

9 FISHERIES IMPACT ASSESSMENT

9.1 INTRODUCTION

9.1.1 This Section of the EIA Report presents the findings of a desk-top assessment and focussed field survey of the impacts of the construction and operation of the proposed Theme Park and associated developments on existing fisheries resources, fishing operations and fish culture activities.

9.1.2 The objectives of the assessment are as follows:

- to establish the importance to Hong Kong's fisheries of the habitats which may be affected by the construction and operation of the proposed Theme Park and associated developments;
- to identify fisheries sensitive receivers;
- to assess the scale of potential impacts to fisheries from the works associated with the construction and operation of the Theme Park and associated developments, and identify any significant or unacceptable impacts;
- to identify any mitigation measures and residual impacts; and
- to assess the need for a fisheries monitoring and audit programme.

9.2 LEGISLATION AND STANDARDS

9.2.1 The criteria for evaluating fisheries impacts are laid out in the *EIAO TM*. *Annex 17* of the *EIAO TM* prescribes the general approach and methodology for assessment of fisheries impacts arising from a project or proposal, to allow a complete and objective identification, prediction and evaluation of the potential fisheries impacts. *EIAO TM Annex 9* recommends the criteria that can be used for evaluating fisheries impacts.

9.2.2 Other legislation which applies to fisheries includes:

- the *Fisheries Protection Ordinance (Cap 171) 1987* which provides for the conservation of fish and other aquatic life and regulates fishing practices; and
- *Marine Fish Culture Ordinance (Cap 353) 1983* regulates and protects marine fish culture and other related activities.

EX GRATIA ARRANGEMENTS

Capture Fisheries

9.2.3 Fishermen do not have legal ownership of the water they habitually fish. They are, therefore, not entitled to any statutory compensation for loss of fishing grounds. However, according to existing policy, fishermen affected by reclamation or development projects may be granted *ex gratia* allowances subject to certain eligibility criteria. Since 1993, *ex gratia* allowances have been based on the notional value of three years fish catch in the gazetted works area for the proposed project under the Foreshore and Seabed (Reclamations) Ordinance (Cap 127), and should be applied to

all dredging and dumping projects. Such *ex gratia* allowances serve as allowances for a permanent loss of fishing grounds and are aimed at assisting the affected fishermen in relocating their activities to other fishing grounds or to move into another industry.

Culture Fisheries

9.2.4 *Ex gratia* arrangements for mariculturists affected by dredging or dumping projects were approved in July 1993. If, at any one time, the suspended solids concentration exceeds 50 mg L⁻¹ or exceeds by 100% the highest level recorded at the Fish Culture Zone (FCZ) during the five years before commencement of works in the vicinity, mariculturists are eligible for *ex gratia* allowance payments. Should *ex gratia* payments be triggered the eligible mariculturists may then opt to:

- continue mariculture in the same place at their own risk, in which case they would be eligible for an *ex gratia* allowance equivalent to 50% of the normal two-year fish culture cycle; or
- suspend mariculture operations for two years, in which case they would be eligible for an *ex gratia* allowance equivalent to the notional loss of income for a normal two-year fish cycle; or
- cease mariculture operations permanently, in which case they would receive the existing *ex gratia* allowance payable for extinguishment, which contains elements for the notional loss of income for two years and the loss of capital investment in rafts and cages.

9.3 EXISTING ENVIRONMENT AND FISHERIES SENSITIVE RECEIVERS

9.3.1 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). On the basis of preliminary information from the water quality assessment, perturbations to water quality are unlikely to extend outside the area presented in *Figure 9.2a*. Consequently, this assessment of impacts has focussed on the fisheries resources of this area.

9.3.2 In Hong Kong, the commercial marine fishing industry is divided into capture and culture fisheries. To assess the capture fishery within the Assessment Area, the most up-to-date information on the Hong Kong fishery was consulted ⁽¹⁾. Information from other relevant studies within the Assessment Area were also reviewed in order to determine if the areas are important nursery and spawning grounds for commercial fisheries ⁽²⁾. Updated mariculture information was obtained from AFCD.

CAPTURE FISHERIES

9.3.3 In 1997, the estimated fisheries production in Hong Kong waters from both capture and culture fisheries amounted to 186,000 tonnes, valued at HK\$ 2,459 million ⁽³⁾. Capture fisheries accounted for 96% by weight of the total production while the remaining 4% corresponded to the culture sectors of the industry. Within Hong Kong waters, the highest yields for local fisheries were mainly derived from the eastern and north-eastern coasts ⁽⁴⁾. The five most abundant fish species

1) Agriculture, Fisheries and Conservation Department (1998) Port Survey 1996 - 1997.

2) ERM (1998) Fisheries Resources and Fishing Operations in Hong Kong Waters, Final Executive Summary, for Agriculture, Fisheries and Conservation Department.

3) Agriculture, Fisheries and Conservation Department (1998), Annual Departmental Report 1997-1998

4) ERM (1998) *Op cit.*

landed by weight from the capture sector were golden thread (*Nemipterus virgatus* 14%), lizardfish (*Saurida* sp 9%), big-eyes (*Priacanthus* sp 5%), scads (*Decapterus* sp 5%) and yellow belly (*Nemipterus bathybius* 4%)⁽¹⁾.

- 9.3.4 In 1989-91 AFCD devised a system whereby the waters of Hong Kong were divided up into Fishing Zones. Data was gathered at that time on the catches of the Hong Kong fleet derived from these Fishing Zones⁽⁵⁾. Since this first Hong Kong wide survey, AFCD have updated the information which now indicates that the number of Fishing Zones equates to 189 of which 179 are actively fished by vessels in the Hong Kong fleet.
- 9.3.5 The up-to-date information from AFCD is available for use in this EIA and can be collated to allow an assessment be made of the importance of Fishing Zones in the Assessment Area to the Hong Kong fishery (*Figure 9.2a*). The designated Fishing Zones within the Assessment Area have been identified and the importance of these zones will be assessed and discussed below.
- 9.3.6 The Assessment Area within which potential impacts arising from the construction and operation of the Theme Park and associated developments may occur, consists of thirteen Fishing Zones (*Figure 9.2a*). These zones are found in northern and eastern Lantau Island. Of these 13 fishing zones only three fall in some part under the footprint of the two reclamations for the Theme Park (0023 - Yam O, 0002 - Pa Tau Kwu and 0003 - Penny's Bay).
- 9.3.7 In comparison with other parts of Hong Kong these fishing zones show a low ranking for fisheries production. Out of the 189 fishing zones in Hong Kong that reported catches Pa Tau Kwu 149 and Penny's Bay 133. The main fishing operations in these areas are by small scale vessels operating gill nets, hand lines and long lines. These vessels originate from three of the home ports of Silvermine Bay, Ma Wan and Peng Chau. The Pa Tau Kwu and Penny's Bay fishery zones are also ranked as low (the lower third of all fishing zones) for Hong Kong in terms of catch value. The fishing zone at Yam O ranks as medium (82 out of 189) when compared to other zones in Hong Kong for both catch weight and value. Neither of these three zones recorded any fry capture activities.
- 9.3.8 Of the other fishing zones in the Assessment Area the more important ones that rank as of high fisheries production (top third of all fishing zones) are Tsing Chau Tsai East, Ma Wan, Peng Chau and Tsing Lung Tau. Fish fry capture activities were reported from Tsing Chau Tsai, Ma Wan, Kau Yi Chau and Tsing Lung Tau. However, none of these four zones can be regarded as important areas for fry production. The main fish species reported in catches from the Theme Park footprint are of low commercial value including, mantis shrimp, mixed species (juveniles of trash fish species such as pony fish, scad, rabbitfish and sardine), croaker, crabs and sole. Only one species of medium value are reported from the area those being the sea breams.
- 9.3.9 Results of a 12-month fishery survey initiated in August 1995 around Penny's Bay⁽⁶⁾ revealed that the fisheries resources in the area are generally in a poor state as indicated by the low numbers collected per unit of fishing effort, the extremely low encounter rate for large schools of the dominant pelagic fish, and the undersized nature of the catch. The cause of this poor state of the

5) Agriculture, Fisheries and Conservation Department (1991) Port Survey 1989 - 1991.

6) CES (Asia) Ltd (1997) Lantau Port Development Stage 1 Fisheries Resources Survey. Final Report submitted to Civil Engineering Department, June 1997.

resource was attributed by the authors to a combination of overfishing and habitat degradation from pollution and disturbance (dredging and dumping).

- 9.3.10 To further facilitate the assessment of capture fisheries in the Assessment Area, ichthyoplankton trawls were conducted in Penny's Bay. The results of these trawls are described in detail in *Annex H* and are summarised below with particular comparison to similar trawls conducted in surrounding waters.
- 9.3.11 While Penny's Bay showed the highest abundance of ichthyoplankton when compared to the results obtained for Little Green Island, Green Island and Hong Kong Island, the majority of the species identified are of low commercial value. Based on the results obtained from surveys, Penny's Bay waters does not appear to be an important nursery and spawning habitat for fish fry species.

CULTURE FISHERIES

- 9.3.12 The closest AFCD designated Fish Culture Zone (FCZ) to the Assessment Area is located at Ma Wan. Information from the AFCD indicates that, as at 31 Jan 2000, the Ma Wan FCZ consists of 132 licensed rafts from 82 licenses issued, with a total licensed area of 14,557 m² (total gazetted area = 46,300 m²). There are no figures available for individual production at this FCZ, although the annual production of fish reared in Hong Kong has dropped from 2,960 tonnes in 1997 to 1,200 tonnes in 1998 as a result of a red tide outbreak. In March and April 1998, widespread red tide algal blooms caused fish kills at many of the FCZs in Hong Kong. However, the Ma Wan FCZ, due to the fast currents in the vicinity, was the least affected of the FCZs and only minimal fish kills occurred (AFCD *pers comm*). The main species cultured in Hong Kong were the spotted grouper (*Epinephelus chlorostigma*), gold-lined seabream (*Rhabdosargus sarba*), mangrove snapper (*Lutjanus argentimaculatus*) and the pompano (*Trachinotus blochii*).

IDENTIFICATION OF SENSITIVE RECEIVERS

- 9.3.13 Based on the preceding review of the available information on the fisheries resources of the waters of the Assessment Area and its immediate vicinity, the only sensitive receiver which may be affected by the proposed works associated with the Theme Park has been identified as the Ma Wan FCZ.

FISHERIES IMPORTANCE

- 9.3.14 The importance of the fisheries within the Assessment Area is addressed based on the baseline information provided above. The Fishing Zones within the Assessment Area, situated within the footprint of the Theme Park reclamation are characterised as generally of low value. The catches from these zones are composed of juvenile mixed species which are used as fish feed in mariculture. However, the size and subsequent value of the catches characterises these Fishing Zones as of low importance to the Hong Kong fishery.
- 9.3.15 The *EIAO TM (Annex 9)* states that nursery areas can be regarded as an important habitat type as they are critical to the regeneration and long term survival of many organisms and their populations. Although previous literature identified part of the Assessment Area as a spawning and nursery area for many commercially important species, recent information and ground truthing field surveys

reveal that the Penny's Bay area is not an important fisheries spawning or nursery ground (see results of Ichthyoplankton Trawls conducted in Penny's Bay detailed in *Annex H*). The AFCD Fisheries Study ⁽⁷⁾ identified the most important fisheries spawning and nursery areas in Hong Kong waters (*Figure 9.2b* and *9.2c*). As can be seen from the figures the Penny's Bay area was not regarded as an important spawning or nursery area.

9.4 ASSESSMENT METHODOLOGY

9.4.1 A desktop literature review and supporting field surveys (summarised above in *Section 9.3* and detailed in full in *Annex H*) were conducted in order to establish the fisheries importance of the area within and surrounding the Theme Park Assessment 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 based on information from the water quality impact assessment (*Section 5*). This area became the focus for this fisheries impact assessment. The importance of potentially impacted fishing resources and fisheries operations identified within the Assessment 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 17* guidelines) and the impacts evaluated (based on the criteria in *EIAO TM Annex 9*).

9.5 IDENTIFICATION OF ENVIRONMENTAL IMPACTS - CONSTRUCTION

9.5.1 Impacts associated with the Theme Park and associated developments are divided into those occurring during the construction phase, and those in the operation phase. This section of the EIA discusses impacts from the construction phase.

9.5.2 Impacts to fisheries resources and fishing operations arising from the construction may be divided into those arising from direct disturbance to the habitat and those arising from perturbations to key water quality parameters.

DIRECT IMPACTS

9.5.3 Bearing in mind the low value of fisheries in the area, direct impacts to fisheries resources and fishing operations include habitat loss due to the dredging and reclamation associated with the proposed Theme Park. The construction of the extension will lead to the permanent loss of portions of three AFCD fishing zones:

- 10 ha of the Yam O Fishing zone (1.9%);
- 205 ha of the Penny's Bay Fishing zone (73.7%); and,
- 75 ha of the Pa Tau Kwu Fishing zone (9.2%).

9.5.4 These losses equate to a reduction in value of the Hong Kong fishery of 0.1% which is regarded as low.

⁷⁾ ERM (1998) *Op Cit.*

INDIRECT IMPACTS

9.5.5 Indirect impacts to fisheries resources and fishing operations 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.

SUSPENDED SOLIDS

9.5.6 Suspended sediment fluxes occur naturally in the marine environment and consequently fish have evolved behavioural adaptations to tolerate increased SS loads, including clearing their gills by flushing water over them. Where SS levels become excessive, fish will move to clearer waters. Susceptibility generally decreases with age, with eggs the most vulnerable and the adults the least sensitive to effects from sediments. Other factors such as the rate, season and duration of SS elevations will interact with life stage sensitivity to influence the type and extent of impact upon fish.

DISSOLVED OXYGEN

9.5.7 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. Elevated SS can also cause increased energy retention from sunlight, resulting in higher temperatures, and thus the potential for lower oxygen levels as oxygen is more soluble in cold water. 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 high metabolic rates.

NUTRIENTS

9.5.8 High levels of nutrients 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 decreases in the levels of dissolved oxygen. This decrease will initially occur in the surface water, and then deepen 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 fish, especially juveniles, due to oxygen deprivation. The results of the water quality assessment examining dispersion of sediment plumes associated with the dredging and filling works for the reclamation have shown that the predicted maximum levels are localised to within and around the dredging works. It is expected that the concentrations within the Assessment Area as a whole will be maintained at environmentally acceptable levels (compliant with the water quality objectives see *Section 5*).

9.5.9 Impacts to the sensitive receivers listed above are predicted, as a result of the construction of the Penny's Bay and Yam O reclamations, to be within environmentally acceptable levels (as defined by compliance with the Water Quality Objectives - WQO for the area). Impacts to the Ma Wan

Fish Culture Zone as a result of the construction and reclamation activities are unlikely to be severe as the increase in SS near the Ma Wan waters is expected to be small. Elevations are predicted to be in the order of 4.2 mg L^{-1} under the worse case scenario of filling (Penny's Bay) which are compliant with the WQO. Impacts arising from the Yam O reclamation are of lower magnitude and also environmentally acceptable. Reductions in DO as well as increases in nutrient levels as a consequence of SS elevations are anticipated to be small and compliant with the WQO. Therefore, severe impacts on the FCZ due to the proposed works are not expected to occur. Due to the low severity of predicted impacts it is not expected that growth of fish in the Ma Wan FCZ will be affected by the construction activities associated with the Penny's Bay or Yam O reclamations, or potential increases in fish mortalities will occur as a result.

9.5.10 The cumulative assessment of impacts to water quality (*Sections 5.6.1 & 5.7.1*) from concurrent projects has indicated that suspended solids elevations do exceed the water quality objective. The total predicted increases in concentrations at the Ma Wan Fish Culture Zone will be reduced from a value of 14.3 mg L^{-1} before mitigation, to a value of maximally 12.0 mg L^{-1} after mitigation, to which the construction of the Penny's Bay reclamation contributes 15.8%. The contribution due to the construction of the Penny's Bay reclamation has thus been reduced as much as is practicable by partial seawalls (ie to less than 2 mg L^{-1}) and any further reductions in the impacts at the Ma Wan Fish Culture Zone will thus fall to the other concurrent projects. The duration of the WQO exceedance is discussed in *Section 5.7.1*. It should be noted that in the assessment the contributions of other concurrent projects at the Ma Wan Fish Culture Zone was based on worst case scenarios for each of those projects (ie the concurrent projects were assumed to be operating at their highest allowable rates) and that the probability of each of those worst case scenarios operating concurrently is considered to be low. Furthermore, it has been assumed that the maximum predicted increases in concentrations at the Ma Wan Fish Culture Zone for each of the concurrent projects occur at the same time within the tidal cycle, which may not necessarily be the case. It may thus be concluded that the cumulative impacts assessed here are very much worst case and that the actual impacts are likely to be very much lower, which will be determined through monitoring.

9.5.11 It is noted that, despite the very conservative nature of the cumulative impact assessment, the above predicted increases in suspended solids concentrations do not exceed tolerance thresholds established in the literature. The total values for SS (including the elevations) are predicted under the worst case scenario to be 39.3 mg L^{-1} . Literature reviews indicate that lethal responses had not been reported in adult fish at values below 125 mg L^{-1} ⁽⁸⁾ and that sublethal effects were only observed when levels exceeded 90 mg L^{-1} ⁽⁹⁾. It should be noted that these tolerance thresholds were taken from international literature as there are no sediment tolerance data specific to Hong Kong species. Taking all of the above into consideration adverse cumulative impacts to culture fisheries resources at the Ma Wan Fish Culture Zone are not predicted to occur as the values are within reported tolerance levels for fish species.

(8) References cited in BCL (1994) Marine Ecology of the Ninepin Islands including Peddicord R and McFarland V (1996) Effects of suspended dredged material on the commercial crab, *Cancer magister*. in PA Krenkel, J Harrison and JC Burdick (Eds) Dredging and its Environmental Effects. Proc. Speciality Conference. American Society of Engineers.

(9) Alabaster JS & Lloyd R (1984) Water Quality Criteria for Freshwater Fisheries. Butterworths, London.

9.6 ASSESSMENT OF ENVIRONMENTAL IMPACTS - CONSTRUCTION

9.6.1 From the information presented above, the fisheries impact associated with the construction of the Theme Park and associated developments is considered to be low. An evaluation of the impact in accordance with *Annex 9* of the *EIAO TM* is presented below.

- *Nature of impact:* Permanent impacts will occur as a result of loss of fishing grounds in the area to be reclaimed for the Penny's Bay and Yam O reclamations. Temporary impacts to pelagic and demersal fisheries resources as a result of minor perturbations to water quality are predicted to occur only in the vicinity of the reclamations.
- *Size of affected area:* The main areas affected by the construction of the Theme Park and associated developments are 10 ha of fishing ground within the Yam O Fishing Zone and 205 ha of the Penny's Bay Fishing Zone and 75 ha of the Pa Tau Kwu Fishing Zone. Sediment dispersed during construction of the Theme Park and associated developments will cause short term increases in suspended sediment (SS) levels close to the works activities.
- *Size of fisheries resources / production:* In comparison with other parts of Hong Kong two of the three affected fishing zones show a low ranking for fisheries production (Pa Tau Kwu 149 and Penny's Bay 133). The Yam O Fishing Zone is the least affected by the reclamation activities and is ranked as medium for Hong Kong (82 out of 189).
- *Destruction and disturbance of nursery and spawning grounds:* No identified nursery and spawning grounds in the vicinity of the Project.
- *Impact on fishing activity:* The area to be reclaimed for the Yam O reclamation translates into the loss of 1.9% of the Yam O Fishing Zone and a potential loss of 1,190 kg annually of fish catches. This equates to a 0.009% decrease in the value of the Hong Kong fishing industry and is regarded as low. The area to be reclaimed for the Penny's Bay reclamation translates into the loss of 9.2% of the Pa Tau Kwu Fishing Zone and 73.7% of the Penny's Bay Fishing Zone. This reduction equates to potential loss of 9,938 kg annually of fish catches. This equates to a 0.1% decrease in the value of the Hong Kong fishery and is regarded as low. These permanent losses may be subject to claims for *ex gratia* allowances which are administered by the Planning and Lands Bureau.
- *Impact on aquaculture activity:* Based on the Water Quality Objectives, the Ma Wan Fish Culture Zone is not predicted to be impacted by either SS elevations, DO depletions or nutrient elevations as a result of the construction of the Yam O and Penny's Bay reclamations.

9.7 MITIGATION OF ADVERSE ENVIRONMENTAL IMPACTS - CONSTRUCTION

9.7.1 In accordance with the guidelines in the *EIAO TM* on fisheries impact assessment the general policy for mitigating impacts to fisheries, in order of priority, are avoidance, minimization and compensation.

9.7.2 Impacts to fisheries resources and fishing operations have largely been avoided during construction through constraints on the works operations associated with the sand filling, public filling and dredging for the reclamation sites. These constraints were recommended in *Section 5* to control water quality impacts to within acceptable levels, are also expected to control impacts to fisheries resources.

9.7.3 Water quality mitigation measures include conducting filling behind partially completed seawalls for the Penny's Bay reclamation to minimise dispersion of sediment outside the works area. The

proposed mitigation will also serve to protect the Ma Wan FCZ from cumulative impact (*Section 5*). Hence, no fisheries-specific mitigation measures are required during construction.

9.8 IDENTIFICATION OF ENVIRONMENTAL IMPACTS - OPERATION

9.8.1 This section of the EIA discusses impacts from the Theme Park and associated developments operation phase. Operational impacts to fisheries resources may occur through the following:

HYDRODYNAMIC REGIME

9.8.2 Impacts to fish culture operations at Ma Wan 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 decreased 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 fish culture operations and fish growth. However, the hydrodynamic modelling has predicted that the reclamation's for the Theme Park and associated developments in Penny's Bay and the reclamation at Yam O will have minimal effects on tidal discharges through major channel flows (*Section 5*). The only effects on tidal current speeds and directions are in the immediate vicinity at Penny's Bay, which are not considered to be significant. As result, adverse water quality impacts to the FCZ at Ma Wan are also not considered to be significant and, therefore, it is not expected that growth of fish in the Ma Wan FCZ will be affected by operational activities associated with the Theme Park, or potential increases in fish mortalities will occur as a result.

STORMWATER RUN-OFF AND DRAINAGE

9.8.3 During the operation of the Theme Park pollutants derived from sewage effluent and storm water will be discharged to the marine waters. Sewage effluents from the Theme Park will be collected and transported to the Siu Ho Wan Sewage Treatment works 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. In the future, during the operation of the Theme Park, the Siu Ho Wan STW will treat also effluents from the Chek Lap Kok airport, the Tung Chung and Tai Ho developments and Discovery Bay. The increase in the treated effluent flows and loads from the Theme Park will have the potential to cause adverse impacts to water quality and subsequent impacts to fisheries resources. Stormwater run-off from the Theme Park developments 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. The stormwater may contain contaminants, which would have the potential to cause adverse impacts to water quality and fisheries resources, most likely in the immediate vicinity of the discharge points due to the relatively low flow rates from these culverts.

9.8.4 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 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.

- 9.8.5 The water quality modelling has predicted that the stormwater discharges from the operation of the Theme Park have not been predicted to have any adverse effects to water quality (*Section 5*). As a result, no adverse effects to fisheries resources is expected to occur. A precautionary measure of installing silt traps on all storm drains on the Theme Park and associated developments has been recommended in the *Water Quality Section (Section 5)*, which will additionally reduce any potential impacts to water quality and consequently also add as an additional mitigation measure for impacts to fisheries resources.

SEWER DAMAGE AND EMERGENCY DISCHARGES

- 9.8.6 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 both capture and culture fisheries resources, should no adverse impacts to water quality occur, then impacts to these resources are not predicted to be unacceptable.

9.9 ASSESSMENT OF ENVIRONMENTAL IMPACTS - OPERATION

- 9.9.1 From the information presented above, the fisheries impact associated with the operation of the Theme Park and its associated developments is considered to be low. An evaluation of the impact in accordance with *Annex 9* of the *EIAO TM* is presented below.

- *Nature of impact:* As no adverse operational impacts are predicted to occur to water quality as there is no exceedence of the WQO objectives, no operational impacts predicted to occur to fisheries resources
- *Size of affected area:* Operational impacts are predicted to be within acceptable levels and are expected to be within close proximity to the reclamation areas for the Theme Park and associated developments.
- *Size of fisheries resources / production:* In comparison with other parts of Hong Kong two of the three fishing zones in proximity to the reclamations show a low ranking for fisheries production (Pa Tau Kwu 149 and Penny's Bay 133). The Yam O Fishing Zone is the least affected by the reclamation activities and is ranked as medium for Hong Kong (82 out of 189).
- *Destruction and disturbance of nursery and spawning grounds:* No identified nursery and spawning grounds in the vicinity of the Project.
- *Impact on fishing activity:* No unacceptable impacts are predicted to occur to the Hong Kong fishery as a result of the Theme Park and its associated developments.
- *Impact on aquaculture activity:* The Ma Wan Fish Culture Zone is not predicted to be impacted by either SS elevations, DO depletions or nutrient elevations as a result of the operation of the Theme Park and its associated developments. Discharges are expected to meet licence standards and consequently impacts to water quality and fisheries resources will be avoided. Changes to the hydrodynamic regime are not expected to impact the water quality of the FCZ as current speeds are expected to be only minimally affected.

9.10 MITIGATION OF ADVERSE ENVIRONMENTAL IMPACTS - OPERATION

- 9.10.1 In accordance with the guidelines in the EIAO TM on fisheries impact assessment the general policy for mitigating impacts to fisheries, in order of priority, are avoidance, minimization and compensation.
- 9.10.2 Impacts to fisheries resources and fishing operations have largely been avoided during operation of the Theme Park and its associated developments through compliance on discharge standards. Compliance with the relevant discharge standards were recommended to control water quality impacts to within acceptable levels, are also expected to control impacts to fisheries resources. Hence, no fisheries-specific mitigation measures are required during operation.

9.11 RESIDUAL ENVIRONMENTAL IMPACTS

- 9.11.1 Based on the value to the fishery of the areas discussed in the previous sections and the specified mitigation requirements the residual impact (ie remaining after mitigation) can be determined. Residual impact to fisheries resources and operations have been identified and are defined and evaluated below following the guidelines presented in *Section 4.4.3* of the *EIAO TM*.

FISHING GROUND LOSS

- 9.11.2 The identified residual impact occurring during the construction of the Yam O and Penny's Bay reclamations is the permanent loss of 10 ha of the Yam O Fishing zone (1.9%); 205 ha of the Penny's Bay Fishing Zone (73.7%); and, 75 ha of the Pa Tau Kwu Fishing Zone (9.2%). The loss of this part of these fishing grounds, although potentially detrimental to some fishermen is unlikely to cause a noticeable reduction in fish catches. Although not implemented specifically to mitigate for the loss of fishing grounds, the provision of rubble mound seawalls on which more diverse and abundant ecological assemblages than present on the existing flat muddy seabed can colonise and grow, has the potential to provide habitat and shelter for juveniles or adults.
- 9.11.3 The combination of the small area lost, the small-scale nature of fishing operations and the potential environmental benefits of the seawall combine to reduce the magnitude of this residual impact to acceptable levels. It should be noted however, that permanent loss of fishing ground may be subject to claims for *ex gratia* allowances which are administered by the Planning and Lands Bureau.

ARTIFICIAL REEF DEPLOYMENT

- 9.11.4 An additional habitat enhancement measure has undertaken by the Project proponent is the deployment of Artificial Reefs. At present the Agriculture, Fisheries and Conservation Department are conducting a programme to enhance existing marine habitats and fisheries resources through the siting, construction and deployment of ARs. ARs act as fish enhancement 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.

- 9.11.5 Information from the AFCD's Artificial Reef Deployment Study⁽¹⁰⁾ 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).
- 9.11.6 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).

9.12 ENVIRONMENTAL MONITORING AND AUDIT

- 9.12.1 In order to protect against unacceptable impacts to fisheries resources, an Environmental Monitoring and Auditing programme has been designed to specifically detect and mitigate any unacceptable impacts to water quality (see *Annex N*).

9.13 CONCLUSIONS

- 9.13.1 A review of existing information on capture fisheries indicates that the adult fisheries resources in the marine areas close to the Assessment Area are in general low. Adult capture fisheries resources are unlikely to be adversely impacted by the Project as they will likely avoid the works areas. Although impacts to fish fry may occur through the permanent loss of habitat and/or elevated suspended sediment levels as a result of the proposed reclamation works, these impacts have been deemed acceptable as these waters are not an important nursery area for commercial fisheries species. Any impacts which are predicted can be mitigated through Project design. Any measures which are required to reduce impacts to water quality will also serve to protect against unacceptable impacts to capture fisheries resources. In terms of residual impacts to capture fisheries, the small loss of fishing grounds is expected to be compensated for by the potential environmental benefits of the proposed rubble mound seawalls. Artificial Reefs have been recommended for deployment as an additional marine ecology and fisheries habitat enhancement measure. As a result, the residual impacts to capture fisheries through the construction and operation of the Theme Park and associated developments has been deemed acceptable.
- 9.13.2 In terms of impacts to the culture fisheries, the Ma Wan Fish Culture Zone (FCZ) is not predicted to be impacted by either suspended solids elevations, dissolved oxygen depletions or nutrient elevations as a result of the either the construction or operation. Discharges comply with WPCO standards and any potential impacts to water quality and, therefore, culture fisheries resources at the FCZ, will be avoided. Project changes to the hydrodynamic regime are not expected to impact the water quality of the FCZ as current speeds are expected to be only minimally affected.
- 9.13.3 Fisheries impacts arising from the proposed project are summarised in *Table 9.13a*.

⁽¹⁰⁾ ERM (1999) Artificial Reef Deployment Study. Final Report for AFCD

Table 9.13a - Fisheries Impact Summary

Impact	Summary
Sensitive Receiver (s)	Ma Wan Fish Culture Zone
Assessment Criteria	Compliance with the relevant water quality objectives.
Fishing Ground Loss	<p>The identified residual impact occurring during the construction of the Yam O and Penny's Bay reclamations is the permanent loss of 10 ha of the Yam O Fishing zone (1.9%); 205 ha of the Penny's Bay Fishing Zone (73.7%); and, 75 ha of the Pa Tau Kwu Fishing Zone (9.2%). The loss of this part of these fishing grounds, although potentially detrimental to some fishermen is unlikely to cause a noticeable reduction in fish catches. Although not implemented specifically to mitigate for the loss of fishing grounds, the provision of rubble mound seawalls on which more diverse and abundant ecological assemblages than present on the existing flat muddy seabed can colonise and grow, has the potential to provide habitat and shelter for juveniles or adults.</p> <p>The combination of the small area lost, the small-scale nature of fishing operations and the potential environmental benefits of the seawall combine to reduce the magnitude of this residual impact to acceptable levels. It should be noted however, that permanent loss of fishing ground may be subject to claims for <i>ex gratia</i> allowances which are administered by the Planning and Lands Bureau.</p>
Culture Fisheries	The Ma Wan Fish Culture Zone is not predicted to be impacted by either SS elevations, DO depletions or nutrient elevations as a result of the operation of the Theme Park and its associated developments. Discharges are expected to meet licence standards and consequently impacts to water quality and fisheries resources will be avoided. Changes to the hydrodynamic regime are not expected to impact the water quality of the FCZ as current speeds are expected to be only minimally affected.