

8 MARINE ECOLOGY

8.1 INTRODUCTION

8.1.1 This section of the report presents the findings of the marine ecological (including Indo-Pacific Humpbacked Dolphins or Chinese White Dolphin, *Sousa chinensis*, and Finless Porpoises, *Neophocaena phocaenoides*) impact assessment. Baseline information on the potentially affected existing marine ecological resources and the findings of various field surveys conducted for the assessment are presented and evaluated.

8.1.2 The objectives of the marine ecological assessment are as follows:

- to establish the ecological importance of the habitats affected by the works associated with the construction and operation of the Theme Park and associated developments;
- to identify marine ecological sensitive receivers;
- to assess the scale of possible marine ecological impacts from the proposed Project;
- to highlight any insurmountable impacts to marine ecological resources arising from the proposed Project;
- to identify any necessary mitigation measures and evaluate residual impacts; and
- to assess the need for a marine ecological monitoring and audit programme.

8.2 LEGISLATION, STANDARDS, GUIDELINES AND CRITERIA

8.2.1 The criteria for evaluating marine ecological impacts are laid out in the EIAO TM. *Annex 16* sets out the general approach and methodology for assessment of marine ecological impacts arising from a project or proposal. This assessment allows a complete and objective identification, prediction and evaluation of the potential marine ecological impacts. *Annex 8* recommends the criteria that can be used for evaluating marine ecological impacts.

8.2.2 Other legislation which apply to marine species includes:

- The Wild Animals Protection Ordinance (Cap. 170) 1980 which protects all cetaceans and sea turtles.

8.3 EXISTING ENVIRONMENT

8.3.1 This section summarises the ecological value of marine ecological resources within the Marine Ecology Study Area and identified sensitive receivers. The Assessment Area was defined in the Study Brief as all sensitive receivers within the North Western, Western Buffer and Southern Water Control Zones (WCZs). This area, however, is very extensive and consequently in order to provide a more focused assessment of impacts a refined area, referred to as the Marine Ecology Study Area has been used. On the basis of preliminary information from the water quality assessment, perturbations to water quality, and thus indirect impacts to marine ecology, are unlikely to extend outside the area presented in *Figure 8.2a*. Consequently, this assessment of impacts has focused on the marine ecological resources of this area.

SUMMARY OF MARINE ECOLOGY BASELINE CONDITIONS

- 8.3.2 The availability of literature on the marine ecology of the Marine Ecology Study Area is variable. As with the majority of Hong Kong it appears that certain ecological components have been comprehensively studied whereas others have not. The list of relevant reports in the Study Brief has been reviewed along with relevant information pertaining to the ecological characteristics of the Penny's Bay and East Lantau area. The detailed review of literature is presented in full in *Section 2 of Annex G*.
- 8.3.3 Due to the limited literature available for some components of the marine ecosystem, field surveys were considered necessary to fill the information gaps identified and enable a complete and robust assessment of impacts to marine ecology to be performed. The findings of the field surveys are presented in *Section 3 of Annex G*.

Summary of Baseline Conditions

- 8.3.4 The following presents a summary of the literature review and field surveys conducted for this EIA and detailed in full in *Annex G*.
- 8.3.5 **Soft Substratum Habitats:** Benthic studies have been undertaken at locations within or close to the Study Area. Findings from the majority of these studies were that the benthos of the seabed in the vicinity of Penny's Bay was dominated by polychaetes and characterised by low species diversity and low species biomass. Surveys conducted for this Study in Penny's Bay concluded that the assemblages were of a higher abundance than surrounding areas. However, in context with those assemblages in sediments around Hong Kong, the infaunal assemblages of Penny's Bay can be considered to be similar. The assemblages were dominated by polychaetes and all the species recorded occur frequently in Hong Kong and no rare species were observed.
- 8.3.6 **Intertidal Habitats:** The natural shorelines within the Marine Ecology Study Area consist mainly of hard rocky or boulder shores, such as those at Fa Peng, Pa Tau Kwu and Sze Pak. Small sandy or cobble beaches are observed in such bay areas as Yam Tsai Wan, Luk Keng Bay and inner Penny's Bay at Wan Tuk next to the Cheoy Lee shipyard. Soft sandy/cobble shores are also located along the east coast of the Tsing Chau Tsai headland, including Kwai Shek, Tso Wan, Fa Peng and Pa Tau Kwu. The assemblages surveyed for this Study were typical of exposed rocky shore communities with high abundances of barnacles, chitons, limpets and periwinkles. No rare species have been recorded from these surveyed shores. The sandy shores at Yam Tsai Wan and Pa Tau Kwu Pak Wan were surveyed and findings from both the wet and dry season showed that these beaches supported benthic assemblages of low diversity.
- 8.3.7 **Artificial Seawalls:** The majority of the coastal areas on North Lantau, ie from Siu Ho Wan to Yam Tsai Wan and from Yam O Tuk to To Kau Wan, have been reclaimed and replaced by sloping artificial seawalls. The east coast of Penny's Bay from Chok Ko Wan to Wan Tuk has also been reclaimed and lined with vertical artificial seawalls. Few surveys have been conducted on the colonization of organisms on artificial seawalls in Hong Kong, however, fouling organisms have been anecdotally recorded as common on

artificial seawalls, wharf piles and other marine structures⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾. Various species of algae, coelenterates, ascidians, bryozoans, sponges, crustaceans, molluscs and polychaetes are also commonly observed on these artificial structures. Therefore, it can be presumed that species commonly found on these surfaces in Hong Kong waters will be found on the artificial seawalls of the established complexes at north Lantau and Penny's Bay. On the subtidal portions of artificial seawalls corals have been reported to colonise the habitats. An example of this is the High Island Dam in the eastern waters of Hong Kong which supports high percentage cover of the rare coral *Acropora* on the dolosse block sloping seawalls. It is known in Hong Kong that depending on the location of the artificial seawalls, and the prevailing environmental conditions, especially with reference to water quality, that the habitats have the potential to support high ecological value assemblages. Due to the relatively recent construction of the artificial seawalls at Yam O (1997) and the vertical nature of those at Penny's Bay it is unlikely that at present the assemblages are of high ecological value but the potential is noted. It should be noted that the subtidal portions of vertical seawalls do not offer ideal habitat for coral colonisation unlike sloping seawalls which provide a more complex habitat and better surface for settlement of marine invertebrates.

8.3.8 Hard Substratum Habitats: Dive surveys conducted within Penny's Bay revealed that the assemblages are composed of a shallow, thin veneer of common hard coral species. Percent live coral cover is generally low, however, the inner part of the bay would appear to still support a relatively healthy, simple coral community. The findings are of some significance as the presence of scleractinian (reef building) corals in Penny's Bay extends the known local geographic range for local hard corals. Given the presence of hard corals in Penny's Bay, it has been assumed that the nearby coasts of wet Pa Tau Kwu, Pat Tau Kwu East, and Sze Pak support similar assemblages. This assumption may be overly conservative as these sites are more exposed than Penny's Bay and hence likely support coral assemblages of even lower diversity and abundance. Nevertheless, it does allow for a precautionary approach to be taken when assessing impacts.

8.3.9 It should be noted, however, that the assemblages at Pa Tau Kwu East will be lost as part of the Northshore Lantau Development and consequently are not discussed further here as a sensitive ecological habitat. Their loss is assessed, and mitigation measures proposed, in the Northshore Lantau Development Feasibility Study EIA.

8.3.10 Hard coral assemblages have also been reported from Kau Yi Chau which is in proximity to the reclamation area. However as discussed in *Annex G* these assemblages are neither as diverse or abundant as those in Penny's Bay and have, therefore, been classified as of medium ecological value.

8.3.11 Marine Mammals: The Indo-Pacific Humpbacked Dolphin, *Sousa chinensis*, and the Finless Porpoise, *Neophocaena phocaenoides*, are the only species of marine mammal regularly sighted in Hong Kong waters. As sightings of *Neophocaena phocaenoides* have

(1) Binnie Consultants Limited (1996) Fill management Study - Phase IV Investigation and Development of Marine Borrow Areas: Coral Growth at High Island Dam. Report submitted to CED GEO, July 1996.

(2) Binnie Consultants Limited (1997) Chek Lap Kok Qualitative Survey. Final report to CED GEO, December 1997.

(3) Morton B and Morton J (1983) The Seashore Ecology of Hong Kong. Hong Kong: Hong Kong University Press.

(4) Huang ZG, Yan SK, Lin S and Zheng DQ (1992) Biofouling communities on pier pilings in Mirs Bay. In The Marine Flora and Fauna of Hong Kong and Southern China III (ed B Morton). Proceedings of the Fourth International Marine Biological Workshop: The Marine Flora and Fauna of Hong Kong and Southern China, Hong Kong 1989, p 529-543. Hong Kong: Hong Kong University Press.

mainly been in southern waters of Hong Kong and none have been reported within or close to Penny's Bay this species is not under threat from impacts due to the proposed Project. The population of *Sousa chinensis* is reported to be centred around the Pearl River Estuary and Hong Kong waters are thought to represent the eastern portion of its range. North Lantau represents the major area of distribution of dolphins in Hong Kong waters, and is the only place in Hong Kong where dolphins are seen year round. Findings of work conducted by Dr Tom Jefferson of the Ocean Park Conservation Foundation indicate that the abundance of the dolphin is low in East Lantau and that they use the area seasonally in winter. East Lantau is not thought to represent a critical habitat for this dolphin species.

8.3.12 The ecological characteristics of the different habitat types within the Marine Ecology Study Area have been compared with habitats in other areas of Hong Kong in order to establish their ecological importance (*Annex G*).

ECOLOGICAL IMPORTANCE

8.3.13 According to the EIAO TM *Annex 8*, the ecological value/importance of a habitat can be evaluated using the following criteria:

- Naturalness
- Size
- Diversity
- Rarity
- Re-creatability
- Ecological Linkage
- Potential value
- Nursery Ground
- Age
- Abundance

8.3.14 The criteria listed above have been applied to the information gathered and/or reviewed on the marine ecology of the habitats within the Marine Ecology Study Area in order to determine the ecological value. The application of these criteria has led the habitats to be classified as presented in *Table 8.3a*. Complete details of how each habitat was evaluated against the criteria presented above are presented in *Section 4* of *Annex G*. Only habitats where permanent or temporary impacts are expected to occur through either direct impact associated with habitat loss or indirect impacts through perturbations to water quality parameters have been evaluated. Information on the extent and severity of water quality impact are presented in the water quality impact assessment (see *Section 5*).

Table 8.3a - Summary of Ecological Value of Assemblages Present on the Different Habitat Types in the Marine Ecology Study Area

Assemblage Type	Low	Medium	High
Subtidal Soft Benthos (Penny's Bay)	*		
Sandy Shore (Penny's Bay)	*		
Intertidal Rocky Shore (Penny's Bay)		*	
Subtidal Hard Surface (Penny's Bay)			*
Subtidal Hard Surface (Sze Pak)			*
Subtidal Hard Surface (Kau Yi Chau)		*	
Artificial Seawall (Penny's Bay & Yam O)	*		
Marine Mammal Habitat (Penny's Bay) ^a	*		
Marine Mammal Habitat (Yam O) ^a	*		
Marine Mammal Habitat (North Lantau)		*	
Marine Mammal Habitat (East Lantau)	*(Finless Porpoise)	(Indo - Pacific Humpbacked dolphin)	

Note: ^a refers to the marine waters inside the reclamation areas only

8.3.15 A map detailing the locations of these habitats is presented on *Figure 8.3a*.

8.4 ASSESSMENT METHODOLOGY

8.4.1 A desktop literature review and supporting field surveys (summarised above in *Section 8.3* and detailed in full in *Annex G*) were conducted in order to establish the ecological profile of the area within and surrounding the Marine Ecology Study Area. Information from the water quality assessment was used to refine the size of the area under study as that potentially affected by perturbations to water quality parameters (*Figure 8.2a*). This area became the focus for this ecological impact assessment. The importance of potentially impacted ecological resources identified within the Marine Ecology Study Areas were assessed using the EIAO TM. The potential impacts due to the construction and operation of the Theme Park and associated developments were then assessed (following the EIAO TM *Annex 16* guidelines) and the impacts evaluated (based on the criteria in EIAO TM *Annex 8*).

8.5 IDENTIFICATION OF ENVIRONMENTAL IMPACTS - CONSTRUCTION

8.5.1 Impacts to marine ecological resources arising from the construction works may be divided into those due to direct disturbances to that habitat and those due to perturbations to key water quality parameters.

DIRECT IMPACTS

8.5.2 Direct impacts to marine ecological resources include habitat loss due to the dredging and reclamations at Penny's Bay and Yam O associated with the Project. The construction of these reclamations will lead to the permanent loss of approximately 290 hectares of seabed (280ha at Penny's Bay and 10ha at Yam O).

Subtidal Soft Benthos

8.5.3 Impacts to benthic organisms are dependent upon the location of the assemblages in relation to the reclamation site. Within the reclamation site, primary impacts will be the removal and/or burial of organisms which are present there. These impacts will necessarily occur during dredging and sandfilling operations associated with the reclamation works. It is important, therefore, to determine whether the reclamation site contains unique or otherwise noteworthy benthic assemblages which will be lost. Findings from a review of the literature, supported by focused field surveys, indicate that the benthic assemblage within, and in the vicinity of, the reclamation was dominated by polychaetes and similar to elsewhere in Hong Kong in terms of species composition and abundance. All the species recorded occur frequently in Hong Kong and no rare species were observed. As a result, the assemblages were regarded as being of low ecological value.

8.5.4 Although epifaunal benthic surveys have identified sparsely distributed colonies of gorgonians and soft corals of ecological interest 6 km to the east of the area to be reclaimed, no rare or environmentally sensitive species were recorded in proximity to the reclamation area. Although the proposed reclamation will result in the loss of approximately 280 hectares of subtidal soft benthic habitats, the severity of the impact is anticipated to be acceptable as the areas to be reclaimed are of low ecological value.

Subtidal Hard Surface Habitats

8.5.5 The construction of the Penny's Bay and Yam O reclamations for the Project will result in the permanent loss of subtidal hard surface habitats as follows:

- High Ecological Value - 0.22 ha (2,200 m in length and 1 m in depth) along the southern coastline of Penny's Bay;
- High Ecological Value - 0.078 ha (780 m in length and 1 m in depth) along the northeastern edge of Penny's Bay;
- Low Ecological Value - 2,000 m of vertical artificial seawall and 0.11 ha of sloping artificial seawall along the eastern coast of Penny's Bay (371 m in length and 3 m in depth);
- Low Ecological Value - 0.27 ha (900 m in length and 3 m in depth) of subtidal portions of sloping artificial seawall along the Yam O coastline.

8.5.6 The assemblages within the Penny's Bay reclamation area and Yam O reclamation area will be lost through the burial of organisms present there. These impacts will necessarily occur during dredging and filling operations associated with the reclamation works.

8.5.7 Rubble mound seawalls will be used along the southern and eastern sections of the Penny's Bay reclamation and will provide 4.3 ha⁽⁵⁾ of habitat for subtidal organisms to colonise. It has been demonstrated that marine organisms have recolonised such seawalls after construction⁽⁶⁾ ⁽⁷⁾. 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 hard corals recorded in the field surveys of this Study. The potential habitat provided by the total surface area of the rubble mound seawalls on the southern and eastern sections of the Penny's Bay reclamation (greater than 4.3 ha) is expected to mitigate for the loss of high ecological value assemblages of hard corals within the reclamation sites (approximately 0.298 ha). The locations of the seawalls are depicted on *Figure 8.5a*.

Intertidal Habitats

8.5.8 A total length of 3.08 km of the natural intertidal habitats, 2.98 km of medium ecological value rocky shores along the southern and northeastern shores of Penny's Bay and 100 m of low ecological value sandy beach along the southern shore of Penny's Bay, will be lost as a result of reclamation activities in Penny's Bay for the Theme Park. Although part of the 2.2 km shore on the southern coast of Penny's Bay will be retained in the form of an open channel the intertidal assemblages will be lost as the channel will be used for stormwater discharges. A 2.37 km stretch of artificial shoreline within Penny's Bay and a strip of 900 m east of Yam O on the northern coast of Lantau will be lost as a result of reclamation activities. The results from field surveys indicated that the intertidal assemblages recorded on the rocky shores are typical of exposed rocky shore communities observed in Hong Kong. The sandy beach in Penny's Bay supports low species diversity. These intertidal habitats will be replaced by a total of 3.9 km of ecologically enhancing

(5) Theme Park seawalls provide 4.6 ha of habitat (5m depth, 1:2.5 slope and 3.2km length).

(6) Binnie Consultants Limited (1996) Coral Growth at High Island Dam, for Civil Engineering Department.

(7) Binnie Consultants Ltd (1997) Chek Lap Kok Qualitative Survey Final Report. For the Geotechnical Engineering Office, Civil Engineering Department, December 1997.

rubble mound sloping artificial seawalls (net gain in sloping seawalls = 3.9 km - 1.27km = 2.63km). The artificial seawalls can, 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, the more diverse a community the habitat can support such as tetrapods or rubble mound. The seawall should, therefore, be designed to maximise substrate heterogeneity in an attempt to create a productive post-reclamation area. Although the reclamation works will result in the loss of 3.08 km of natural intertidal habitats, the severity of the impact is reduced by the provision of ecologically enhancing, sloping rubble mound, seawalls as a mitigation measure.

Marine Mammals

- 8.5.9 Reclamations and other marine construction activities can result in a loss of habitat for dolphins and porpoises. The physical loss of habitat during and after reclamation works could affect a small number of humpback dolphins that utilise the Penny's Bay area on a seasonal basis. As Penny's Bay is not critical habitat for the dolphin this impact is unlikely to affect the dolphin population as a whole and is deemed acceptable. Because Finless Porpoises occur only to the south of Penny's Bay and, therefore, habitat loss should not be a factor for this species.
- 8.5.10 As discussed above a small reclamation will be constructed at Yam O which will cause the loss of 10 ha of habitat for the dolphins. Although North Lantau waters, especially the western part, is an important area to the dolphins, the area to be reclaimed is relatively small and there have been few dolphin sightings within or around the reclamation area (*Figure 8.3b*). This impact is unlikely to affect the dolphin population as a whole and is deemed acceptable. Because Finless Porpoises do not occur only in north Lantau waters habitat loss at Yam O should not be a factor for this species.

Cumulative Effects on Marine Mammals

- 8.5.11 Although many development projects may have an insignificant impact on the status of the dolphin population in Hong Kong when viewed in isolation, impacts of several projects may be important when assessed together. In view of this fact, it is important to evaluate the cumulative effects of various reclamation projects around Lantau Island on the dolphins. The major reclamation around Lantau Island in recent years was that associated with the development of Hong Kong's new International Airport at Chek Lap Kok. At that time, no studies were undertaken to gather baseline data in order to assess what impacts the loss of this potential habitat may have had on the dolphins. However, based on recent studies of the dolphins home range patterns (Hung 2000), it is speculated that these works may have had an adverse impact. Certainly, the combined loss of habitat in the North Lantau and northwestern New Territories has reduced the amount of natural coastal habitat for dolphins, however, due to the fact that humpback dolphins do not appear to be highly concentrated near shorelines in Hong Kong's inshore waters, such loss of habitat is probably not of major importance to the population.

8.5.12 The primary concern with the loss of habitat, and the accumulation of impacts from concurrent projects is the overall loss of natural coastline and its concomitant effects on the prey species of the dolphins. Information from the fisheries impact assessment (*Section 9*) indicates that direct impacts due to the reclamation are not predicted to seriously impact fisheries production due to the low levels of production from the fishing zones at Yam O and Penny's Bay. Neither Yam O nor Penny's Bay is a recognized spawning and nursery area and hence juvenile fish stocks are unlikely to be affected. The consequences of this are that impacts to marine mammals through loss of food supply (fisheries resources) are not predicted to occur as impacts to fisheries resources are regarded as of low severity and acceptable.

INDIRECT IMPACTS

8.5.13 Indirect impacts to marine ecological resources during the construction phase include sediment release associated with the above construction projects. Potential impacts to water quality from sediment release are listed below:

- increased concentrations of suspended solids (SS);
- a resulting decrease in DO concentrations; and,
- an increase in nutrient concentrations in the water column.

8.5.14 Sensitive receivers for marine ecological impact assessment are identified to assess the potential impacts to resources outside the reclamation areas as a result of perturbations to water quality, during both the construction and operation phases. Information presented in the review of literature and in the results of the comprehensive field surveys has indicated that the Marine Ecology Study Area (excluding the habitats within Penny's Bay) contains the following marine ecology sensitive receivers:

- Habitat for the Indo-pacific Humpbacked Dolphin in the coastal waters of East Lantau and North Lantau.
- Assumed high ecological value hard coral assemblages located at Sze Pak Wan.
- Medium ecological value hard coral assemblages located on Kau Yi Chau.

8.5.15 It is considered important to the environmental acceptability of the Project that construction and operational activities of the proposed Theme Park do not unacceptably impact these sensitive receivers. The following sections discuss and evaluate the potential impacts to marine ecological habitats specifically focusing on those listed in *Table 8.3a*.

Suspended Solids (SS)

8.5.16 **Subtidal Hard Surface Habitats:** Soft corals, gorgonians, hard corals and anemones may be injured by both high suspended sediment concentrations and high deposition rates. Damage (sublethal effects) or mortality (lethal effects) can result from a reduction in light penetration which kills the photosynthesizing symbiotic algae associated with the hard corals, and also from the deposition of sediment onto the corals surface which physically blocks the respiratory and feeding apparatus. An assessment of the effects of backfilling in Mirs Bay⁽¹⁾ assumed that prolonged turbidity and a sustained sedimentation rate of 20 mg cm⁻² day⁻¹ (= 0.2 kg m² day⁻¹) was damaging to corals. Impacts to corals on the rocky coasts of Sze Pak Wan and Kau Yi Chau are unlikely to occur as sediment deposition rates from the reclamation works are predicted to be less than 0.11 kg m² day⁻¹ at both of these

(8) Binnie Consultant Ltd (1992) South Mirs Bay Borrow Area. IAR

sensitive receivers (see water quality assessment in *Section 5*) which is below the threshold value discussed above for corals. Consequently impacts are predicted to be within environmentally acceptable levels. Negative impacts to corals may also arise from increased SS in the water column. A threshold value is, however, unavailable for corals specific to Hong Kong waters. The habitats identified as supporting hard coral assemblages at Kau Yi Chau and Sze Pak Wan were represented in the water quality modelling. Elevations of SS at these locations were predicted to be less than 1 mg L^{-1} above ambient under the worst case scenario (see *Table 5.6h* in *Section 5*). An elevation of this magnitude is very small and the total SS level is within the WQO for this area. It is thus expected that unacceptable impacts to corals at Kau Yi Chau and Sze Pak Wan arising from elevated SS levels will not occur.

- 8.5.17 Subtidal Soft Benthos:** Sessile organisms within the benthos will be susceptible to the effects of increased sediment loads. Effects can be lethal or sublethal (eg reduction in reproductive potential due to stress incurred by constantly having to flush out the depositing material). The effects of sedimentation on organisms will also depend on other factors, such as an organism's tolerance, growth orientation of sessile organisms and water movement. Infaunal benthic assemblages in Hong Kong are located in soft muds and sands which are frequently disturbed by storms, seabed currents and constant trawling activity which reworks the sediments creating high suspended sediments loads in the water column. Benthic invertebrates are therefore not likely to be adversely affected by the dredging and filling operations with respect to sediment suspension and settlement but more so from direct habitat loss within the reclamation areas (see above for discussion).
- 8.5.18** Impacts to benthic assemblages immediately outside of the reclamation site are expected to occur temporarily as deposition rates are predicted to be $0.33 \text{ kg m}^{-2} \text{ day}^{-1}$. The area is expected to be small as sediment will be deposited within a short distance of the dredging and filling works. At Sze Pak Wan, levels are much lower and predicted to be less than $0.11 \text{ kg m}^{-2} \text{ day}^{-1}$. These predicted deposition rates are not likely to impact the natural benthic assemblages as the area is often disturbed by demersal trawling and seabed erosion due to the main flow channel from Ma Wan; the organisms present are thus assumed to be adapted to seabed disturbances. Based on the assumption that eventually the affected areas will be recolonised by fauna typical of the area, then the temporary loss of these low ecological value assemblages are deemed acceptable.
- 8.5.19 Intertidal Habitats ⁽⁹⁾ :** Intertidal habitats within the Marine Ecology Study Area which may be affected by the reclamation activities include the sandy shores and ungazetted beaches located at Sze Pak Wan, Sam Pak Wan, Yi Pak Wan and Discovery Bay. Sediment dispersion results predict that SS concentrations will not exceed the WQO's at any of these shores. However, the water quality assessment predictions will be verified in the field during construction using the environmental monitoring and audit programme (EM&A). Should the EM&A show unacceptable impacts (with reference to exceedances of the WQO) then mitigation measures such as a further reduction in dredging/filling rates will be employed. Based on these conditions, impacts to the ecological assemblages present at these beaches are not predicted to be unacceptable.

(9) Intertidal habitats at Pa Tau Kwu and Fa Peng which include sandy and rocky shores have not been assessed as these habitats will be directly lost as a result of the Northshore Lantau Development. The assessment of impacts and the need for any mitigation measures is consequently discussed in the Northshore Lantau Development Feasibility Study EIA.

- 8.5.20 Higher than normal sediment loads arising from nearby dredging works were deposited on an assemblage of coralline algae at Cape d'Aguilar to the south of Hong Kong. This resulted in overgrowth of the coralline assemblage by the red turf alga, *Gelidium pusillum*, which became the most abundant species⁽¹⁰⁾. Scouring, due to very high SS levels (eg > 100 mg L⁻¹) may inhibit the survival of algae, thereby reducing the food supply to the numerous rocky shore herbivores and causing intolerant or less competitive species to become locally extinct. The water quality assessment scenarios indicate that no exceedances of the WQO will occur at the rocky coastal areas at Sze Pak Wan. The predictions will be verified in the field during construction using the EM&A. Should the EM&A show unacceptable impacts (with reference to exceedances of the WQO) then mitigation measures such as a further reduction in dredging/filling rates or the use of silt curtains will be employed. It is thus expected that unacceptable impacts to these intertidal assemblages arising from elevated SS levels will not occur.
- 8.5.21 **Marine Mammals:** Mobile animals such as marine mammals have the ability to avoid areas where SS levels have increased, thus avoiding any impacts. Impacts can occur to these mammals as an indirect result of increased SS levels. The construction of the Theme Park and associated facilities may cause perturbations to water quality which have the potential to impact the fisheries resources of the East Lantau area. The Indo-Pacific Humpbacked Dolphin, *Sousa chinensis*, in Hong Kong waters feed primarily on fish. The dolphins are often seen associated with pair trawlers which are likely to provide them with increased feeding opportunities; this appears to be confirmed by the limited data available from stomach contents analyses. By examining the stomachs of 12 stranded dolphins, Jefferson (1998) found that, with the exception of one individual's stomach content which contained some squid remains, only fish had been consumed. At least twenty species of fish belonging to 13 families were found in the stomach of these stranded dolphins. The most abundant families were anchovies - Engraulidae, croakers - Sciaenidae, and sardines - Clupeidae accounting for more than 81% of all fish in the stomachs of the stranded dolphins.
- 8.5.22 The Finless Porpoise, *Neophocaena phocaenoides*, is thought to be an opportunistic feeder with known prey including crustaceans (shrimps and prawns), cephalopods (squid and octopus) and small pelagic fish of low commercial value (anchovies, croakers and sardines). They are thus likely to be affected by any significant changes in key water quality parameters (such as SS and DO) arising from the development. A deterioration in water quality is likely to cause these mobile fish to move out of the area thus interfering with the dolphin and porpoises normal feeding patterns. As mentioned above for corals, the predicted elevations of SS in areas where the mammals are frequently sighted (such as S Lamma for the Finless Porpoise or the Brothers for the Indo-pacific Humpbacked Dolphin) are small and within environmentally acceptable levels (as defined by the WQOs). It is thus expected that unacceptable impacts to these marine mammals arising from elevated SS levels will not occur.
- 8.5.23 Introduction of environmental contaminants desorbed from suspended sediment particles (especially inorganic contaminants such as mercury and pesticides such as DDT) can have damaging effects on dolphins and porpoises. As discussed in the water quality assessment

(10) Kaehler S & Williams GA (1996) Distribution of algae on tropical rocky shores: spatial and temporal patterns of non-coralline encrusting algae in Hong Kong. *Marine Biology* 125: 177-187

contaminant release (specifically copper which is the only metal which exceeds the Class C sediment criteria standard) from dredging of contaminated sediments is not predicted to exceed environmental standards (as defined by EU water quality standards). Consequently, unacceptable impacts to marine mammals from contaminant release during dredging are not predicted to occur.

Dissolved Oxygen

8.5.24 The relationships between SS and DO are complex, with increased SS in the water column combining with a number of other effects to reduce DO concentrations in the water column. Elevated SS (and turbidity) reduces light penetration, lowers the rate of photosynthesis by phytoplankton (primary productivity) and thus lowers the rate of oxygen production in the water column. This has a particularly adverse effect on the eggs and larvae of fish, as at these stages of development, high levels of oxygen in the water are required for growth due to their high metabolic rate. Although respiratory responses and tolerance of hypoxia were studied in two marine fish⁽¹¹⁾, it is not possible to set critical thresholds for this parameter for other marine organisms due to lack of tolerance data for species in Hong Kong. DO depletions are most likely to affect sessile organisms as they cannot move away from areas where DO is low (unlike mobile species such as fish). Depletions of DO as a result of construction activities for the reclamation at Penny's Bay are very small (0.05 mg L^{-1} immediately outside of the works area and $< 0.017 \text{ mg L}^{-1}$ at Sze Pak Wan and Ma Wan) and for Yam O reclamation the operations are compliant with the WQO at 200m distance from the works. It is evident that the small depletions in DO are within environmentally acceptable levels (as defined by the WQO of 4 mg L^{-1}) and do not impact and marine ecological sensitive receivers. It is thus expected that unacceptable impacts to the marine ecological habitats and populations present in the vicinity of the Penny's Bay reclamation arising from very small depletions in DO levels will not occur.

Nutrients

8.5.25 High levels of nutrients (total inorganic nitrogen - TIN and ammonia) in seawater can cause rapid increases in phytoplankton often to the point where an algal bloom occurs. An intense bloom of algae can lead to sharp increases in DO levels in surface water. However, at night and when these algae die there is usually a sharp decrease in the levels of dissolved oxygen in the water as dead algae fall through the water column and decompose on the bottom. Anoxic conditions may result if DO concentrations are already low or are not replenished. This may result in mortality to marine organisms due to oxygen deprivation. Increases in TIN in the vicinity of the Penny's Bay works area are predicted to increase by 0.018 mg L^{-1} which is 7% increase over the background and is regarded as acceptable as there are no sensitive marine ecological habitats affected by the increase, for unionised ammonia the increases in the vicinity of the works area are $0.000014 \text{ mg L}^{-1}$ which are compliant with the WQO. For the Yam O reclamation the elevations at a distance of 200m from the works area of TIN are 0.008 mg L^{-1} which is compliant with the WQO and for unionised ammonia the elevations at the same distance are $0.00002 \text{ mg L}^{-1}$ which is also compliant with the WQO. It is thus expected that unacceptable impacts to the marine ecological habitats and populations present in the

(11) Wu RSS & Woo NYS (1984). Respiratory Responses and Tolerance to Hypoxia in Two Marine Teleosts, *Epinephelus akaara* (Temminck & Schlegel) and *Mylio macrocephalus* (Basilewsky). *Hydrobiologia* 119: 209-217

vicinity of the Penny's Bay and Yam O reclamations arising from very small elevations in nutrient levels will not occur.

High and Low Frequency Noise

- 8.5.26 As cetaceans are protected under the *Wild Animals Protection Ordinance* (Cap 170), 1980 any lethal and sublethal impacts due to underwater noise on marine mammals will be deemed unacceptable. Cetaceans are animals that rely heavily on acoustic information to communicate and to explore their environment. Therefore, any significant noise that disrupts communication or echolocation channels would be potentially harmful. High explosives produce pulses with a very rapid onset (shock waves), which change to conventional acoustic pulses as they propagate. The reactions from impacted cetaceans can range from brief interruption of normal activities to short- or long-term displacement from noisy areas. Strong sound may cause temporary or permanent reductions in hearing sensitivity. Information from the engineering consultants indicates that no explosives will be used in the construction process in the sea or nearshore environment.
- 8.5.27 Studies have shown that because of the efficient transfer of sound in water, dolphins can detect noises associated with vessels similar to dredgers at distances up to approximately 5 km⁽¹²⁾. Noise disturbance interferes with communication and echolocation pulses which are used for navigation and feeding, leading to behavioural changes. There is evidence suggesting that some cetacean species will minimise their use of areas affected by underwater noise.
- 8.5.28 Most dolphins can hear within the range of 1 - 150 kHz though the peak for a variety of species is between 8 - 90 kHz¹³. Dredging and large vessel traffic generally results in mostly low frequency noise typically in the range of 0.02 - 1 kHz¹⁴ which are below the peak range of 8 - 90 kHz reported for dolphins and therefore, would not likely cause problems. Percussive piling work will be involved in the construction process but only for the two ferry piers on the southern part of the Theme Park reclamation. Mitigation measures will be required during construction to prevent unacceptable impacts to marine mammals in the vicinity of the works if the construction takes place during the autumn and winter when dolphins are thought to use the area.

Vessel Traffic

- 8.5.29 Increases in marine traffic may disturb normal cetacean movement patterns through potential collision with vessels, increased turbidity generated by propellers and submerged equipment. Both dolphins and porpoises in Hong Kong have been found to have been killed by vessel collisions (Parsons and Jefferson in press). Additionally, vessel passes and noise can cause behavioural disturbance to these animals. This could affect both species. Increased vessel traffic through the Kap Shui Mun channel would likely affect mostly humpback dolphins and any increase in traffic from the south of Penny's Bay would most likely have an impact on finless porpoises. Vessel traffic from Victoria Harbour to the east should not adversely impact either species. A moderate increase in the number of large, slow-moving (less than 10 knots) vessels in the area should not cause a significant impact to

(12) Richardson et al (1995) *Marine Mammals and Noise*. Academic Press.

(13) Richardson et al (1995). *Op cit*.

(14) *Ibid*.

dolphins or porpoises. Smaller, faster outboard-driven boats would be more of a concern, because of the fast approach speeds and higher potential for high frequency noise. However, it is not anticipated that vessels associated with construction of the Theme Park will be of the latter type.

8.6 ASSESSMENT OF ENVIRONMENTAL IMPACTS - CONSTRUCTION

8.6.1 The following section discusses and evaluates the impacts to marine ecological habitats in Penny's Bay and Yam O. From the information presented above the marine ecological impact associated with the construction of the Project has been evaluated in accordance with the *EIAO TM Annex 8 Table 1* as follows:

- *Habitat Quality:* The reclamation works will result in the permanent loss of 0.298 ha of high ecological value hard surface habitat. Although the soft bottom habitat and rocky shores within the areas to be reclaimed will be permanently lost, these habitats are of low and medium ecological value respectively. Critical habitats utilised by the Finless Porpoise and Indo-Pacific Humpbacked Dolphin are not predicted to be affected by construction activities (dispersion of sediment plumes, vessel traffic, construction underwater noise);
- *Species:* The only organisms of ecological interest recorded during the field surveys and reported from the literature were hard corals within Penny's Bay and a seasonal population of the Indo-Pacific Humpbacked dolphin. The hard corals will be permanently lost through the reclamation works whereas the habitat for the dolphins will only be affected through minor perturbations to water quality parameters that are compliant with the WQO;
- *Size:* The low ecological value benthic assemblages within the 290 ha dredging and reclamation areas at Penny's Bay and Yam O will be directly lost. A small area of high ecological value coral habitat within Penny's Bay will also be lost (0.298 ha) as well as 3.08 km of low and medium ecological value natural intertidal habitats. As a result of the two reclamations 1.27 km of artificial sloping seawalls will also be directly lost. Areas outside the dredging and filling areas will experience short term impacts as a result of small amounts of sediment deposition;
- *Duration:* Increases in SS levels in the vicinity of sensitive receivers are expected to be low and temporary, and due to constraints on dredging and filling operations, within environmentally acceptable limits (as defined by the WQO's). Impacts to benthic and intertidal assemblages within the reclamation sites will be permanent;
- *Reversibility:* Impacts to benthic and intertidal assemblages within the reclamation sites are irreversible, whereas impacts to assemblages outside of the reclamation site are expected to be transient and recolonization should occur; and
- *Magnitude:* The impacts to the ecologically sensitive habitats outside of the reclamation areas defined in this review will be of low magnitude during construction of the Project. Impacts to assemblages within the reclamation site are of high severity, however, mitigation measures reduce this severity to low and acceptable.

8.7 MITIGATION OF ADVERSE ENVIRONMENTAL IMPACTS - CONSTRUCTION

MARINE ECOLOGICAL RESOURCES: GENERAL

8.7.1 The above assessment indicates that during reclamation works the potential impacts (before mitigation) are unlikely to be acceptable with respect to subtidal hard bottom habitat and marine mammals. Impacts to intertidal communities and subtidal soft bottom assemblages are anticipated to be environmentally acceptable. Constraints on controlling impacts to water quality to within acceptable levels during reclamation are expected to also control impacts on marine ecology. In accordance with the guidelines in the *EIAO TM* on marine ecology impact assessment the general policy for mitigating impacts to marine ecological resources, in order of priority, are:

- **Avoidance:** Potential impacts should be avoided to the maximum extent practicable by adopting suitable alternatives;
- **Minimisation:** Unavoidable impacts should be minimised by taking appropriate and practicable measures such as constraints on intensity of works operations (eg dredging rates) or timing of works operations; and
- **Compensation:** The loss of important species and habitats may be provided for elsewhere as compensation. Enhancement and other conservation measures should always be considered whenever possible.

8.7.2 The previous discussion (*Section 8.5*) has indicated that the following subtidal hard surface habitats within the Study Area will be lost:

- High Ecological Value - 0.22 ha (2,200 m in length and 1 m in depth) along the southern coastline of Penny's Bay;
- High Ecological Value - 0.078 ha (780 m in length and 1 m in depth) along the northeastern edge of Penny's Bay;
- Low Ecological Value - 2,000 m of vertical artificial seawall and 0.11 ha of sloping artificial seawall along the eastern coast of Penny's Bay (371 m in length and 3 m in depth);
- Low Ecological Value - 0.27 ha (900 m in length and 3 m in depth) of subtidal portions of sloping artificial seawall along the Yam O coastline.

8.7.3 The loss of these habitats is expected to be mitigated through provision of seawalls that provide adequate surfaces for colonisation once reclamation works have been completed.

- 3.2 km of sloping rubble mound seawalls will be provided at the Penny's Bay reclamation which will provide 4.3 ha of habitat for colonisation by corals;
- 0.7 km of sloping rubble mound seawalls will be provided at Yam O.

8.7.4 In order to assist in rehabilitating the area after reclamation, a rubble mound design should be adopted for the construction of the seawalls. It has been demonstrated that marine organisms have recolonised these seawalls after construction⁽¹⁾. It is anticipated that intertidal and subtidal assemblages similar to those recorded in the field surveys, will settle on and recolonise the newly constructed seawalls of the reclamation.

MARINE ECOLOGICAL RESOURCES: MARINE MAMMALS

8.7.5 Measures to mitigate the impact of the construction of the Project have been developed in consultation with Dr Tom Jefferson of the Ocean Park Conservation Foundation. The following recommendations should be followed to minimize potential construction impacts on dolphins and porpoises:

- 1) All vessel operators working on the Project construction should be given a briefing, alerting them to the possible presence of dolphins and porpoises in the area, and the rules for safe vessel operation around cetaceans. If high speed vessels are used, they should be required to slow to 10 knots when passing through a high density dolphin area;

(15) Binnie Consultants Ltd (1997) Chek Lap Kok Qualitative Survey Final Report. For the Geotechnical Engineering Office, Civil Engineering Department, December 1997.

- 2) A policy of no dumping of rubbish, food, oil, or chemicals should be strictly enforced. This should also be covered in the contractor briefing;
- 3) Every attempt should be made to minimize the effects of construction of the Project on the water quality of the area;
- 4) Any construction work that could potentially harm dolphins (underwater piling) should be planned to take place in spring or summer, when dolphin abundance is apparently lowest. In particular, the winter season should be avoided;
- 5) If piling must be done in autumn or winter, then the following steps should be taken:
 - An exclusion zone of 500 m radius should be scanned around the work area for at least 30 minutes prior to the start of piling. If cetaceans are observed in the exclusion zone, piling should be delayed until they have left the area; and
 - A bubble curtain should be used to surround the piling barge and work area, and the bubble curtain should be in operation during any time in which piling occurs.
- 6) Reclamation construction-phase dolphin/porpoise monitoring should be conducted by a qualified research team, to evaluate whether there have been any effects on the animals. The resulting data should be compatible with, and should be made available for, long-term studies of small cetacean ecology in Hong Kong.

8.8 IDENTIFICATION OF ENVIRONMENTAL IMPACTS - OPERATION

8.8.1 Operational impacts to marine ecological resources may occur through the following:

Hydrodynamic Regime

- 8.8.2 Impacts to marine ecological resources could potentially occur if the shape of the reclamation causes a change on the hydrodynamic regime of the East Lantau coastline. Impacts of this nature could lead to increased seabed current speeds which may cause seabed scour thus impacting subtidal assemblages, or conversely the current speeds may drop affecting flushing and water exchange of an area. Inadequate flushing could lead to reduction in dissolved oxygen (DO) an increase in nutrients and consequent impacts to marine ecological resources (DO and nutrient impacts were discussed in *Section 8.5*).
- 8.8.3 The hydrodynamic modelling (described in *Section 5*) has predicted that the reclamations for the Theme Park at Penny's Bay and Yam O will have minimal effects on tidal discharges through major flows channels. The only effects on tidal current speeds and directions are in the immediate vicinity of the reclamation at Penny's Bay, which are not considered to be significant. Mitigation measures for changes to tidal discharges and current patterns are, therefore, not considered to be necessary. The modelling has, however, predicted that there will be a reduction in the flushing of Sze Pak Wan and Discovery Bay, as demonstrated by the increased salinity in these areas. This effect may cause changes in the water quality of these areas. The acceptability of such changes has been assessed through water quality modelling, which has determined such a change in the hydrodynamic regime will result in only a minimal adverse effect on water quality with no breach in the WQO's (see *Section 5*).

Stormwater Run-off and Drainage

- 8.8.4 During the operation of the Theme Park pollutants derived from sewage effluent and stormwater will be discharged to the marine waters. Sewage effluents from the Theme Park and associated developments (eg hotels) will be collected and transported for treatment to the Siu Ho Wan Sewage Treatment Works (STW) via sub-surface sewerage pipelines. The effluents will be treated at the Siu Ho Wan STW and discharged to the marine waters to the north of the STW via a submarine outfall. During the operation of the Theme Park and associated developments, the Siu Ho Wan STW will also treat effluents from the Hong Kong International Airport, the Tung Chung and Tai Ho developments and Discovery Bay. The increase in the treated effluent flows and loads from the Theme Park and associated developments will have the potential to cause adverse impacts to water quality and subsequent impacts to marine ecological resources. Stormwater run-off from the Theme Park and associated development areas will be discharged to the marine waters to the south and east of the Theme Park at Penny's Bay via three large culverts
- 8.8.5 The stormwater may contain contaminants, which would have the potential to cause adverse impacts to water quality and marine ecology, most likely in the immediate vicinity of the discharge points due to the relatively low flow rates from these culverts.
- 8.8.6 All discharges during the operational phase of the Project are required to comply with the *Technical Memorandum for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters* (TM) issued under *Section 21* of the *WPCO*. The TM defines discharge limits to different types of receiving waters. Under the TM, effluents discharged into the drainage and sewerage systems, inshore and coastal waters of the WCZs are subject to pollutant concentration standards for particular discharge volumes. Any new discharges within a WCZ are subject to licence conditions and the TM acts as a guideline for setting discharge standards for the licence. It is anticipated that all stormwater discharges through surface run-off or drainage systems will be compliant with the TM. Compliance with the TM will ensure that no adverse impacts will occur to marine ecological resources in the vicinity of the project. Compliance is expected to be achieved according to the measures outlined in *Section 5* of this EIA.

Vessel Traffic

- 8.8.7 Increases in marine traffic may disturb normal cetacean movement patterns through potential collision with vessels, increased turbidity generated by propellers and submerged equipment. Both dolphins and porpoises in Hong Kong have been found to have been killed by vessel collisions (Parsons and Jefferson in press). Additionally, vessel passes and noise can cause behavioural disturbance to these animals. This could affect both species. Increased vessel traffic through the Kap Shui Mun channel would likely affect mostly humpback dolphins and any increase in traffic from the south of Penny's Bay would most likely have an impact on finless porpoises. Vessel traffic from Victoria Harbour to the east is not expected to impact either species.
- 8.8.8 Information indicates that traditional outlying islands style ferries will operate between the Theme Park and Victoria Harbour. It is expected that there would be an increase of 40 ferries per day during the week and 80 at the weekend (daylight hours). It is not

anticipated that this would cause unacceptable problems to the dolphins due to the infrequent use of the habitat by these mammals and the comparatively slow movements of the vessels (less than 10 knots). Smaller, faster outboard-driven boats would be more of a concern, because of the fast approach speeds and higher potential for high frequency noise. However, it is not anticipated that vessels associated with operation of the Theme Park will be of the latter type.

Sewer Damage and Emergency Discharges

8.8.9 The potential risk of damage to the sewer system for the Theme Park and associated developments is small and design features are such that the occurrence of such damage is minimal. Furthermore, the implementation of suitable mitigation measures, proposed in the *Water Quality Section (Section 5)*, will limit the duration of the potential discharges, therefore only short term impacts to water quality are expected. Following resumption of normal service, water quality will return to previous levels, thereby minimising the impact of such an event. In terms of potential impacts to marine ecology, should no adverse impacts to water quality occur, then impacts to these resources are not predicted to be unacceptable.

8.9 ASSESSMENT OF ENVIRONMENTAL IMPACTS - OPERATION

8.9.1 The following section discusses and evaluate the potential impacts to marine ecological habitats as a result of Project operational activities. From the information presented above the marine ecological impact associated with the operation of the Theme Park and its associated infrastructure has been evaluated in accordance with the *EIAO TM Annex 8 Table 1* as follows:

- *Habitat Quality:* Operation of the Theme Park and associated developments is not anticipated to affect any ecologically sensitive habitats;
- *Species:* The organisms of ecological interest recorded during the field surveys and reported from the literature that could potentially be impacted by operation of the Theme Park are the hard corals at Sze Pak and the seasonal population of the Indo-Pacific humpbacked dolphin. An increase in vessel traffic due to ferries carrying passengers to the Theme Park may cause disturbances to the dolphins use of the area;
- *Size:* Stormwater run-off is expected to affect a small area in the vicinity of the drainage channels to the southwest of the Theme Park. The discharges will be compliant with the WPCO discharge standards and are expected to be environmentally acceptable;
- *Duration:* Vessels to the ferry piers at the Theme Park will operate on a daily basis. Stormwater run-off and discharges are expected to be continuous, although will be greatest during the wet season;
- *Reversibility:* No irreversible impacts from the operation of the Theme Park and associated developments are predicted to occur; and
- *Magnitude:* The impacts to the ecologically sensitive habitats outside of the reclamation area defined in this assessment will be of low magnitude during operation of the Theme Park.

8.10 MITIGATION OF ADVERSE ENVIRONMENTAL IMPACTS - OPERATION

MARINE ECOLOGICAL RESOURCES: GENERAL

8.10.1 Impacts to marine ecological resources during operation of the Theme Park and associated developments are predicted to be within environmentally acceptable levels in ecologically important areas through controls on sewage discharges and site run-off (as discussed in

Section 5 - Water Quality). Hence no marine ecology specific mitigation measures to control discharges are required during Project operation.

MARINE ECOLOGICAL RESOURCES: MARINE MAMMALS

8.10.2 Measures to mitigate the impact of the operation of the Theme Park have been developed in consultation with Dr Tom Jefferson of the Ocean Park Conservation Foundation. The following recommendations should be followed to minimize potential operational impacts on dolphins and porpoises:

- 1) All vessel operators working on the Project should be given a briefing, alerting them to the possible presence of dolphins and porpoises in the area, and the rules for safe vessel operation around cetaceans. If high speed vessels are used, they should be required to slow to 10 knots when passing through a high density dolphin area.
- 2) The vessel operators should be required to use predefined and regular routes, as these will become known to dolphins and porpoises using these waters;
- 3) The vessel operators should be required to control and manage all effluent from vessels;
- 4) Operation-phase dolphin/porpoise monitoring should be conducted by a qualified research team, to evaluate whether there have been any effects on the animals. The resulting data should be compatible with, and should be made available for, long-term studies of small cetacean ecology in Hong Kong.

8.11 RESIDUAL IMPACT

8.11.1 Taking into consideration the ecological value of the habitats discussed in the previous sections and the resultant mitigation requirements, residual impacts have been determined. Disturbances to the seasonal marine mammal populations in the vicinity of the construction works has been identified from this assessment as a result of underwater percussive piling work (for the Ferry Piers) and moderate increases in vessel traffic. Mitigation measures proposed during construction and operation (discussed above) will reduce the severity of these impacts to acceptable levels.

8.11.2 The other residual impacts occurring as a result of the proposed Theme Park and associated development construction are as follows:

- The loss of 3.08 km natural intertidal habitats which are of low to medium ecological value and the loss of 1.27 km of sloping seawalls. The residual impact is considered to be acceptable as the loss of these organisms will be compensated by the provision of 3.9 km of sloping seawalls that have been demonstrated to become recolonised by assemblages of similar nature after construction;
- The loss of 0.298 ha subtidal hard surface habitats which are of high ecological value. The residual impact is considered to be acceptable as the loss of these organisms is compensated by the provision of at least 4.3 ha of sloping seawalls that have been demonstrated to become recolonised by assemblages of similar nature after construction; and,
- The loss of 280 ha of the subtidal soft bottom assemblages within the Penny's Bay Park reclamation site and 10 ha within the Yam O site. The residual impact is considered to be acceptable as the habitat is of low ecological value.

- 8.11.3 The previous discussion (*Section 8.5*) has indicated that the loss of intertidal and subtidal assemblages within the Project area is expected to be mitigated through provision of seawalls that provide adequate surfaces for colonisation once reclamation works have completed. In order to assist in rehabilitating the area after reclamation, a rubble mound design should be adopted for the construction of the seawalls. It has been demonstrated that marine organisms have recolonised these seawalls after construction⁽¹⁾. It is anticipated that intertidal and subtidal assemblages similar to those recorded in the field surveys, will settle on and recolonise the newly constructed seawalls of the reclamation. The residual impact is considered to be acceptable as corals and intertidal organisms are expected to colonise the seawalls after construction. The potential habitat provided by the surface area of the 3.9 km (3.2 km Penny's Bay and 0.7 km in Yam O) rubble mound seawalls (4.3 ha in Penny's Bay) is expected to effectively mitigate for the loss of the small area (0.298 ha) of hard corals lost within the reclamation site.
- 8.11.4 As an additional habitat enhancement measure the Project proponent has undertaken to deploy Artificial Reefs (ARs) in Hong Kong waters at a site (or sites) to be decided upon consultation with the Director of Agriculture, Fisheries and Conservation. At present the Agriculture, Fisheries and Conservation Department is conducting a programme to enhance existing marine habitats and fisheries resources through the siting, construction and deployment of ARs. ARs act as fish aggregation devices and provide hard bottom, high profile habitat in areas without natural cover. Colonisation of ARs occurs through settlement of the spores and larvae of algae, corals and other benthic organisms. The AR subsequently will provide food, shelter and a nursery ground for commercial fish and, over the long term enhance fishery stocks. Enhanced fish stocks in the area will not only benefit local fishermen but will also increase the availability of prey items for the seasonal population of marine mammals that use the area.
- 8.11.5 Information from the AFCD's Artificial Reef Deployment Study⁽¹⁷⁾ has reported that Japanese researchers have claimed that for ARs to be effective in enhancing marine resources they should have a minimum volume of 400m³. The Study also determined that the stocking density of ARs should be no less than 1,500m³ km⁻². The total area of seabed lost through reclamation works is 290ha (280 ha at Penny's Bay and 10 ha for Yam O). In order to enhance an equivalent area of this size 4,350m³ of ARs should be deployed (1,500 m³ x 2.9 km⁻²). One potential location for the deployment of the ARs is the area north of the Luk Keng headland. It should be noted that the location and scale of AR deployment within a particular site is limited by a variety of constraints detailed in full in the *Final Report* for the Artificial Reef Deployment Study (CE 8/97).

8.12 ECOLOGICAL MONITORING AND AUDIT REQUIREMENTS

- 8.12.1 Monitoring and auditing of marine ecological resources has been recommended for both the construction and operation phase. The specific monitoring requirements are detailed in *Annex N* of this EIA Report which comprises the stand-alone Project EM&A Manual.

(16) Binnie Consultants Ltd (1997) Chek Lap Kok Qualitative Survey Final Report. For the Geotechnical Engineering Office, Civil Engineering Department, December 1997.

(17) ERM-Hong Kong, Ltd (1999) Artificial Reef Deployment Study. Final Report for the AFCD.

8.13 CONCLUSIONS

- 8.13.1 Literature reviews of existing information supplemented with the results of recently undertaken field surveys on marine ecological resources indicate that the intertidal rocky shores within the Study Area are of medium ecological value whereas for the sandy habitats, low ecological value was assigned. Soft bottom habitats identified in the review were regarded as of low ecological value. A small area containing high ecological value assemblages of hard corals will be lost as a result of the reclamation activities. Information on baseline conditions suggests that no species of conservation importance have been recorded from the marine areas close to the reclamation site, with the exception of the Indo-Pacific Humpbacked Dolphin. However, the waters near the proposed reclamation sites do not appear to be highly utilised by the dolphins, it is unlikely that this area contains critical *Sousa chinensis* habitat.
- 8.13.2 Potential impacts to marine ecological resources from the proposed construction works may arise either indirectly, eg through perturbations of the surrounding water quality, or directly as a result of habitat loss. The natural intertidal and subtidal assemblages within the Penny's Bay and Yam O reclamation areas will be lost permanently due to the proposed reclamation works. However, it is anticipated that given adequate seawall design, assemblages typical of those lost will recolonise after reclamation. Indirect impacts during the reclamation process, such as an increase in SS levels and decrease in DO in the water column may impact intertidal and subtidal filter feeders and other marine organisms. However, the effects are not expected to be severe and no unacceptable impacts are predicted to occur.
- 8.13.3 Operational impacts to marine ecological resources may occur through disturbances to water quality due to changes in the hydrodynamic regime of the area or due to polluted discharges into the marine environment. It is expected that all discharges will comply with the WPCO discharge standards and consequently marine ecological resources will be protected from impacts. Minor changes in the local hydrodynamic regime are predicted although these are not expected to alter water quality to an extent that marine ecological resources are affected. An increase in the number of vessels travelling to and from Victoria Harbour and the Theme Park is predicted to occur. However, as these vessels will not be high speed and this area is not regarded as critical habitat to the Indo-Pacific Humpbacked Dolphin unacceptable impacts are not predicted to occur with appropriate mitigation measures.
- 8.13.4 Mitigation measures specific to marine ecology include the provision of rubble mound seawalls on the southern edges of the Penny's Bay reclamation, and at Yam O, to facilitate colonisation by intertidal organisms and corals which will be lost as a result of the construction of the reclamation. Mitigation measures designed to minimise impacts to the seasonal population of marine mammals that use the area include restrictions on vessel speed and the use of bubble curtains during percussive piling work for construction of the two Theme Park ferry piers. Other mitigation measures designed to mitigate impacts to water quality to acceptable levels (compliance with WQO's), including constraints on dredging and filling operations, are also expected to mitigate impacts to marine ecological resources.

- 8.13.5 The impacts occurring as a result of construction and operation of the Theme Park and associated developments are the direct loss of 290 ha of the low ecological value soft benthic assemblages, 3.08 km of medium and low ecological value natural intertidal shores, 1.27 km of sloping artificial seawalls, and 0.298 ha of high ecological value coral habitat. The loss of the habitat within the areas to be reclaimed can be mitigated through the provision of 3.9 km of rubble mound seawall, of which 4.3 ha would be suitable for corals to colonise and grow. This mitigation measure reduces the magnitude of the residual impact to acceptable levels.
- 8.13.6 An ecological monitoring and audit programme involving the use of dive surveys will be conducted to report on the progress of colonisation of the rubble mound seawalls once construction works have ceased. As an additional habitat enhancement measure the Project proponent has undertaken to deploy Artificial Reefs in Hong Kong waters at a site (or sites) to be decided upon consultation with the Director of Agriculture, Fisheries & Conservation. Construction-phase dolphin/porpoise monitoring should be conducted by a qualified research team, to evaluate whether there have been any effects on the animals. The resulting data should be compatible with, and should be made available for, studies of small cetacean ecology in Hong Kong.
- 8.13.7 In order to protect against unacceptable impacts to marine ecological resources, an EM&A programme has been designed to specifically detect and mitigate any unacceptable impacts to water quality (see *Section 5*). Operation-phase dolphin/porpoise monitoring should be conducted by a qualified research team, to evaluate whether there have been any effects on the animals. The resulting data should be compatible with, and should be made available for, studies of small cetacean ecology in Hong Kong.

Table 8.13a - Marine Ecology Impact Summary

Impact	Summary
Sensitive Receiver (s)	<ul style="list-style-type: none"> • Habitat for the Indo-pacific Humpbacked Dolphin in the coastal waters of East Lantau and North Lantau. • Assumed high ecological value hard coral assemblages located at Sze Pak Wan. • Medium ecological value hard coral assemblages located on Kau Yi Chau.
Assessment Criteria	<p>For indirect impacts the water quality objectives are used.</p> <p>For sediment deposition the criterion of 0.2 kg m² day⁻¹ is used.</p>
Disturbances to the seasonal marine mammal populations from underwater percussive piling and vessel traffic.	Disturbances to the seasonal marine mammal populations in the vicinity of the construction works has been identified from this assessment as a result of underwater percussive piling work (for the Ferry Piers) and moderate increases in vessel traffic. Mitigation measures proposed during construction and operation (discussed above) will reduce the severity of these impacts to acceptable levels.
Loss of intertidal habitat.	The loss of 3.08 km natural intertidal habitats which are of low to medium ecological value and the loss of 1.27 km of sloping seawalls. The residual impact is considered to be acceptable as the loss of these organisms will be compensated by the provision of 3.9 km of sloping seawalls that have been demonstrated to become recolonised by assemblages of similar nature after construction.
Loss of subtidal hard surface habitat.	<p>The loss of 0.298 ha subtidal hard surface habitats which are of high ecological value. The residual impact is considered to be acceptable as the loss of these organisms is compensated by the provision of at least 4.3 ha of sloping seawalls that have been demonstrated to become recolonised by assemblages of similar nature after construction.</p> <p><i>Final Report for the Artificial Reef Deployment Study (CE 8/97).</i></p>
Loss of subtidal soft bottom habitat..	<p>The loss of 280 ha of the subtidal soft bottom assemblages within the Penny's Bay Park reclamation site and 10 ha within the Yam O site. The residual impact is considered to be acceptable as the habitat is of low ecological value.</p> <p>As an additional habitat enhancement measure the Project proponent has undertaken to deploy Artificial Reefs. The total area of seabed lost through reclamation works is 290ha (280 ha at Penny's Bay and 10 ha for Yam O). In order to enhance an equivalent area of this size 4,350m³ of ARs should be deployed (1,500 m³ x 2.9 km²). One potential location for the deployment of the ARs is the area north of the Luk Keng headland. It should be noted that the location and scale of AR deployment within a particular site is limited by a variety of constraints detailed in full in the</p>