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In Hong Kong, the commercial marine fishing industry is divided into capture and culture fisheries. To assess the capture fishery within the Study Area, the most up-to-date (i.e. 2001/2002) information on the Hong Kong fishery was utilised (1). Information from other relevant studies (i.e. 1998) was also reviewed in order to determine if the Study Area presents important nursery and spawning grounds for commercial fisheries (2). Updated mariculture information was obtained from the Agriculture, Fisheries and Conservation Department (AFCD).

In 2005, the estimated fisheries production in Hong Kong waters from both capture and culture fisheries amounted to 165,531tonnes, valued at HK$ 1,686 million (3). Capture fisheries accounted for 98% by weight (93.3 % by value) of total production while the remaining 2% (6.7% by value) 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 northeastern coasts. The five most abundant fish species landed from the capture sector were golden thread (*Nemipterus virgatus,* 14% of total biomass of landed fish), lizardfish (*Saurida* sp 9%), big-eyes (*Priacanthus* sp 5%), scads (*Decapterus* sp 5%) and yellow belly (*Nemipterus bathybius* 4%)(4).

10.3.1 *Culture Fisheries*

No Fish Culture Zones (FCZ) are located close to the proposed Black Point LNG terminal. The closest AFCD designated FCZ is located at Ma Wan (over 20 km from the proposed site) and thus is not expected to be affected by the development.

As shown in *Figure 10.1,* there are no gazetted oyster farming locations in Hong Kong; however, oyster farming has long been practiced on the Deep Bay mudflats. The oyster production areas located along the shore from Tsim Bei Tsui to Ha Pak Nai are also unlikely to be affected by the development due to the large separation distance from the Black Point LNG terminal (>5 km).

10.3.2 *Capture Fisheries*

Based on the latest (i.e. 2001/2002) AFCD Port Survey data (5), the highest fisheries production (600 to 1,000 kg ha^{-1}) was recorded near Cheung Chau, Penny's Bay, Kau Yi Chau, Po Toi, Ninepin Group and Tap Mun. The top 10 families captured in Hong Kong were rabbitfish (Siganidae), sardine (Clupeidae), croaker (Sciaenidae), scad (Carangidae), squid, shrimp, anchovy (Engraulidae), crab, seabream (Sparidae) and threadfin bream (Nemipteridae).

(1) Agriculture, Fisheries and Conservation Department (2002). Port Survey 2001/2002. Web site www.afcd.gov.hk.

(2) ERM-HK Ltd. (1998). Fisheries Resources and Fishing Operations in Hong Kong Waters, Final Report, for Agriculture and Fisheries Department.

(3) Agriculture, Fisheries and Conservation Department (2006)

(4) *Ibid.*

(5) *Ibid.*

10 FISHERIES IMPACT ASSESSMENT

10.1 INTRODUCTION

This Section of the EIA Report presents the findings of an impact assessment on existing fisheries resources, fishing operations and fish/oyster culture activities from the construction and operation of the proposed LNG terminal at Black Point. The assessment is based on the Project Description (*Part 3 Section 3*) and the findings of the Water Quality Impact Assessment (*Part 3 Section 6*).

10.2 LEGISLATIVE REQUIREMENTS AND EVALUATION CRITERIA

10.2.1 Technical Memorandum

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 the assessment of fisheries impacts arising from a project or proposal, to allow a complete and objective identification, prediction and evaluation of the potential impacts. *EIAO-TM Annex 9* recommends the criteria that are to be used for evaluating fisheries impacts.

10.2.2 Other Legislation

Other legislation which applies to fisheries includes:

- *Fisheries Protection Ordinance (Cap 171) 1987* which provides for the conservation of fish and other aquatic life and regulates fishing practices.
- *Marine Fish Culture Ordinance (Cap 353) 1983* regulates and protects marine fish culture and other related activities.
- *Environmental Impact Assessment Ordinance (cap. 499), Section 5(7) - Environmental Impact Assessment Study Brief no. ESB-126/2005 Section 3.4.6* which outlines the key fisheries impacts to be reviewed and assessed in the EIA Report.

10.3 BASELINE CONDITIONS AND FISHERIES SENSITIVE RECEIVERS

The fisheries Study Area was the same as that for the Water Quality Impact Assessment (see *Part 3 Section 6*). Consequently, this assessment of impacts has focussed solely on the fishing operations and fisheries resources within the Study Area. For a description of the physical and biological characteristics of the marine environment of the Study Area please refer to *Part 3 Sections 6* and *9* respectively.

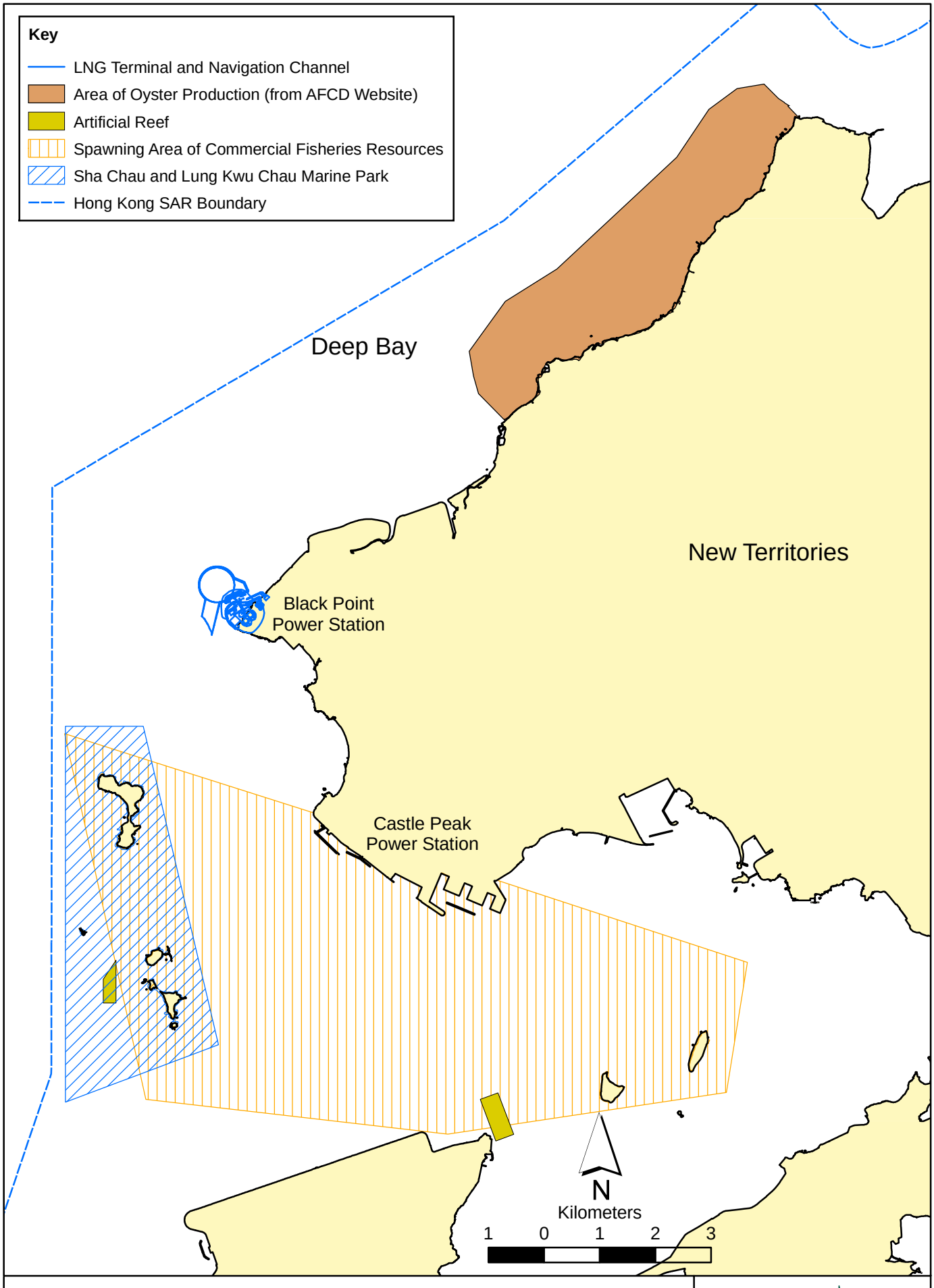

FIGURE 10.1

Fisheries Sensitive Receivers at Black Point

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Date: 04/08/2006

Environmental Resources Management

ERM

Deep Bay produced an estimated annual catch of 73 tonnes of adult fish and zero fry with reference to AFCD's information provided in 1998(1). The area and number of vessels operating during 2001/2002 in the waters around the proposed LNG terminal at Black Point are presented in *Figure 10.2* (2). Approximately 100 to 400 vessels were recorded around Black Point in 2001/2002. The majority of fishing vessels were small in size with lengths not exceeding 15 metres. The fishing vessels observed throughout the Study Area were mainly sampans, gill-netters and shrimp trawlers.

With reference to the grid system developed by AFCD (*Figure 10.3*), less than 50 kg ha^{-1} of adult fish production was recorded around Black Point in 2001/2002 (3). The overall adult fish production within the Study Area was relatively low when compared with areas in the eastern waters. Fishermen recorded zero fish fry production in the waters around the proposed LNG terminal (*Figure 10.4*).

Deep Bay waters, in the area where the proposed LNG terminal is to be located, ranked 12th of the 12 fishing sectors in Hong Kong waters, in terms of production of adult fish and value of catch (4). Deep Bay is not considered to be a key fishing area due to the shallow water depths which constrain vessel navigation and the abundance of cargo vessels that ply the waters between the Shenzhen River and the Pearl River. The catch value of the waters surrounding the proposed LNG terminal at Black Point range from HK$1,000 to HK$2,000 ha^{-1}, which is relatively low in comparison to other areas in Hong Kong waters (*Figure 10.5*). The recent AFCD survey indicated that the waters surrounding the proposed LNG terminal at Black Point do not support a fish fry industry with no records of juvenile catch (*Figure 10.4*).

From the available fisheries information for the Study Area, it is concluded that the adult fish production is relatively low in comparison to elsewhere in Hong Kong waters. Low numbers and size of fishing vessels, low fish catch value and production characterise the waters in the vicinity of Black Point, highlighting its low productivity.

(1) Agriculture, Fisheries and Conservation Department (2002). *Op cit.*

(2) Agriculture, Fisheries and Conservation Department (2002). *Op cit.*

(3) *Ibid.*

(4) AFCD (1998). *Op cit.*

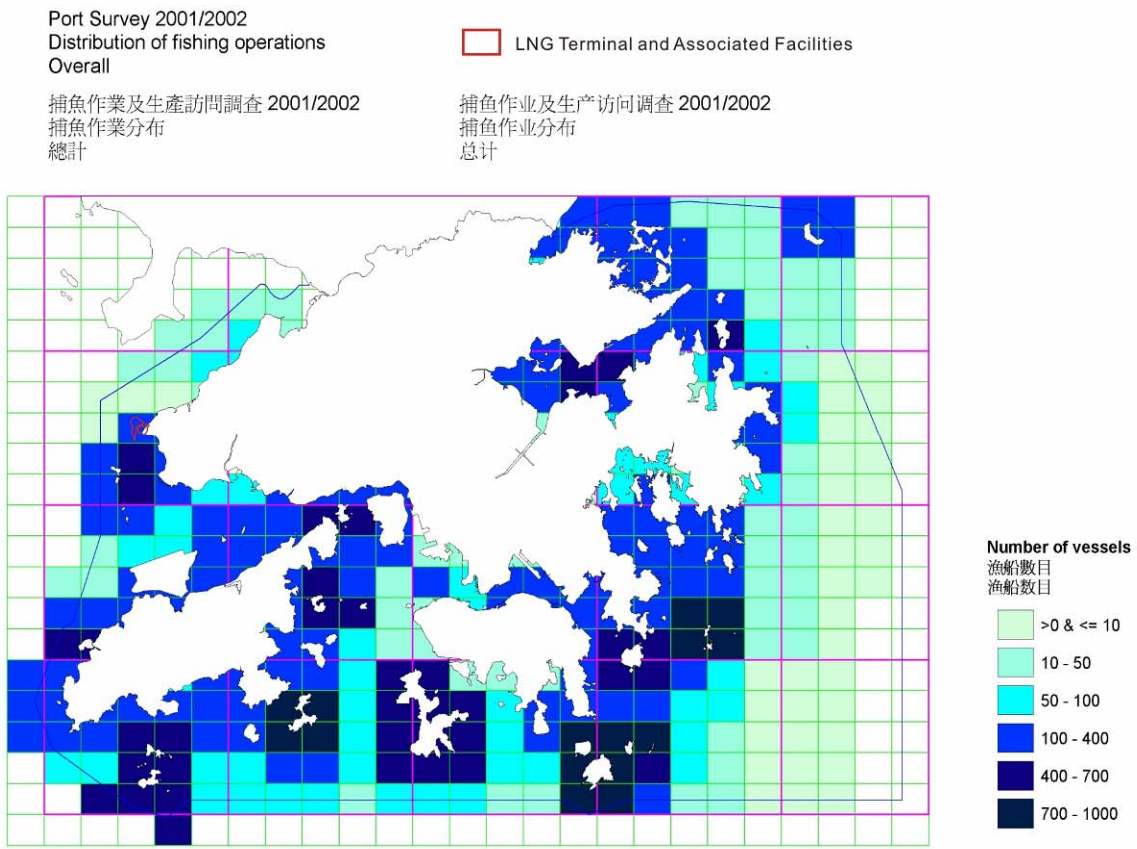

Figure 10.2 Distribution of Fishing Operations (All Vessels) in Hong Kong Waters as recorded by Agriculture, Fisheries and Conservation Department in Port Survey 2001/2002

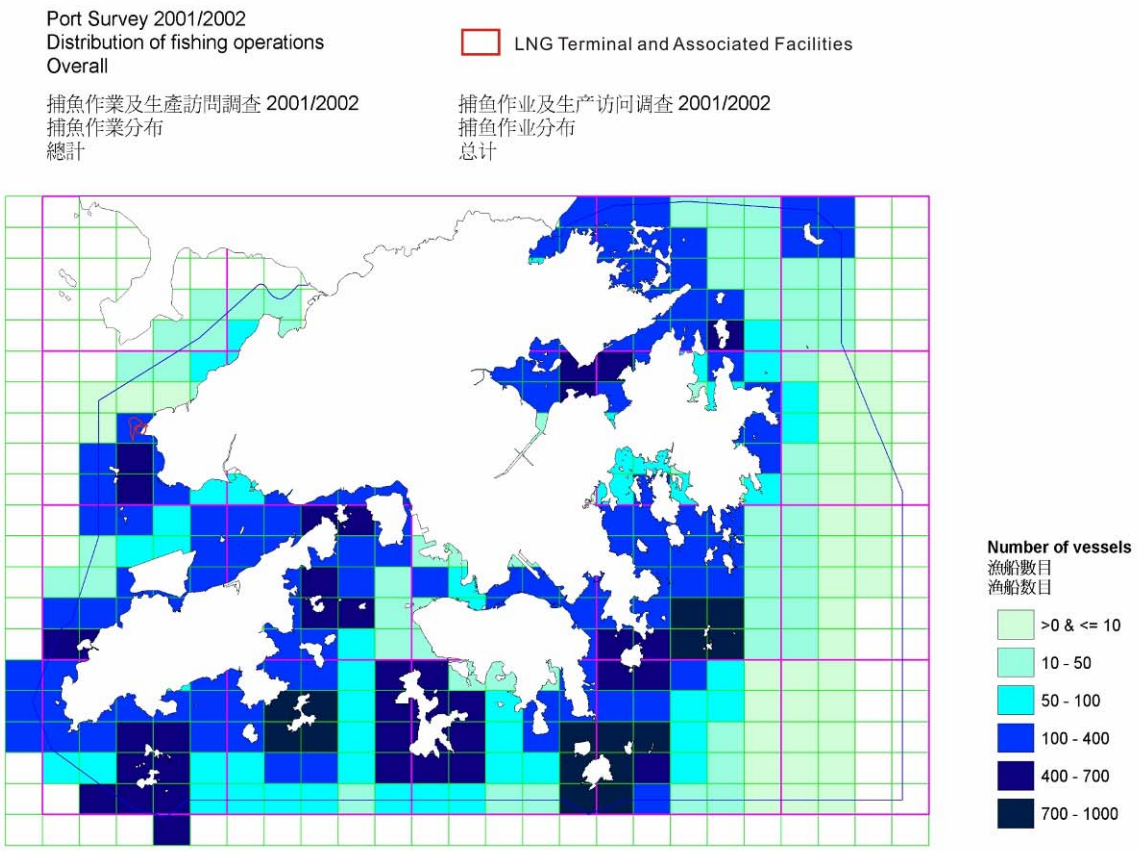

Figure 10.3 Distribution of Fisheries Production (Adult Fish) in terms of Weight in Hong Kong Waters as recorded by Agriculture, Fisheries and Conservation Department in Port Survey 2001/2002

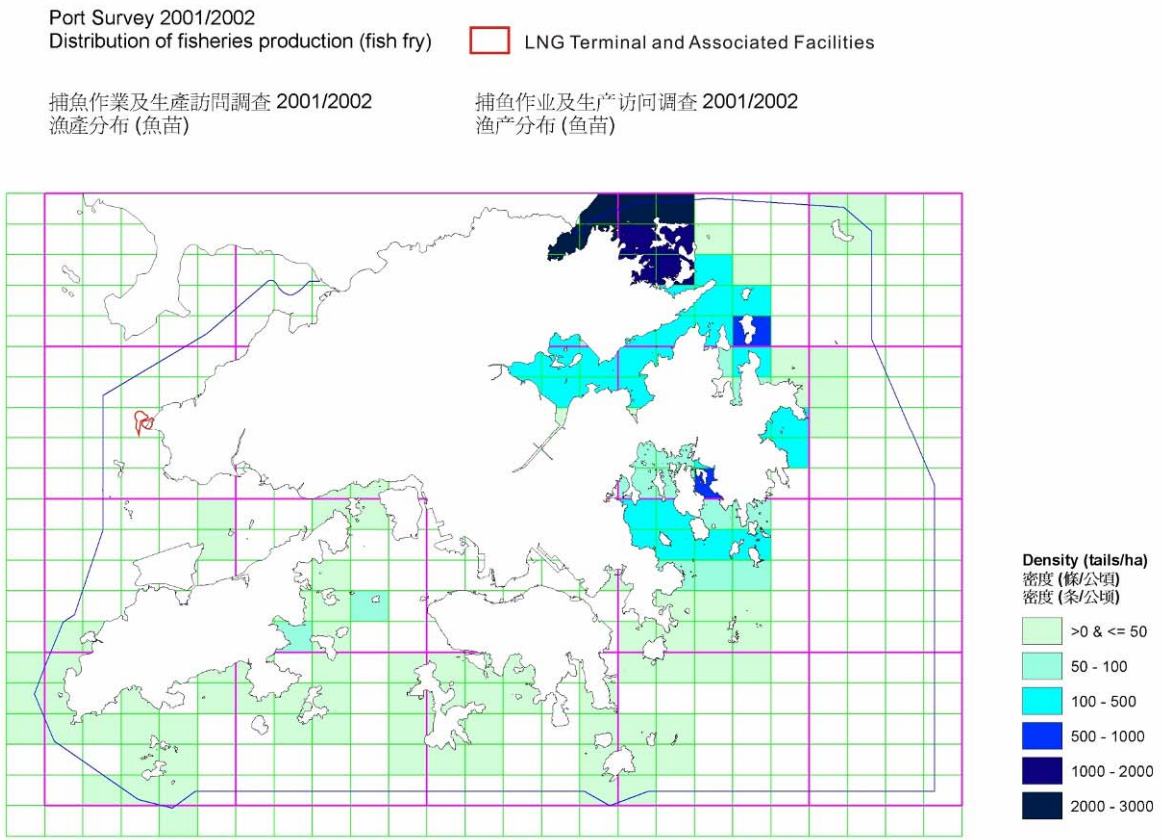

Figure 10.4 *Distribution of Fisheries Production (Fish Fry) in Hong Kong Waters as recorded by Agriculture, Fisheries and Conservation Department in Port Survey 2001/2002*

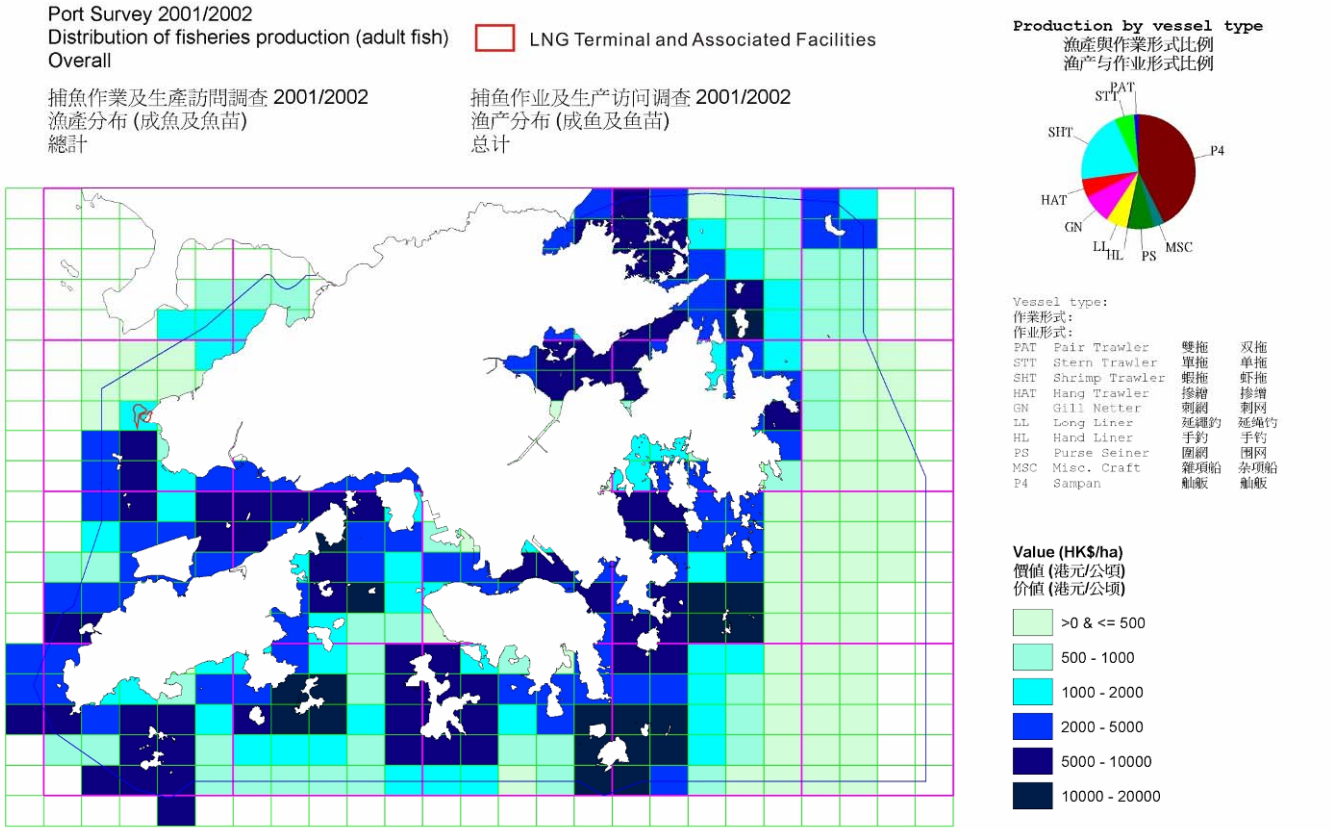

Figure 10.5 *Distribution of Fisheries Production (Adult Fish) in terms of Value in Hong Kong Waters as recorded by Agriculture, Fisheries and Conservation Department in Port Survey 2001/2002*

Fisheries Resources - Spawning Areas

The northern Lantau waters were previously identified in 1998 as fisheries spawning grounds for high value commercial species (*Figure 10.1*) (1). The main commercial fish species reported in the north Lantau spawning area included *Leiognathus brevirostris* (ponyfish), *Lateolabrax japonicus* (sea bass/ perch) and *Clupanodon punctatus* (gizzard shad).

The majority of commercial species recorded in Hong Kong aggregate and spawn in the open water during the period from June to September (2). Some fish species reported for the spawning grounds, including *Platycephalus indicus* (flathead) and *Clupanodon punctatus* (gizzard shad), spawn in the late winter/early spring (i.e., February to April) and a few are known to spawn in January. *Caranx kalla* (shrimp scad) spawns in the early summer (around June) whilst *Leiognathus brevirostris* (ponyfish) and croakers were found to be reproductive throughout most of the year from May to December. The spawning period of most of the crustacean species, including *Metapenaeus joyneri* was found to be from April to November (3).

A recognised spawning area is located 2.7 km south of the proposed LNG terminal (*Figure 10.1*). This area is approximately 10 km long (from Tai Mo To island to Lung Kwu Chau Island) and 5 km wide (from Castle Peak to the northernmost tip of the Airport) and has been identified as an important area for commercial species (4).

10.3.3 Artificial Reef Deployment

The AFCD is undertaking a programme to enhance existing marine habitats and fisheries resources through the siting, construction and deployment of artificial reefs (ARs). ARs provide hard bottom, high profile habitat in areas without natural cover and potentially act as fish enhancement devices. The Sha Chau AR (*Figure 10.1*) was deployed in March 2000 with the primary aim of enhancing the marine habitat quality and fisheries resources (5). Forty two concrete-coated containers with a total volume of 940 m^3 have been deployed. They are located approximately 6.4 km away from the proposed Black Point LNG terminal and are considered too remote from the project to be affected by the works.

10.3.4 Fisheries Importance

The importance of the fisheries within the Study Area is addressed based on the baseline information discussed above. The fishing areas within the Study Area are characterised as being generally of low commercial value. The

(1) ERM-HK Ltd. (1998). *Op cit.*

(2) *Ibid.*

(3) *Ibid.*

(4) AFCD (1998). *Op cit.*

(5) AFCD (2003) Hong Kong Artificial Reef Deployment Study. Webpage: www.afcd.gov.hk (accessed on 6/1/2005).

catches from these areas are composed of juvenile mixed species. The size and subsequent value of the catches characterises these waters as of comparatively low importance to the Hong Kong fishing industry.

The *EIAO-TM (Annex 9)* states that spawning grounds 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. No spawning area has been identified within the footprint of the LNG terminal at Black Point. The closest recognised spawning area is located approximately 2.7 km south of the LNG terminal site at Black Point.

10.3.5 Sensitive Receivers

Based on the preceding review of the available information on the capture and culture fisheries of the waters in the vicinity of the LNG terminal, the potential sensitive receivers that may be affected by the proposed works associated with the Project are identified as follows:

- Spawning ground of commercial fisheries resources in north Lantau (2.7 km from the LNG terminal);
- Artificial reefs in the Sha Chau & Lung Kwu Chau Marine Park (located 6.4 km from the proposed LNG terminal).

The locations of the sensitive receivers are shown in *Figure 10.1*. Due to their distances from the proposed Black Point LNG terminal, oyster production areas and FCZs are not considered to be sensitive receivers and are not expected to be affected by the Project.

10.4 FISHERIES IMPACT ASSESSMENT METHODOLOGY

A desktop literature review was conducted in order to establish the fisheries importance of the area surrounding the proposed Black Point LNG terminal. Information from the water quality assessment was used to refine the size of the Study Area as that potentially affected by perturbations to water quality parameters (*Part 3 Section 6*). This area became the focus for this fisheries impact assessment. The importance of potentially impacted fishing resources and fisheries operations within the Study Area was assessed. The potential impacts due to the construction and operation of the Project and associated developments were then assessed (with reference to the *EIAO-TM Annex 17* guidelines) and the impacts evaluated (with reference to the criteria in *EIAO-TM Annex 9*).

10.5 IDENTIFICATION OF FISHERIES IMPACTS

10.5.1 Construction Phase

As discussed in *Part 3 Section 3* the construction of the proposed LNG terminal at Black Point will involve dredging and reclamation works.

Dredging and Reclamation

Construction phase impacts to fisheries resources and fishing operations 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

Direct impacts to fisheries resources and fishing operations include habitat loss due to the dredging and reclamations works. Construction will lead to the permanent loss of approximately 16 ha and a temporary interference of approximately 47 ha, due to the dredging of the approach channel and turning circle. Temporary loss of less than 1 ha of fishery habitat will also be associated with the installation of the intake pipe.

Due to the relatively small area of the fishing grounds permanently lost to reclamation and due to its low fisheries value no significant adverse impacts to local fisheries resources are predicted.

Though a larger surface area is impacted by the dredging activities of the approach channel and turning basin, it is expected that the temporary nature of the interference will not cause significant impacts on the fishery resources and activities. Fisheries resources are expected to return to the area following the cessation of dredging. The potential impacts of maintenance dredging are discussed below.

In view of the small area and the short term nature of the loss of fisheries habitat, no significant impacts are expected to be associated with the installation of the seawater intake pipe.

Indirect Impacts

Indirect impacts to fisheries resources and fishing operations during the construction phase include sediment release associated with the marine works. Potential impacts to water quality from sediment release are listed below:

- Increased concentrations of suspended solids (SS);
- A resulting decrease in dissolved oxygen (DO) concentrations;
- An increase in nutrient concentrations in the water column.

The reclamation activities for the LNG terminal will involve dredging of the existing marine sediments along the line of the seawalls. The existing marine sediments in areas defined for the turning basin and approach channel with a depth less than 15 m, will be dredged to allow the safe navigation of the LNG carrier.

Suspended Solids: Suspended solid (SS) fluxes occur naturally in the marine environment and consequently fish have evolved behavioural adaptations to tolerate changes in SS load (e.g., clearing their gills by flushing water over them). However, the increase in suspended solids concentrations that would arise from the dredging would be uncharacteristic of the normal variable marine conditions. Concentrations of SS generated via dredging are expected to be greater, particularly in the immediate vicinity of the dredger. Beyond the active dredging area, dispersion will cause a rapid decrease in the suspended solids concentrations.

Larvae and post-juvenile fish are more susceptible to variations in SS concentrations than more mature fish since their sensory system is less developed. Adult fish are more likely to move away when they detect sufficiently elevated suspended solids concentrations and therefore are unlikely to be significantly impacted. Larvae and post-juvenile fish are more likely to be impacted as they may not be able to detect and avoid areas with elevated levels of SS.

The SS level at which fish move into clearer water is defined as the tolerance threshold and varies from species to species at different stages of the life cycle. If SS levels exceed tolerance thresholds and the fish are unable to move away from the area, the fish are likely to become stressed, injured and may ultimately die. Susceptibility to SS generally decreases with age such that eggs are the most vulnerable and adults the least sensitive to the effects of high SS concentrations. The rate, timing and duration of SS elevations will influence the type and extent of impacts upon fish and potentially crustaceans (1) (2).

Literature reviews indicate that lethal responses had not been reported in adult fish at values below 125 mg L^{-1} (3) and that sublethal effects were only observed when levels exceeded 90 mg L^{-1} (4). However, guideline values have been identified for fisheries and selected marine ecological sensitive receivers as part of a study for AFCD, *Consultancy Study on Fisheries and Marine Ecological Criteria for Impact Assessment*. The values are based on international

(1) Species Profiles: Life Histories and Environmental Requirement (Gulf of Mexico) - Brown Shrimp, US Fish and Wildlife Service, 1983.

(2) The Shrimp Fishery of the Gulf of Mexico – A regional Management Plan, Gulf Coast Research Laboratory, 1977

(3) 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.

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

marine water quality guidelines for the protection of ecosystems (1). The AFCD study recommends a maximum SS concentration of 50 mg L^{-1} (based on half of the no observable effect concentrations).

Temporarily elevated levels of SS are likely to occur in the immediate vicinity of the marine works (see *Part 3 Section 6 - Water Quality Assessment*). These predicted increases do not exceed the tolerance threshold of 50 mg L^{-1} established by AFCD and therefore impacts to fisheries resources as a result of potential elevations of SS are not expected to occur. The water quality assessment has also shown that unacceptable water quality impacts due to the release of heavy metals and organic micro-pollutants associated with suspended sediments are not expected to occur (see *Part 3 Section 6.6*).

Finally it should be noted that the Black Point site is at the mouth of Deep Bay on the eastern bank of the Pearl River Estuary. As a result of discharges from the Pearl River and the Shenzhen River in Deep Bay, the background variation in SS is acknowledged as being high. Water quality data gathered by EPD has indicated that in the vicinity of the Black Point site SS values can reach over 200 mgL^{-1} (*Part 3 Section 6*). Therefore, impacts to fisheries resources as a result of potential elevations of SS from the construction works are not expected to occur.

Dissolved Oxygen: 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. 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. Furthermore, the potential release of sediment contaminants into the water column may consume the DO in the receiving water. The resulting overall DO depletion has the potential to cause an adverse effect on the eggs and larvae of fish and crustaceans, as at these stages of development high levels of oxygen in the water are required for growth to support high metabolic growth rates.

The results of the water quality assessment (*Part 3 Section 6*) examining dispersion of sediment plumes associated with the LNG terminal's marine works have shown that the predicted maximum levels of SS are localised. Aside from the immediate vicinity of the dredging works, SS concentrations within the Study Area as a whole will remain compliant with the Water Quality Objectives (WQOs). The subsequent effect on dissolved oxygen within the surrounding waters is, therefore, predicted to be minimal. Unacceptable impacts to fisheries from the reduction of DO concentration are not expected to occur.

(1) City University of Hong Kong (2001). Agreement No. CE 62/98, Consultancy Study on Fisheries and Marine Ecological Criteria for Impact Assessment, AFCD, Final Report July 2001.

Nutrients: High levels of nutrients in seawater can cause rapid increases in phytoplankton, on occasions 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 seabed. Anoxic conditions may result if DO concentrations are already low or are not replenished. As discussed above, reduced levels of DO can impact the eggs and larvae of fish and crustaceans which require high levels of oxygen for development. Significantly low levels of DO may also result in mortality to fish.

As with dissolved oxygen, the effect of the localised increases in suspended solid concentrations on nutrients within the surrounding waters is expected to be minimal (see *Part 3 Section 6*). Unacceptable impacts to fisheries are therefore not anticipated.

Impacts on Sensitive Receivers

- Seasonal Spawning Grounds: No impacts to the seasonal spawning grounds in North Lantau are likely to occur due to elevated levels of suspended solids (depth averaged < 1 mg L^{-1}) since they are compliant with the assessment criterion (*Part 3 Section 6*). Reductions in DO and increases in nutrient levels as a consequence of SS elevations are not expected to occur. Adverse impacts on the seasonal spawning grounds due to the proposed works are not expected to arise. Introduction of environmental contaminants desorbed from suspended sediment particles can have damaging effects on fisheries resources. As discussed in the water quality assessment (*Part 3 Section 6*) contaminant release from dredging of contaminated sediments is expected to be minimal and not predicted to exceed environmental standards. Consequently, unacceptable impacts to fisheries resources from contaminant release during dredging are not predicted to occur.

- Artificial Reefs (ARs) in Marine Park: Impacts to the ARs in the Sha Chau & Lung Kwu Chau Marine Park (located 6.4 km from the proposed LNG terminal) are not expected to occur, as elevated levels of suspended solids (depth averaged < 1 mg L^{-1}) are compliant with the WQO.

Contaminant Release

Another potential impact on fisheries resources associated with disturbance of bottom sediment that require assessment in accordance with *Clause 3.4.6.5* of the Study Brief, are release of potential toxic contaminants. The potential for release of contaminants from dredged sediments has been assessed in *Part 2 Section 6*, whereas, a comprehensive set of data on the quality of marine sediment is provided in *Part 2 Section 7 – Waste Management.*

As discussed in *Part 2 Section 6*, unacceptable water quality impacts due to the potential release of heavy metals and micro-organic pollutants from the

dredged sediment are not expected to occur, impacts on fisheries resources due to bioaccumulation of released contaminants from dredged sediments are also not expected to occur.

10.5.2 *Operational Phase*

The potential impacts of the operational phase of the Project on the fisheries of the Study Area can be divided into three main categories:

- Impacts arising from the loss of fisheries habitat and the alteration of the marine hydrodynamic regime;
- Impacts arising from the alteration of the benthic habitat due to maintenance dredging of the approach channel and periodical disturbance caused by the LNG carrier's passage;
- Impacts arising from the uptake, treatment and discharge of the seawater used in the vaporization process, mainly physical damage to marine organisms and the alteration of the physical and chemical parameters of the seawater.

Habitat Loss

From the overview of the importance and value of the local fisheries performed in *Part 3 Section 10.3* and the outcome of the assessment of the coastal habitat in *Part 3 Section 9* it is evident that the quality of the existing littoral habitat of the Study Area is low. The potential impacts associated with the loss of 600 m of natural coastline (*Marine Ecological Impact Assessment, Part 3 Section 9*) are estimated to be low. Furthermore, it is deemed that the enhancement effect of the new seawalls will reduce the impacts to the local fish populations by providing habitat and shelter for juveniles or adult fisheries resources as ecological assemblages may eventually colonise and grow on the boulders. This will, in the longer term, counteract the initial loss to the natural environment.

Marine Hydrodynamic Regime

Impacts to fisheries resources could potentially occur if the shape of the reclamation causes a change to the hydrodynamic regime of the Black Point coastline. Impacts of this nature could lead to increased seabed current velocities which may cause seabed scour thus impacting subtidal assemblages, or conversely, the current velocities may drop affecting flushing and water exchange of an area.

Inadequate flushing could lead to a reduction in dissolved oxygen (DO), an increase in nutrients and consequent impacts to fisheries resources. The hydrodynamic modelling (*Part 3 Section 6*) has indicated that the reclamation in Black Point will have an overall minimal effect on current velocity.

Adverse impacts from changes to the hydrodynamic regime and also water quality are, therefore, not expected to occur.

Maintenance Dredging

To the maximum extent possible, the selection of the fairway transit and approach channel for the LNG carrier was based on the availability of the required charted water depth (approximately -15mPD) in order to reduce the dredging quantities and hence impacts to water quality. These will in turn serve to reduce impacts to fisheries resources. Maintenance dredging is anticipated to be required at a frequency of once every four years. No long term direct impacts are expected from the maintenance dredging works. As a result, the fisheries resources are not predicted to be adversely affected by the maintenance dredging.

Carrier Passage

Carrier passage in the dredged approach channel can potentially lead to sediment re-suspension due to the turbulence created by the carrier's propellers and thrusters. The disturbance of the substrate may potentially increase the recovery time of the benthic communities which colonize the channel, reducing their productivity. Due to the low frequency of the LNG carriers passage (once every five to eight days) and the low quality of the existing benthic community it is expected that the overall impact due to reduced productivity of the channel's benthic community will be minimal (see *Marine Ecological Impact Assessment, Part 3 Section 9*).

Water Intake, Treatment and Discharge

Stored LNG will need to be re-gasified in order for it to be transported by pipeline to the point of use. This will be accomplished via vaporisers, which will either utilise piped seawater (in open rack vaporisers) or hot combustion gases (referred to as submerged combined vaporisers) to raise the temperature of the LNG to its gaseous state.

- Open Rack Vaporisers (ORVs) – ORVs are heat exchangers where seawater flows downward over the exterior vaporizer panels while high-pressure LNG flows internally upwards. This counter current flow between the warm seawater and cold LNG results in the vaporization or heating of the LNG. The seawater falls over the external panels to a trough and is then discharged back to the sea. The seawater will pass through a series of screens to remove debris to prevent blockage or damage to the seawater pumps. Upon leaving the vaporisers, the (cooled) seawater will be collected in a sump and discharged back to the sea via a submarine outfall. The design seawater temperature drop is 8.5°C at the discharge point.

- Submerged Combined Vaporisers (SCVs) –In SCVs, the LNG is heated by flowing through tubes that are submerged in a heated water bath.

The present design for the LNG terminal calls for ORVs as the primary vaporization method with a SCV unit as back-up.

The intake volume and velocity of the ORV system may have potential impacts, namely:

- Physical alterations of the seawater due to the heat exchange process which delivers cooler water at the outfall location. Cooler water potentially can impact the physiology of marine organisms (e.g. changes to natural development and growth rates),
- Potential physical damage to marine organisms, particularly fish eggs and larvae, due to impingement on the intake pipe's protection screen and entrainment into the vaporizing system; and,
- Chemical alteration of seawater due to the antifouling additives (e.g., sodium hypochlorite) which can causes stress and potentially death to marine organisms, particularly fish eggs and larvae, zooplankton and phytoplankton.

The potential fisheries impacts of the ORV process are discussed in the following sections.

Discharge of Cooled Water

Induced temperature changes to natural aquatic habitats have been proven to have detrimental effects on the physiology of fishes. The decline in temperature has the potential to alter the rate of development of fish embryos, larvae and gonad maturation. A slower growth rate means that fish larvae remain longer in the delicate early development stages, potentially increasing mortality (1). The altered development of gonad maturation could ultimately reduce the spawning success of fish species and the altered mechanism of muscle development (2) could potentially reduce the chance of survival of juvenile fish.

Cooled water with a temperature of approximately 12.5°C below ambient will be discharged at the LNG terminal's seawater outfall, located near the bed layer of the water column. The results of the water quality modelling presented in *Part 3 Section 6* indicate that a temperature change of +/-2°C (the Water Quality Objective) will remain within approximately 200m from the outfall in the dry season and approximately 70m in the wet season.

The results presented in *Part 3 Section 6* indicate that the impacts to seawater temperature caused by the open circuit process are predicted to be localised.

(1) Houde, ED (1987) Fish Early Life Dynamics and Recruitment Variability. P. 17-29. In Hoyt, RD (ed). Proceedings of the 10th Annual Larval Fish Conference held in Miami, FL May 18-23, 1986. American Fisheries Society Symposium 2. American Fisheries Society, Bethesda. MD.

(2) Govoni, JJ (2004) The Development of Form and Function in Fishes, and the Question of Larval Adaptation. American Fisheries Society, Bethesda, MD.

It is therefore expected that the cooled water discharge will not cause unacceptable impacts to the fisheries resources.

Impingement and Entrainment

The discharge and intake points for the seawater to be used in the proposed open circuit system (i.e., Open Rack Vaporisers or ORVs) will be separated to reduce the re-circulation of the cooled water and therefore maximise the efficiency of the heat exchange process.

In order to draw in the warmest water to the vaporisers for optimum efficiency in the regasification process, the seawater intake will be designed to be as high as possible within the water column. For this purpose the intake will be installed through the revetment of the seawall structure. The intake will be appropriately screened to reduce the uptake of marine organisms and suspended material. From a fisheries perspective the high volume and velocity of inflowing seawater may have negative effects on fish, fish eggs and crustaceans (e.g., shrimp) due to the physical damage caused by collisions with the screen (impingement) and due to their uptake and exposure to the vaporization process (entrainment).

The swimming speeds of juvenile and larval fishes vary greatly but are generally less than the water velocity of the intake pipe. Owing to their larger size, juvenile fish are generally more susceptible to impingement, whilst, fish and crustacean larvae and eggs, zooplankton and phytoplankton are more exposed to entrainment, as their small size enables them to pass through the screen (1) (2).

Whilst it is acknowledged that the uptake of seawater for the open loop vaporization process may minimally increase the natural mortality rate of fish larvae, crustaceans and fish eggs due to impingement and entrainment, it has to be noted that the significance of such impacts is strongly dependant on the ecological sensitivity and productivity of the impacted area. From the assessment completed in *Part 3 Section 10.3* it is evident that the quality of the near shore marine ecosystem of the Study Area is low and that there are no identified spawning areas in the proximity of the intake pipe. In addition, the AFCD Port Survey of 2001/2002 reported that zero fish fry production was found in the waters around the proposed LNG terminal with no records of juvenile catch (*Part 3 Section 10.3.2 - Figure 10.4*).

By virtue of the low value of the marine ecosystem of the Study Area and its low fisheries production level, it is predicted that no unacceptable adverse impacts to important fisheries resources will occur.

(1) Fernando Martinez-Andrade and Donald M. Baltz (2003). Coastal Marine Institute: Marine and Coastal Fishes subject to Impingement by Cooling-Water Intake Systems in the Northern Gulf of Mexico - An Annotated Bibliography. U.S. Department of the Interior.

(2) Turnpenny, A. W. H (1988) Fish impingement at estuarine power stations and its significance to commercial fishing. Journal of Fish Biology, Vol. 33, pp. 103-110.

Antifoulants

There are potential operational issues caused by the growth or encrustation of marine organisms on the open loop vaporization system (i.e., pipes, valves etc.). Operationally, the colonization of marine organisms such as algae, bryozoans, molluscs and cirripedes within cooled water circuits could result in losses in thermal efficiency and reduced reliability of the system (including total shutdown). To counteract settling and growth of marine organisms, cooled water circuits are typically dosed with chemicals (usually sodium hypochlorite). Such chemicals are known as antifoulants and they inhibit the growth of organisms within the circuit by creating unsuitable living conditions. A secondary consequence of this form of treatment is associated with the discharge of the treated seawater into the marine environment.

Research has been conducted internationally on the effects of chlorine discharges on marine ecological and fisheries resources. The international review provides data which can be used as a benchmark to evaluate potential impacts. Work on the toxic effects of chlorine on fish eggs and larvae has indicated that abnormal development may occur at concentrations of 0.31 to 0.38 mg L^{-1} (1). However, behavioural studies have indicated that adult fish will avoid areas where concentrations of free residual chlorine in the water exceed 0.035 mg L^{-1} (2).

The proposed LNG terminal is predicted to discharge residual free chlorine at a concentration of < 1.0 mg L^{-1}. This concentration is similar to that found in the cooling waters of power stations operating in Hong Kong and is below EPD's discharge limit of 1.0 mg L^{-1} (3).

Concentrations of residual chlorine have been shown to diminish rapidly with time and distance from the discharge point (4). A concentration of residual chlorine of 0.01 mg L^{-1} (daily maximum) at the edge of the mixing zone is the criterion used in the *Water Quality Assessment* (*Part 3 Section 6*). The modelling exercise conducted in the assessment indicates that maximum residual chlorine concentrations exceeding 0.01 mg L^{-1} are only likely to occur within 300 m of the outfall and are mainly confined to lower layers of the water column. These predicted increases do not exceed tolerance thresholds established in the literature (0.02 mg L^{-1}) and are in accordance with those levels recommended in previous studies in Hong Kong (0.01 mg L^{-1}).

(1) Morgan RP & Prince RD (1977) Chlorine Toxicity to eggs and larvae of five Chesapeake Bay fishes. Transaction of the American Fisheries Society. 106 (4): 380 - 385.

(2) Grieve JA et al (1978) A program to introduce site-specific chlorination regimes at Ontario hydro generating stations. Pages 77-84 in Jolley RL et al (1978) Water Chlorination. Environmental Impacts and Health Effects, Volume 2. Michigan: Ann Arbour Science.

(3) Technical Memorandum Standards for Effluents Discharged from Drainage and Sewerage Systems, Inland and Coastal Waters, Water Pollution Control Ordinance, Cap 358.

(4) Mattice JS & Zittel HE (1976) Site specific evaluation of power plant chlorination. Journal of Water Pollution Control. 48 (10): 2284 - 2308.

Consequentially, significant impacts to fisheries resources as a result of the discharge of chlorinated water are not expected to occur.

Sewage

Impacts due to operational sewage discharge on fisheries resources would not be expected as the discharge should satisfy the requirement of *WPCO-TM* effluent discharge standard (details refer to *Part 3 Section 6.7.5*).

10.6 ASSESSMENT OF ENVIRONMENTAL IMPACTS

From the information presented above, the fisheries impact associated with the Project is not considered to be significant. An evaluation of the impacts according to *Annex 9* of the *EIAO-TM* is presented below:

- *Nature of Impact*: Permanent impacts will occur as a result of the loss of fishing grounds in the 16 ha area to be reclaimed for the LNG terminal. Short-term impacts will occur to fisheries resources in the Study Area as a result of the dredging of seawall trenches and the dredging of the approach channel and turning basin. Temporary impacts to pelagic and demersal fisheries resources as a result of minor perturbations to water quality are predicted to occur only in the immediate vicinity of marine works. Maintenance dredging activities are also not predicted to cause unacceptable impacts to fisheries due to their localised and infrequent nature. Discharges of cooled water are not predicted to pose adverse impacts to fisheries resources and discharges of residual free chlorine are predicted to be in compliance with the EPD's allowable discharge level. No significant adverse impacts to fisheries resources are expected from the impingement and entrainment of fish larvae or eggs in the open circuit's vaporization system.

- *Size of Affected Area*: The construction of the LNG terminal will result in the permanent loss of approximately 16 ha of natural marine habitat. This loss is not considered to be significant for the local fishery resources in view of the small portion of habitat lost and due to the low fisheries production in these waters.

- *Size of Fisheries Resources/production*: The value of the fisheries resources/production of the marine waters around the turning basin and approach channel, and the proposed LNG terminal is low in comparison to other waters in Hong Kong.

- *Destruction and Disturbance of Nursery and Spawning Grounds*: No spawning grounds have been identified within the Study Area. A recognised spawning area for fisheries resources lies 2.7 km from the proposed LNG terminal. As the water quality modelling results show, impacts to water quality will be localised and hence impacts to spawning grounds are not expected to occur.

- *Impact on Fishing Activity*: Due to the small size of the affected area and the low intensity of the fishing operations, impacts on fishing activity are expected to be minimal.

- *Impact on Aquaculture Activity*: No impact has been identified on fish and oyster culture activity as SS and total residual chlorine elevations are compliant with the relevant standards, and the Fish Culture Zones and oyster production areas are too remote to be affected by the Project.

10.7 MITIGATION MEASURES

In accordance with the guidelines in the *EIAO-TM* on fisheries impact assessment, the policy adopted in this EIA for mitigating impacts to fisheries, 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 confining works in specific area or season, restoration (and possibly enhancement) of disturbed fisheries resources and habitats;

- **Compensation:** When all possible mitigation measures have been exhausted and there are still significant residual impacts or when the impacts are permanent and irreversible, consideration shall be given to off-site compensation. It may include enhancement of fisheries resources and habitats elsewhere.

Construction impacts to fisheries resources and fishing operations have largely been avoided (ie spawning area of commercial fisheries resources) and minimised through the planning and design of the works; in particular those associated with the backfilling and dredging. The main works have been designed to control water quality impacts to within acceptable levels and hence are also expected to control and minimise impacts to fisheries resources. No fisheries-specific mitigation measures or compensation are required during construction.

Significant impacts to fisheries resources and fishing operations are not expected to occur during the operational phase of the LNG terminal. Compliance with the relevant discharge standards to control water quality impacts to within acceptable levels is also expected to control impacts to fisheries resources. Furthermore, entrainment of fisheries resources will be reduced through the appropriate design of the intake screens on the seawater intake. No additional fisheries-specific mitigation measures or compensation are required during operation.

10.8 ENVIRONMENTAL MONITORING AND AUDIT (EM&A)

10.8.1 *Construction Phase*

As no unacceptable impacts have been predicted to occur during the construction of the LNG terminal at Black Point, monitoring of fisheries resources during the construction phase is not considered necessary.

10.8.2 *Operation Phase*

As no unacceptable impacts have been predicted to occur during the operation of the LNG terminal at Black Point, monitoring of fisheries resources during the operation phase is not considered necessary.

10.9 RESIDUAL ENVIRONMENTAL IMPACTS

The identified residual impact occurring during the construction phase is the permanent loss of approximately 16 ha of seabed required for the LNG terminal reclamation. The construction of rubble mound seawalls on the edges of the LNG terminal's reclaimed land has the potential to provide habitat and shelter for juveniles or adult fisheries resources as ecological assemblages may eventually colonise and grow on the boulders. The enhancement effect of the seawalls will further reduce the potential impacts of the reclamation works on the local fishing and will not adversely affect the fishery as a whole.

The combination of very limited habitat loss, 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 within acceptable levels.

10.10 CUMULATIVE IMPACTS

At present there are no committed projects that could have cumulative impacts with the construction of the terminal at Black Point. No projects are planned to be constructed in sufficient proximity to the Project to cause cumulative effects and hence, cumulative impacts are not expected to occur.

10.11 CONCLUSIONS

Reviews of existing information on commercial fisheries resources and fishing operations surrounding the waters adjacent to the proposed LNG terminal have been undertaken. Information from a study on fishing operations in Hong Kong and the AFCD Port Survey 2001/2002 indicate that fisheries production values in the vicinity of the assessment area are low. Sensitive receivers such as spawning grounds, artificial reefs, fish culture zones and oyster production areas have been identified; however, the water quality modelling results show that these areas will not be affected.

Adult capture fisheries resources are unlikely to be adversely impacted by the LNG terminal as they will likely avoid the works areas. Although impacts to fish fry may occur through the permanent loss of habitat, the small size of the reclaimed area and the low fisheries and fish fry value of the habitat lost greatly reduce the significance of the impact to a level that is acceptable.

Impacts arising from the proposed dredging works are predicted to be largely confined to the specific works areas and to be temporary in nature. The predicted elevations of suspended sediment concentrations due to the Project are not predicted to exceed the assessment criteria over large areas or at sensitive receivers and they are not expected to cause adverse impacts to water quality or to any fishing grounds or species of importance to the fishery. Dredging operations have been designed to minimise potential impacts on the water quality which will, in turn, reduce impacts on fisheries resources. No fisheries-specific mitigation measures are required during construction.

Significant operational phase impacts to fisheries resources and fishing operations are not expected to occur. Entrainment of fisheries resources will be mitigated through the appropriate design of the intake screens. Unacceptable impacts from discharges of cooled water are not anticipated to occur as the effects from these discharges will be localised. Compliance with the relevant discharge standards to control water quality impacts to within acceptable levels is also expected to control impacts to fisheries resources. No additional fisheries-specific mitigation measures are required during operation.

All of the potential construction and operational fisheries impacts identified are deemed acceptable.