above, the residual impacts associated with the CWD habitat loss for the TM-CLKL would be considered minor and acceptable.

8.17 Cumulative Impacts

8.17.1 Background

8.17.1.1 Marine systems are exposed to a wide range of impacts although, to date, few studies in Hong Kong have addressed cumulative ecological impacts associated with construction projects. Cumulative ecological impact assessments need to consider all activities in the study area in addition to the impacts predicted directly from the TM-CLKL. The cumulative impacts are, therefore, likely to be wider in scope than the potential impacts attributable only to the TM-CLKL.

8.17.1.2 The predicted impacts from this study are predominantly confined to the construction phase and of short duration, with marine works anticipated to take a maximum of about 3 years and no operational phase maintenance dredging is required. However, some permanent loss of habitat will result but this is considered to not significant compared to other proposed projects. There are many projects being proposed to be implemented in the same study area and those that are concurrent to the TM-CLKL construction phase may cause cumulative impacts to the marine ecology of the study area, potentially resulting in the following (ERM, 1997):

- a prolonged period of impact;
- an increased intensity of the impact; and
- induced synergistic impacts (i.e., effects that are greater in combination than singularly).

8.17.1.3 In addition to the construction phase impacts, projects which comprise land reclamation can result in further temporary or permanent loss of marine habitats. A review of the concurrent projects in the study area is provided in **Appendix A2** of this report. In summary, the following projects detailed in **Table 8.33** below are relevant to the marine environment during the construction and operational phases.

Table 8.33 Summary of Possible Concurrent Projects which could Result in Cumulative Impacts during Construction and Operation

Proposed Development	Impacts to be Considered
Kwai Tsing Container Basin Dredging	Construction and Operation
Lantau Logistics Park (LLP)	Construction (72ha development) Operation (72ha and 40ha developments)
Tonggu Channel	Construction (completed) and Operation (annual maintenance dredging)
Hong Kong Zhuhai Macao Bridge (HZMB)	Construction and Operation (25ha of artifical islands just outside HK marine boundary)
Hong Kong Zhuhai Macao Bridge (HZMB) – Hong Kong Link Road (HKLR)	Construction and Operation (27ha of reclamation required and about 3ha for marine viaduct piers).
HZMB Hong Kong Boundary Crossing Facilities (HKBCF)	Construction and Operation (138ha of reclamation required).
Road P1, Sham Shui Kok to Sunny Bay	Operation (based on assumed programme to be operational in 2026)

Proposed Development	Impacts to be Considered
Remaining Development in Tung Chung (East and West)	Operation (construction to begin after completion of the TMCLKL+HKBCF) (110ha and 50ha for east and west respectively)
Existing Contaminated Mud Disposal Facility at East Sha Chau	Construction and operation
Proposed Contaminated Mud Disposal Facility at East of Sha Chau and South of Brothers	Construction and Operation for Target Year of 2011
Mud Disposal Facility at North Brothers	Operation (when disposal operations might begin is not known but it is possible this facility could be operational after 2009)

8.17.1.4 Projects for which there are few definite details, for example CT10 and the possible third runway for the Hong Kong International Airport, have not been included and the cumulative effects will be assessed by these projects themselves should they proceed.

8.17.2 Alteration of Water Quality

8.17.2.1 Impacts during construction in the form of release of suspension sediments into the water column and any associated alteration to dissolved oxygen and deposition of sediment, have the potential to be increased due to the concurrent construction of the HKBCF, HKLR viaduct and reclamation, the Lantau Logistics Park and HZMB in the mainland water, together with maintenance dredging for the Tonggu Channel, dredging for the Kwai Tsing Basin and dumping operations at the Contaminated Mud Pits. Operationally, the projects detailed in **Table 8.32** above have been considered for their possible effects on flows and, therefore, long term water quality.

8.17.2.2 Section 6 of this EIA on Water Quality has undergone a comprehensive quantitative assessment of the construction and operational phase impacts. As the HKBCF, HKLR and TM-CLKL project are linked and will be constructed together, these have been assessed as effectively one project, with the other projects being considered as cumulative.

8.17.2.3 The water quality assessment has concluded (Section 6.12) that based on the implementation of the TM-CLKL+HKBCF+HKLR projects together, no sensitive receivers are predicted to be significantly adversely impacted with the application of mitigation measures. Some transient exceedances of the WQO will remain in the close vicinity of the works area but these will be in areas which are not key dolphin habitats and would not result in significant impacts.

8.17.2.4 The water quality assessment, also, considered the concurrent construction, not only of the TM-CLKL+HKBCF+HKLR, but also the other projects detailed in **Table 8.33** above. The results of the cumulative modelling indicate that the sediment plumes arise from the project (TM-CLKL+HKBCF+HKLR) generally do not coincide with other discharges except over a small area to the north-west and east of the project site.

8.17.2.5 Based upon these results, as the predicted impacts are predominantly confined to the construction phase and, hence, are short-term, impacts are not expected to result in unacceptable impacts to water quality and, hence, unacceptable marine ecological cumulative impacts are similarly not anticipated.

8.17.3 Habitat Loss and Disturbance to Corals

8.17.3.1 As noted above, as an additional precautionary and enhancement measures, the corals directly affected by the TM-CLKL at Pillar Point seawall will be translocated to a suitable location, possibly to an area around Tai Mo To, subject to the findings of the pre-construction baseline survey and further discussion with the relevant authorities (that is, AFCD and EPD). The HKLR verification and supplementary surveys indicated that gorgonian *Echinomuricea* sp. were found in the waters at the south-eastern side of the Airport. Similar to the present study, a baseline survey to check the status and condition of the coral prior to construction has been recommended. Neither the HKBCF or LLP Phase I projects are expected to affect any coral communities directly. However, there will be a direct loss of coral habitat as result of the works, with the reclamations of the projects above totally 313ha, although the majority of this is not currently a habitat for corals. As noted above, the deployment of a new AR the same size of the AR at the airport exclusion zone to be affected, is recommended, to mitigate for the loss of the original reef but, also, as an enhancement measure, a further 2,400m^2 of AR is proposed to be deployed and this would provide additional marine ecological habitat for fish, corals and benthos for the cumulative impacts. In addition, some new habitat in the form of new seawalls will be provided for each project. Based upon this, adverse residual impacts are not expected.

8.17.3.2 In terms of effects by suspended solids during construction, the water quality modelling in Section 6 has assessed the potential impacts from the combined construction of the TM-CLKL+HKBCF+HKLR. The water quality assessment has concluded that based on the implementation of the TM-CLKL+HKBCF+HKLR projects together, no coral with in study area is predicted to be significantly impacted with the application of mitigation measures. The water quality assessment, also, considered the concurrent construction, not only of the TM-CLKL+HKBCF+HKLR, but also the other projects detailed in **Table 8.33** above. The cumulative modelling results at WSRs relevant to the corals, namely WSR46 and WSR49 near Tai Mo To and WSR22c adjacent to Tai Ho Wan, showed that low level (up to 18.7 mg/L) and infrequent (up to 7% of the time) WQO exceedances would occur around Tai Mo To but the deposition would be below the indicator level of 200 g/m^2/day, above which sustained deposition could harm sediment sensitive hermatypic corals. No WQO exceedances are, however, predicted at Tai Ho and the sedimentation rate would also be below the 200 g/m^2/day tolerance threshold.

8.17.3.3 It is unlikely that either hard or soft corals outside of the dredged areas will encounter unacceptable impacts and it should be noted that the majority of species within the study area are generally ahermatypic (i.e., do not contain symbiotic zooxanthellae which require high light levels for photosynthesis). Soft corals that are more typical of the study area would, also be even more tolerant and there is no reason to believe that they would be impacted.

8.17.4 Disturbance to the Benthic Habitat

8.17.4.1 As noted above, the water quality modelling has shown that the suspended solids should be contained to a localised area. As such, potential cumulative impacts from construction phases suspended solids from the three projects have been addressed and significant residual impacts are not expected.

8.17.4.2 However, assuming the HKBCF, HKLR, TM-CLKL, HZMB and Phase I of the LLP are all constructed at the same time, a total of 313ha of habitat will be lost by 2014 in the North-western waters. It is noted that 2014 has been adopted for assessment purposes as the worst case interim opening date for the HKBCF but an alternative date of 2015 is also proposed (see Section 3). This could increase to approximately 500ha by 2026 if the Phase II LLP (40ha), Remaining Development in Tung Chung (East and West) (160ha), Road P1 reclamation (9.5ha) and the temporary losses associated with the Proposed Contaminated Mud Disposal Facility at East of Sha Chau and South of Brothers (270ha) have, also, got to be taken into account. This does not take into account other possible project such as the third runway for the airport or CT10, for which details are not available at this time. As such, the cumulative permanent seabed loss is much larger than the 47ha predicted for the TM-CLKL alone and with the TM-CLKL making only a limited contribution to the total amount.

8.17.4.3 It is noted that the benthic assemblage within, and in the vicinity of, the reclamations were dominated by polychaetes and characterised by similar species diversity and biomass as elsewhere in Hong Kong. All the species recorded occur frequently in Hong Kong and no rare species were observed. As a result, the assemblages when compared with other areas in Hong Kong were regarded as being of low ecological value. However, the projects will provide some new habitat in the form of new seawalls around the reclamations which should help compensate for the loss, together with a newly deployed artificial reef and, as such, the cumulative impacts are not expected to be significant.

8.17.5 Chinese White Dolphin

8.17.5.1 There could be potential for cumulative impacts to the CWD in the study area due to increased habitat loss, increased noise from construction activities, coupled to the aggregated pressures from shipping, mud disposal at the CMP's and pollution arising from numerous sources both in Hong Kong and Southern China. As noted in **Table 8.32** above, residual impacts associated with permanent and irreversible habitat loss have been assessed in accordance with Section 4.4.3 of the TMEIAO which includes the contribution to cumulative impacts. Further details the extent that the TM-CLKL would trigger or contribute to potential cumulative impacts are provided below.

8.17.5.2 Cumulative impacts of various development projects, which can often work synergistically to compromise the environment (Jefferson et al. 2009). The overall impacts of multiple projects can often be more than just the sum of their individual parts. This point has been increasingly recognized in recent years. As described above, there is potential for the TM–CLKL to cause impacts on Chinese White Dolphins in Hong Kong and the further impacts may occur as a result of the other projects being implemented concurrently in the general area of north Lantau Island.

8.17.5.3 Details of the concurrent projects that could cause cumulative impacts during the construction and operational phases are detailed below.

HZMB, HKBCF and HKLR

8.17.5.4 The proposed HZMB will comprise bridge and tunnel sections, together with two artificial islands at either end of the tunnel section. The HZMB connects with the HKLR viaduct at the Hong Kong marine boundary just west of the airport island, with the road then running along the southern edge of the airport island, tunnel and viaduct sections built on reclaimed land on the east before connecting to the HKBCF, which is formed on a new area of reclaimed land directly to the east of the northeast corner of the airport platform and to which the TM-CLKL is directly connected. The HZMB will be more than 10km away from the main TM-CLKL works and within mainland waters.

8.17.5.5 In addition, the 'footprint' of either the HZMB bridge or the HKLR viaduct themselves are not very large (with about 1.5ha being predicted to be lost from the HKLR viaduct piers) and, therefore, there is not expected to be a large impact on Chinese White Dolphins once these sections are complete. As such, the key issues relate to habitat loss as a result of the reclamations needed for the HKLR and HKBCF, which are large (about 168ha in total) and located in areas of ecological importance to Chinese White Dolphins. As such, the key impact will be the construction of the HKBCF which will have a moderate to major contribution to the overall cumulative impacts on CWD. However, the finless porpoises will not be affected as the project occurs outside the range of this species.

8.17.5.6 During the construction phase, cumulative impacts associated with reclamation dredging and backfilling, bored piling for the HKLR viaduct and also the additional marine traffic could occur. The potential for sediment release during construction works of all three projects has been modelled by the water quality assessment in Section 6 and mitigation measures to protect against the combined impacts of all three projects recommended. The cumulative assessment modelling has shown that significant impacts are not expected with the application of mitigation.

8.17.5.7 However, in respect of acoustic disturbance, the increased number of construction vessels in the area could increase the effects to the CWDs and, also, bored piling for the HKLR will comprise the construction of about 135 piers, to add to the 50 to be constructed by the TM-CLKL for the southern viaduct. As such, applying mitigation in the form of acoustic decoupling for the dredging and reclamation works to the TM-CLKL works only would unlikely be significant and applicable measures will need to be applied to the other projects as well. This would also apply to the control of marine traffic in the construction area which will increase notably by the concurrent construction of these projects.

8.17.5.8 The increase scope and extent of the construction works would, also, have the potential to further disturb or block key dolphin travel corridors. Notwithstanding, the HKBCF and HKLR are subject to EIAs in their own right and mitigation for the predicted impacts will be proposed by these project assessments.

Lantau Logistics Park

8.17.5.9 The proposed Phase I of the Lantau Logistics Park (LLP) will comprise a reclamation of about 72ha of land along the northern coastline of Lantau Island. Phase I is proposed to be constructed between 2010-2012, which would overlap with that of the TM–CLKL, and there is a possibility of a 40ha extension, although this does not currently have a fixed programme.

8.17.5.10 The location of the LLP project is a relatively low-density area for Chinese White Dolphins, although it is only a few kilometres away from the Brothers Islands, which are an important feeding and socializing habitat area for Chinese White Dolphins (see Jefferson 2000; Hung 2008). The site is also very near Sham Shui Kok, which is also recognized as an important area for Chinese White Dolphins (Hung 2008). Based on currently-available information, the construction of this project will overlap for a period of 2 years with the combined HKBCF+TM-CLKL+HKLR but only for 1 year with the works of the TM-CLKL. However, it is understood that the seawall for the LLP will be constructed first and silt curtains applied in order to minimise loss of sediment during construction. Also, the construction equipment and vessels will be confined largely to the coastal area which is a relatively low-density area for the CWD and would not block any dolphin transport corridors. Therefore, overall, this project is considered to have a minor to moderate contribution to the overall cumulative impacts on CWD (none for the finless porpoises) as the reclamation size is fairly large and the site is located closer to Brothers and Sham Shui Kok. .

Future Tung Chung East and West Development

8.17.5.11 The future Tung Chung East and West development comprises additional land reclamation at the east and west of Tung Chung of about 160ha combined for the creation of new housing and a possible theme park or other recreational uses. Construction is currently scheduled for 2015 and as such, the construction of the TM-CLKL would not be concurrent but the reclamations would add to the seabed loss in future.

8.17.5.12 The area directly to the southeast of the airport island (the location of the Tung Chung east and west expansions) is a known low-density area for Chinese White Dolphins. However, it should be remembered that the regions within a few kilometres to the north and northeast of this area are important areas of dolphin habitat, which are used for a variety of activities including feeding (see Hung 2008).

8.17.5.13 Based on its location, this project is considered to have an overall minor contribution to the overall cumulative impacts on CWD and none on finless porpoises (due to being outside the range of the latter species).

Contaminated Mud Pits (North and South of Brothers, East of Sha Chau)

8.17.5.14 Contaminated mud pits have been used in the North Lantau are for well over a decade to dispose of mud contaminated with high levels of heavy metals, organochlorines, and other toxic chemicals. There has been no evidence of contaminants causing significant impacts on water quality nor the surrounding marine ecology, nor evidence of any significant impact on Chinese White Dolphins, either during the placement of the mud or after capping. However, there is evidence that the dolphin use of the area around the mud pits has decreased from 1996 to 2005, probably as a result of disturbance from the extensive dredging and dumping activities involved and reduced prey availability (Hung 2008). Several of these pits are in use near Sha Chau, with other pits available for use at the north Brothers, both important areas for Chinese White Dolphins. While the impact is temporary, it is considered that the operation of the mud pits could likely have a minor contribution to the cumulative impacts on Chinese White Dolphins (and none on finless porpoises).

Tonggu Channel

8.17.5.15 While the project has already been completed, maintenance dredging at a frequency of once per year will be undertaken for the Tonggu Channel. Assuming the dredging will be undertaken concurrently to the project construction, it could have a minor contribution to the cumulative impacts, although the results of the cumulative modelling for the water quality has shown that the plumes from this activity would be small and not disperse into Hong Kong waters.

Assessment of Overall Cumulative Impacts on Chinese White Dolphins

8.17.5.16 Clearly, there are a large number of projects currently in the planning which, in their own right, will have some level of impact on the population of CWD in Hong Kong waters. Based upon the water quality modelling, it have been concluded that assuming concurrent construction of these projects, sufficient mitigation from the HKBCF, HKLR and TM-CLKL can be put in place to minimise the water quality impacts attributable to the project (HKBCF+HKLR+TM-CLKL). The reclamations are, also, not predicted to result in significant effects on flows or water quality.

8.17.5.17 However, there is the possibility of cumulative impacts associated with habitat loss, acoustic disturbance from dredging, reclamation and bored piling works, injury/mortality or disturbance from the increase construction vessel traffic and blockage of dolphin transport corridors, as discussed below:

Habitat Loss

8.17.5.18 If it is assumed that all of these projects with reclamation occurring in North Lantau, TM–CLKL, HKBCF, HKLR, Lantau Logistics Park Phases 1 and 2, Tung Chung Further Development, Proposed Contaminated Mud Disposal Facility at East of Sha Chau and South of Brothers (temporary only) (and possibly the Airport Master Plan 2030 expansion), will actually proceed to construction, then the overall cumulative impacts could be severe for the dolphin population in Hong Kong. This is especially the case when possible impacts of past development is taken into consideration, such as the reduction in densities in North Lantau (Jefferson 2000, 2007) coinciding with peak construction activities, and reduced use of areas around the mud pits and Tuen Mun Area 38 (Hung 2008).

8.17.5.19 The cumulative loss of habitat from all these projects is large (over 500ha (not including the potential airport third runway reclamation works, see Section 8.16 and the temporary impacts associated with the contaminated mud pits at East Sha Chau and south of the Brothers), and the total loss from the TM–CLKL, HKBCF and HKLR is about 215ha, with this being largely attributable to the HKBCF (over 65% of this total). As noted above, the majority of these projects are not in key dolphin habitat (for example, the future Tung Chung East and West Development) and as such, each of these are likely to cause only minor contributions to the cumulative impacts. In addition, the TM-CLKL habitat loss area is relatively small overall and the contribution of the TM-CLKL alone and to the cumulative impacts is expected to be small. As such, the majority of the cumulative impacts would come from the HKBCF reclamation and the potential LLP project because of their large size and permanent and irreversible habitat loss impacts.

8.17.5.20 Notwithstanding, the amount of physical habitat lost from all projects as a whole will represent an amount of the overall habitat of Chinese White Dolphins in Hong Kong (see Hung 2008) and will affect the conduct of the dolphin's critical activities, such as, feeding, resting, socializing, nursing, etc. Having so many projects being constructed in parallel in the same study area is unusual in Hong Kong but given this is case and the study area is a dolphin habitat, efforts to lessen the cumulative impacts will be required.

8.17.5.21 Thus, assuming all the projects go ahead and all have reduced their reclamations and seabed disturbance to a minimum, the level of habitat loss would be considered to have effect on the CWD. Notwithstanding that the study area has not shown itself to be fragile or undisturbed and that the geographic extent of the adverse impacts on the CWD would be confined to a relatively small area compared to their overall range, the overall loss would represent an amount of the overall habitat of Chinese White Dolphins in Hong Kong (see Hung 2008) and specifically in the north Lantau waters. As such, cumulative impacts would be predicted to occur without mitigation. As detailed in **Table 8.32,** the impact from the TM-CLKL alone in terms of permanent habitat loss would be minor but residual impacts considered acceptable given its small contribution overall. Any measures to mitigate the cumulative impacts cannot be made by any one project and would need to be a strategic measure.

8.17.5.22 In order to address the cumulative impacts from all the projects and compensate for the cumulative Chinese White Dolphin habitat loss associated with the three designated projects (HKLR, HKBCF and TMCLKL), the Government has made a firm commitment to seek to designate the Brothers Islands as a marine park for enhancing the CWD habitat in accordance with the statutory process stipulated in the Marine Parks Ordinance. A study will be conducted to works out the details of the proposed marine park before the commencement of the statutory procedures as stipulated in the Marine Parks Ordinance. The designation of the proposed marine park would proceed after the completion of these projects. The Government's commitment to the marine park and its control and management in accordance with the Marine Parks Ordinance, as well as the Marine Parks and Marine Reserves Regulations, would significantly help conserve the CWD, and hence serves as an effective mitigation measure for the loss of CWD habitat arising from these projects. With this committed measure, the residual cumulative impacts to the CWD in terms of permanent habitat loss would be acceptable.

Acoustic Disturbance

8.17.5.23 While there is no possibility of severe damage to Chinese White Dolphins from the acoustic disturbance associated with the dredging and reclamation machinery, the works may result in at least temporary abandonment of the habitat in the area (see Jefferson 2000), and for this reason, for TM-CLKL, a precautionary approach has been adopted and acoustic decoupling of noisy equipment from the vessels to prevent transfer of noise into the marine environment has been recommended, together with use of a dolphin exclusion zone during the marine works. The TM-CLKL works are relatively small compared, particularly to the HKBCF but also the proposed LLP which will have equipment to construct 138ha and 72ha, respectively and will also be divided into two distinct areas at Pillar Point and north of Lantau. The HKBCF is expected to require in the region of 240 dredgers and barges over the 3 year construction period, compared to about 25 for the TM-CLKL.

8.17.5.24 Given that the number of vessels will increase significantly with the HKBCF and HKLR being constructed concurrently, cumulative impacts could occur but with the main component being from the HKBCF project and the contribution from the TM-CLKL being minor, with only 25.4ha of reclamation in the same area. In order to address the cumulative impacts of noise from the dredging and reclamation works, the projects need to apply the same level of mitigation. Based upon this, a dolphin exclusion zone would be proposed around all the works projects and acoustic decoupling would, also, be applied for all three projects and these combined measures would be expected to reduce the magnitude of cumulative impacts.

8.17.5.25 For the TM-CLKL bored piling works, in addition to the avoidance of the peak calving season during metal caisson driving and the application dolphin exclusion zone throughout the works, it is recommended that a comprehensive monitoring programme is undertaken before, during and after the bored piling works. The monitoring plan would include both underwater acoustic monitoring, the study the acoustic behaviour of dolphins near the bored piling works site and theodolite tracking of dolphin movement from land in order to determine the actual magnitude of impacts.

8.17.5.26 The HKLR will comprise piling for 135 piers and take in the region of 30 months to complete, which is notably greater and the works will be more intensive than for the TM-CLKL, which has approximately 50 piers and a 14 month construction programme. While the possibility of severe damage to the Chinese White Dolphins from these bored piling works is not predicted, they may result in some temporary abandonment of habitat (Jefferson 2000). However, as the TM-CLKL southern viaduct is located within an area not highly utilised by the CWD an desertion of the immediate area around the southern viaduct by the dolphin is not expected to have a significant effect on the animals behaviour patterns, health or survival. Therefore, the contribution to the overall cumulative impacts from the TM-CLKL bored piling works is expected to be small compared to the HKLR with its more intensive and longer construction works and location in areas of higher CWD density.

8.17.5.27 It should be noted, however, that the same mitigation measures will be applied to both projects and this should be sufficient to reduce the magnitude of the cumulative impacts to small and acceptable levels.

8.17.5.28 In terms of sheet piling, a temporary sheet piled wall would be required during the construction phase to allow the effective use of the silt curtain. As this is jointly required by the HKBCF and TM-CLKL projects and only one wall will be constructed, no cumulative effects are expected.

Injury/Mortality or Disturbance from Vessel Traffic

8.17.5.29 While the noise from marine vessels is not expected to cause significant impacts, the risk of collision with the CWD remains a concern and the CWD may alter their diving and surfacing patterns to avoid collisions with marine vessels. This could result in some short-term behavioural disturbance to the Chinese White Dolphins and porpoises, or if severe enough, they may even be displaced from their preferred habitats.

8.17.5.30 As it appears that faster-moving vessels are more of a threat to Chinese White Dolphins and porpoises, for the TM-CLKL project, a speed limit of 10 knots has been recommended to be strictly observed within the works area where Chinese White Dolphins are likely to occur, namely all areas north and west of Lantau Island. The temporary mitigation measures of vessel speed limits and predefined and regular routes are only proposed for construction vessels during the construction phases within the works area. Its implementation should only be enforced by the Contractor and applied to their vessels engaging in the construction works under contractual agreement. A specification for defining the Vessel Speed Limits and Restrictions should be prepared and agreed during the detailed design stage for inclusion in the contract documents. As the number of vessels moving in the study area will increase notably when considering the concurrent contraction of the HKBCF and HKLR with the TM-CLKL, the cumulative risk of injury or mortality from collisions with vessels will increase. However, as the HKBCF and HKLR projects will also specify and implement a similar level of mitigation, cumulative impacts can be reduced to acceptable levels.

Blockage of Dolphin Travelling Corridors

8.17.5.31 As noted above, a complete physical blockage of the travelling corridors between north-west and north-east Lantau will not occur for the TM-CLKL. However, the reclamations and potential noise associated with the construction of the TM-CLKL may have some minor impacts in terms of reducing dolphin use of key corridors and in order to monitor if any effects will occur, pre, during and post-construction monitoring of Chinese White Dolphins have been recommended although there will not be a complete physical blockage of the travelling corridors, given the relatively large distance between the southern and northern landfall reclamation areas and the use of the TBM for tunnel construction to minimise impacts and, as such, the Chinese White Dolphins will still be able to move through the area.

8.17.5.32 The HKBCF reclamation works will be confined to specific areas to the east of the airport island in an area not highly utilised by the CWD and further away from the main travelling corridor between the Tuen Mun/Lung Kwu Chau area the area around the Brothers Islands/Sham Shui Kok. However, there is some concern that the HKLR project may block the north-south movements from Marine Park to West Lantau waters. As these implications could increase with all three projects being constructed concurrently, a combined monitoring programme covering the whole study areas should be considered and in this way, further adaptive management recommendations could be made across the board to address any cumulative impacts.

Summary

8.17.5.33 Given the scale and number of concurrent projects in the study area, cumulative impacts to the Chinese White Dolphin would be predicted to occur if mitigation is not implemented. In terms of construction phase cumulative impacts associated with acoustic disturbance, Injury/Mortality or Disturbance from Vessel Traffic and possible blockage of travelling corridors, the impacts would be temporary and reversible and a range of mitigation measures, which are proposed to be applied by all three projects, are considered to reduce cumulative impacts to acceptable levels.

8.17.5.34 In terms of habitat loss, the impacts would be permanent and irreversible and the cumulative habitat lost would represent an amount of the overall habitat of Chinese White Dolphins in Hong Kong (see Hung 2008) and specifically in the north Lantau waters. As such, cumulative impacts would be predicted. Notwithstanding, to enhance the Chinese White Dolphins (CWD) habitat, there is a firm commitment from Government to seek to designate the Brothers Islands as a marine park for the three designated projects (HKLR, HKBCF and TMCLKL). The Government's commitment to the marine park and its control and management in accordance with the Marine Parks Ordinance, as well as the Marine Parks and Marine Reserves Regulations, would significantly help conserve the CWD, and hence serves as an effective mitigation measure for the loss of

CWD habitat arising from these projects. With this committed measure, the residual cumulative impacts to the CWD in terms of permanent habitat loss would be acceptable.

8.18 Ecological Monitoring and Audit Requirements

8.18.1.1 The EIA has predicted the project would lead to some ecological impacts and has recommended a series of measures to avoid, minimise, and mitigate the impacts to an acceptable level have been recommended. An ecological monitoring and audit programme would be needed to ensure the recommended measures are properly implemented. In addition, the EM&A programme also serves other purposes, including but not limited to verify the accuracy of the ecological assessment study and recommending action plans in response to unpredicted impacts or ineffective mitigation.

8.18.1.2 Ecological monitoring for this project related to Chinese White Dolphins involves the collection of pre-construction (baseline), construction-phase, and post-construction (operational-phase) monitoring. These surveys use vessels to collect line-transect and photo-identification data to allow the calculation of densities using line transect (Jefferson 2000, 2007), the estimation of impact indices by the grid method (Hung 2008), and the evaluation of individual movements and ranging patterns from individual identification (Hung and Jefferson 2004). At the completion of these surveys, it will be possible to make an evaluation of effects of the project on Chinese White Dolphins in North Lantau.

8.18.1.3 Detailed specifications for coral translocation, dolphin exclusion zone for use during dredging, reclamation, sheet and bored piling works, artificial reef deployment and the bored piling monitoring will, also, need to be prepared during the detailed design phase. The coral translocation will need to be implemented in advance of the marine works while the other measures will be implemented at the commencement of the bored piling or throughout the works.

8.18.1.4 In addition, regular ecological audit of the application of the acoustic decoupling for dredging and reclamation marine vessels will be required. This audit should be conducted by a qualified person as part of the Environmental Team.

8.18.1.5 Further details of the dolphin monitoring and bored piling monitoring are also provided in the sections below.

Dolphin Monitoring

8.18.1.6 Surveys to monitor the density and behaviour of the animals before, during, and after the period of the potential disturbance are recommended. This objective is to determine if the other mitigation measures have been effective in protecting the animals from disturbance and maintaining their habitat quality. In addition, it is necessary to monitor the effects of the construction works on the use of dolphin travelling corridors. While there is not expected to be a complete physical blockage of the travelling corridors, the works may have some impacts in terms of reducing dolphin use of these corridors. As data on this is scarce, dolphin monitoring is also required to monitor the use of the travel corridors and if the Chinese White Dolphins stop using the corridors, then it will be necessary to provide some remediation to deal with this, in the form of adaptive management.

8.18.1.7 In order for such monitoring to be effective, it needs to be divided into three phases: pre-disturbance (i.e., baseline phase), disturbance (i.e, construction phase), and post-disturbance (i.e., operational phase). Survey techniques must be held constant from phase to phase and survey equipment and personnel should ideally be the same as well. Any apparent differences in density among survey phases should be analysed for trends and the statistical power of the analysis to detect effects of the desired size should be tested. The software TRENDS can be used to test the *a posteriori* statistical power of the analysis (Gerrodette 1993). It can even be used as a planning tool to determine how much effort is needed to detect a particular change in density (as long as relevant data on sighting rates are available *a priori*).

8.18.1.8 Project-specific dolphin monitoring using line transect surveys combined with photo-identification studies, also, have the advantage of being able to provide evaluation of dolphin fine-scale habitat use patterns. This includes 1 km^2 grid densities and grid-based patterns of feeding, socializing and calving, as well as individual ranging patterns, allowing the detection of any smaller-scale impacts and changes in core area use (see Hung 2008).

8.18.1.9 An important consideration in testing for impacts in cetacean density monitoring is to take account of any natural cycles and pre-existing trends in densities, so that any changes can be correctly attributed to their source. Such this approach requires some pre-existing knowledge of the population biology of the affected species. In Hong Kong, small cetacean monitoring has been conducted since late 1995, and, therefore, provides a useful baseline against which to measure current and future potential disturbances (Jefferson 2000; Jefferson et al. 2002).

8.18.1.10 In order to ensure that any shifts in dolphin distribution, or blockages of dolphin travelling corridors, due to works are detected and to determine the efficacy of the recommended mitigation measures, a programme of dolphin monitoring comprising pre-construction, during construction and post-construction phase dolphin monitoring is recommended.

8.18.1.11 Should dolphin sighting numbers or behaviour in the construction or post-construction phases be significantly different (taking into account naturally occurring alterations to distribution patterns such as due to seasonal change) to the pre-construction activity, recommendations for a further post-construction monitoring survey will be made. Data should then be re-assessed and the need for any further monitoring established. Comparison of the pre-construction dolphin monitoring with that of the during and post- construction dolphin monitoring will allow the assessment of the overall efficacy of the project-specific mitigation measures and an Action Plan for the dolphin is included in the EM&A Manual.

8.18.1.12 Considering that AFCD monitoring provides useful data, the monitoring programme should comprise undertaking surveys, 2 days per month. For the pre-construction phase, as 9 months of baseline surveys have been undertaken for the purposes of this EIA, a further 3 months survey would be required. In respect of the construction phase, the monitoring should be undertaken for the duration of the construction and for the post-construction phase, the monitoring should be undertaken for a period of 2 years to ensure sufficient data is collected. In summary, the following monitoring would be required:

- six, one-day survey events to be undertaken at a frequency of 2 per month over a period of 3 months before commencement of construction;
- one-day survey events to be undertaken at a frequency of 2 per month for the duration of the marine works construction period; and
- forty-eight, one-day survey events to be undertaken at a frequency of 2 per month over a period of 24 months following cessation of the construction.

8.18.1.13 The period required for the monitoring is considered to be adequate to derive a reasonably large amount of data, thereby allowing any significant trends in dolphin distribution to be detected (Jefferson pers. comm.).

8.18.1.14 The monitoring should also be undertaken by a suitably qualified person (in biology) and should be independent of the construction contractor and should form part of the independent Environmental Team (ET). The IEC may audit the work of the ET if deemed necessary. Monitoring should be conducted following the methodology detailed in the EM&A Manual.

Bored Piling Monitoring

8.18.1.15 As detailed above, the potential impacts from bored piling on the CWD are largely unstudied and as such, it is considered that a precautionary approach should be taken with respect to protection of the CWDs as the TM-CLKL project will be constructed in its habitat. Potential mitigation for bored piling, as has been applied for percussive piling in previous projects, could include the use of dolphin exclusion zones, bubble curtains and/or geographical/temporal closures. The dolphin exclusion zone is recommended during all bored piling works and a temporal closure between May and June for the metal caisson installation is also proposed.

8.18.1.16 However, in order to take a precautionary approach it is recommended that a comprehensive monitoring plan be implemented before, during and after the bored piling works is proposed. The monitoring plan would include both underwater acoustic monitoring, the study the acoustic behaviour of dolphins near the bored piling works site and tracking of dolphin movement from land in order to determine the actual magnitude of impacts.

Acoustic Monitoring

8.18.1.17 In order to ensure that bored piling noise will not affect the Chinese White Dolphins, noise levels from bored piling activities should be measured, with details of frequency/intensity spectra to be evaluated. The acoustic results of the monitoring should be analysed in terms of both the Broadband range (100 Hz to 25.6 kHz) and, also, the dolphin sensitive range (400 Hz to 12.6 kHz). The monitoring will study the acoustic behaviour of dolphins near the bored piling works site and at a control site for comparison, to determine whether foraging behaviour is affected by the bored piling activities and whether dolphin echolocation clicks are masked by bored piling activity noise.

8.18.1.18 The specification and detailed methodology for the bored piling acoustic monitoring should be prepared as part of the detailed design and submitted to the EPD and AFCD for approval.

8.18.1.19 The acoustic monitoring will be undertaken during the construction phase and commence at the start of the bored piling works. The exact monitoring period will be determined and detailed in the specification to be prepared during the detailed design stage but is likely to comprise as a minimum:

- underwater noise levels measurements from bored piling activities for 10 days from the start of bored piling activities; and
- study the acoustic behaviour of dolphins from a small boat during periods with and without bored piling for 30 days from the start of bored piling activities.

8.18.1.20 The monitoring works will consist of data acquisition and analysis of sound to be gathered by an experienced bio-acoustician with specialised experience in processing of appropriate low frequency (to infrasound, down to 20 Hz) and high frequency (into ultrasound, to at least 100 kHz) hydrophone and digital recording equipment, as well as the appropriate analysis devices and programmes. The bio-acoustician should have at least ten years of dolphin sound data gathering and analysis experience, at least three technical publications related to dolphin sounds.

8.18.1.21 As bored piling will also be undertaken for the HKLR project, it is possible that a combined monitoring could be undertaken.

Land-based Theodolite Tracking

8.18.1.22 The objective of the land-based theodolite tracking of dolphins is to monitor their movements and behaviour near the bored piling works site before, during and after the works and record and note any changes in response to the bored piling noise. The details of the land-based dolphin tracking methodology and frequency will be defined in a specification prepared during detailed design phase. However, as a minimum the monitoring is likely to comprise 30 days before, 30 days during and 30 days after bored piling works.

8.18.1.23 This monitoring would consist of data acquisition and analyses of movement and behavioural information of CWD, as gained from a 5-sec. resolution conventional theodolite and a 5-sec. resolution "total station" theodolite with laser range-finding capability, appropriate hand-held range finders, binoculars with distance-measuring reticles and built-in compass, recording gear of digital voice recorder, data sheets, and computer slaved to theodolites.

8.18.1.24 Two experienced theodolite/behavioural data gathering operators should undertake the monitoring. The primary and secondary theodolite operators should have at least ten years of theodolite and behavioural data gathering and analysis experience, at least three technical publications to cover the subject, and appropriate long-term familiarity with the latest version of the tracking program “Pythagoras”. These experienced operators need to have further experience in detailed power analyses for efficient evaluation of number of samples and time/energy needed for statistical evaluations.

8.18.1.25 Further details of all the measures recommended are provided in the EM&A Manual and summarised in Section 15 of this report.

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