



Development of an Offshore Wind Farm in Hong Kong

Fisheries Enhancement Plan

11 Nov 2014

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1 INTRODUCTION

1.1 BACKGROUND TO THE PROJECT

The **Hongkong Electric Co. Ltd. (HK Electric)** is proposing the development of a 100 MW offshore wind farm in the Southwestern Waters of Lamma Island (the Project). The corresponding Environmental Permit (EP) (No. EP-394/2010) was granted by the Environmental Protection Department (EPD) on 8 June 2010.

According to the EP ⁽¹⁾, a Fisheries Enhancement Plan (FEP) is required to be developed prior to the commencement of the construction of the Project. As per the approved Environmental Impact Assessment (EIA) for the Project, the FEP would be developed in consultation with the Fisheries Review and Consultation Committee (FRCC).

The FRCC has two primary objectives. The first of these is to review whether there is scope to open the area within the turbine array to fishing operations. Such an area is, by way of the EIA, currently proposed to be closed to all fishing operations. The second objective is to investigate any potential enhancement measures that can be built into the turbine array area to enhance fisheries resources. These measures are then to be detailed within the FEP documentation for submission to the EPD.

Through a series of FRCC consultation meetings held between May 2011 and July 2012, opinions of the fisheries sector and AFCD were received and taken into account to establish the fishery management and fishery enhancement measures for the Project (see *Table 1.1* for a summary of the consultation findings). The preferred fishery management and enhancement measures were eventually agreed with the AFCD and FRCC during the 2nd FRCC meeting held in July 2012.

(1) EP Condition 2.7 - The Permit Holder shall, no later than six months before commencement of marine construction works of the wind turbines of the Project, submit to the Director for approval 4 hard copies and 1 electronic copy of the fisheries enhancement plan incorporating suitable enhancement measures such as deployment of artificial reefs. The fisheries enhancement plan shall be developed in consultation with the fishery sector and the Agriculture, Fisheries and Conservation Department.



In accordance with the requirements of the FRCC, the following four deliverables were provided:

- (i) Artificial Reefs Study Report under FRCC Task Group 1 - accepted by AFCD on 6 February 2012 ⁽¹⁾;
- (ii) Fishing Operations Report under FRCC Task Group 2 - accepted by AFCD on 6 February 2012 ⁽²⁾;
- (iii) FRCC Study Report - accepted by AFCD on 29 April 2013 ⁽³⁾; and
- (iv) Artificial Reef Programme Monitoring Plan - accepted by AFCD on 23 December 2013 ⁽⁴⁾.

Table 1.1 *A Summary of Key Results of the FRCC Consultation Meetings*

Date	Meeting	Key Results
3 May 2011	1 st FRCC Meeting	Establishment of the Artificial Reef (AR) Task Group to examine the potential viability of deploying ARs within the wind farm and Fisheries Management (FM) Task Group to address issues related to fisheries management that may be permitted within the proposed wind farm array in Southwest Lamma waters.

- (1) ERM (2012) Artificial Reefs Study Report. Prepared for HKE under the Fisheries Review and Consultation Programme: Task Group 1 Artificial Reefs.
- (2) ERM (2012) Fishing Operations Report. Prepared for HKE under the Fisheries Review and Consultation Programme: Task Group 2 Fisheries Management.
- (3) ERM (2013) FRCC Study Report. Prepared for HKE under the Fisheries Review and Consultation Programme:
- (4) ERM (2013) Artificial Reef Programme Monitoring Plan. Prepared for HKE under the Fisheries Review and Consultation Programme.



Date	Meeting	Key Results
12 October 2011	1 st AR Task Group Meeting	<p>Three conceptual AR options were developed and presented to the Task Group, namely Option 1 – Scour Protection; Option 2 – Artificial Reef; and Option 3 which was a combination of Options 1 & 2.</p> <p>Established the key design principles of the ARs, which were as follows:</p> <ul style="list-style-type: none"> • Artificial Reefs will be deployed within the wind farm array and outside of the Advisory Safety Zone. These will be fishable artificial reefs; • Scour Protection will be installed around the turbines within the Advisory Safety Zone. This will be non-fishable seabed relief with management requirements imposed; and • Artificial Reefs/Seafloor Habitat will also be deployed within the Advisory Safety Zone. These will be non-fishable reefs protected by the recommendations imposed within the Advisory Safety Zone relating to vessel access.
12 October 2011	1 st FM Task Group Meeting	<p>Agreed the establishment of the 50-m Advisory Safety Zone (ASZ) as a voluntary No-Take Zone while other ARs outside the ASZ serve as fishable ARs. The FM Task Group held reservation towards some other fisheries management options.</p>
15 February 2012	2 nd AR and FM Task Group Meeting (a joint meeting was held with AR and FM Task Groups' members)	<p>AR design: Preferred AR option, which was developed based on key design principles agreed in the 1st AR Task Group Meeting, was presented to and agreed by the Task Groups.</p> <p>Fishery management measures: Agreed with Task Groups' members on the establishment of 50-mASZ as voluntary No-Take Zone and area outside ASZ serves as Fishable Zone (as agreed in the 1st FM Task Group Meeting).</p>
11 July 2012	2 nd FRCC Meeting	<p>Agreement with FRCC members on preliminary design of ARs for the offshore windfarm (ie preferred option agreed in the 2nd AR Task Group Meeting) and the fishery management measures.</p>

1.2 *PURPOSE OF THE FISHERIES ENHANCEMENT PLAN (FEP)*

The purpose of this *Fisheries Enhancement Plan (FEP)* is to present the preferred fisheries management and enhancement measures that have been developed for the Project in consultation with the FRCC and accepted by the AFCD. These measures will be implemented during the pre-construction, construction and operation phases of the Project.

1.3 *STRUCTURE OF THE FEP*

Following the introductory section, the remainder of this FEP is organized as follows:

- *Section 2* describes the fisheries resources in the southwestern Lamma waters which is the target area for the implementation of the FEP.
- *Section 3* presents the overall goal of the FEP
- *Section 4* presents the fishery management measures to be implemented with regard to the deployment of ARs within the wind farm, as endorsed by the FRCC and accepted by the AFCD
- *Section 5* describes the preferred artificial reef (AR) deployment option as well as the fisheries enhancement measures, and its monitoring programme for performance evaluation, as endorsed by the FRCC and accepted by the AFCD
- *Section 6* summarizes the overall framework of the FEP.



This section presents a review of the fisheries resources of the Southwestern Lamma waters which is the target area for the implementation of the FEP. Development of fisheries enhancement and management measures under the FEP have thus taken into account the background fisheries information of the area presented below.

2.1 OVERVIEW

There has been a steady decline in Hong Kong's fisheries resources over the last few decades as increasing pressures from over-exploitation and in-direct impacts of coastal development and pollution have taken their toll ⁽¹⁾ ⁽²⁾. An assessment of the fisheries resources of inshore waters of Hong Kong has shown that marine species are displaying indicators synonymous with overexploitation ⁽³⁾.

Fisheries exploitation is primarily concentrated in the waters of Hong Kong, the Pearl River Estuary and the adjacent continental shelf of the South and East China Seas ⁽⁴⁾. Despite being over-exploited, the fisheries of Hong Kong still provide an important contribution to the local socio-economy. The Agricultural, Fisheries and Conservation Department (AFCD) revealed that in 2013 an estimated 170,129 tonnes of fish was produced, which was equivalent to an economic value of about HK\$2,338 million ⁽⁵⁾. In addition, 8,800 local fishermen with approximately 4,000 vessels were servicing in the fishing industry ⁽⁵⁾.

Capture fisheries in Hong Kong waters are regulated by the *Fisheries Protection Ordinance (Cap. 171)*. Destructive fishing practices of use of toxic substances, dynamites, electricity, suction and dredging device have long been prohibited. To further promote the sustainable development of the fishing industry and to conserve fisheries resources in Hong Kong waters, AFCD has implemented a number of fisheries and enhancement measures. On 31 December 2012, an outright trawling ban was put into effect in an attempt to restore the seabed and the depleted fisheries resources ⁽⁵⁾. To complement the trawl ban and bring local fisheries industry back to a sustainable path, the government implemented other fisheries management measures through legislative amendments to the *Fisheries Protection Ordinance (Cap. 171)*. These measures

- (1) ERM (1999) Artificial Reef Deployment Study. Final report for AFCD
- (2) Sumaila, U. R. Cheung, W. and I. Teh, (2007) Rebuilding Hong Kong's Marine Fishery. An evaluation of Management Options. WWF-HK commissioned report produced by the Fisheries Centre, University of British Columbia.
- (3) Pitcher, TJ, Sumaila, U.R, Cheung, W.I. and N. Haggan (2005) Further spatial simulations with MPAs and human-made reefs in Hong Kong's marine ecosystem. Addendum to Fisheries Centre Report 10(3)
- (4) Sumaila, U. R, Cheung, W. and I. Teh (2007) *Op. cit.*
- (5) AFCD (2014) available on www.afcd.gov.hk/english/fisheries/fish_cap/fish_cap_latest/fish_cap_latest.html

include: (1) setting up a registration system for local fishing vessels; (2) limiting new entrants to control the fishing number of fishing vessel and fishing effort; (3) restricting fishing activities of non-fishing vessels and prohibiting fishing activities of non-local fishing vessels; and (4) designating fisheries protection areas. In addition, the Government has implemented an Artificial Reef Project since 1996 to enhance fisheries resources and promote biodiversity in Hong Kong's marine environment. Besides, restocking trials of suitable species have been conducted at identified areas with a view to enhancing fisheries resources.

Since 1999, Mainland Authorities have implemented a fishing moratorium for South China Sea fishing grounds for two months during midsummer (from 1 June to 1 August). The fishing moratorium was later extended to 2.5 months per year in 2009. The moratorium prohibits fishing activity in the South China Sea.

2.2 FISHERIES STATUS IN THE SOUTHWESTERN LAMMA WATERS

Marine Fish Culture

There are no Fish Culture Zones (FCZs) located close to the wind farm site or the proposed cable route. The closest FCZs are located at Lo Tik Wan (> 9 km from the wind farm site; > 6 km from the cable route), Sok Kwu Wan (> 10 km from the wind farm site; > 8 km from the cable route) and Cheung Sha Wan (> 10 km from the wind farm site, > 9 km from the cable route) (Figure 2.1). FCZs were found to be too remote to be affected by the construction and operation of the wind farm. As such, enhancement of FCZ has not been considered as one of the key objectives of the FEP of the Project.

Fishing Vessels

The scale of fishing operations in terms of the number of fishing vessels operating in the waters around the proposed wind farm site and cable route is presented in Figure 2.1.

With reference to findings of the Port Survey 2006 presented using AFCD grid system, the number of vessels that operate in waters at Southwest Lamma varies between 100 - 400 vessels and 400 - 700 vessels. Shrimp trawling is the dominant fishing operation with 50 - 400 vessels operating in waters in proximity to the proposed wind farm site. Within the wind farm site, a relatively higher number of vessels are found operating at the far eastern edge. However, it is worth noting that the precise area where greatest fishing activity is undertaken is not clear from the Port Survey data as the data are presented based on a large grid system, where the grid forms only part of the wind farm site. The area showing relatively high levels of fishing operations extends eastwards to southern Lamma waters and the area of the wind farm site only contributes to a small part of this overall area (less than

Port Survey 2006
 Distribution of fishing operations
 Overall

捕魚作業及生產訪問調查 2006
 捕魚作業分布
 總計

捕鱼作业及生产访问调查 2006
 捕鱼作业分布
 总计

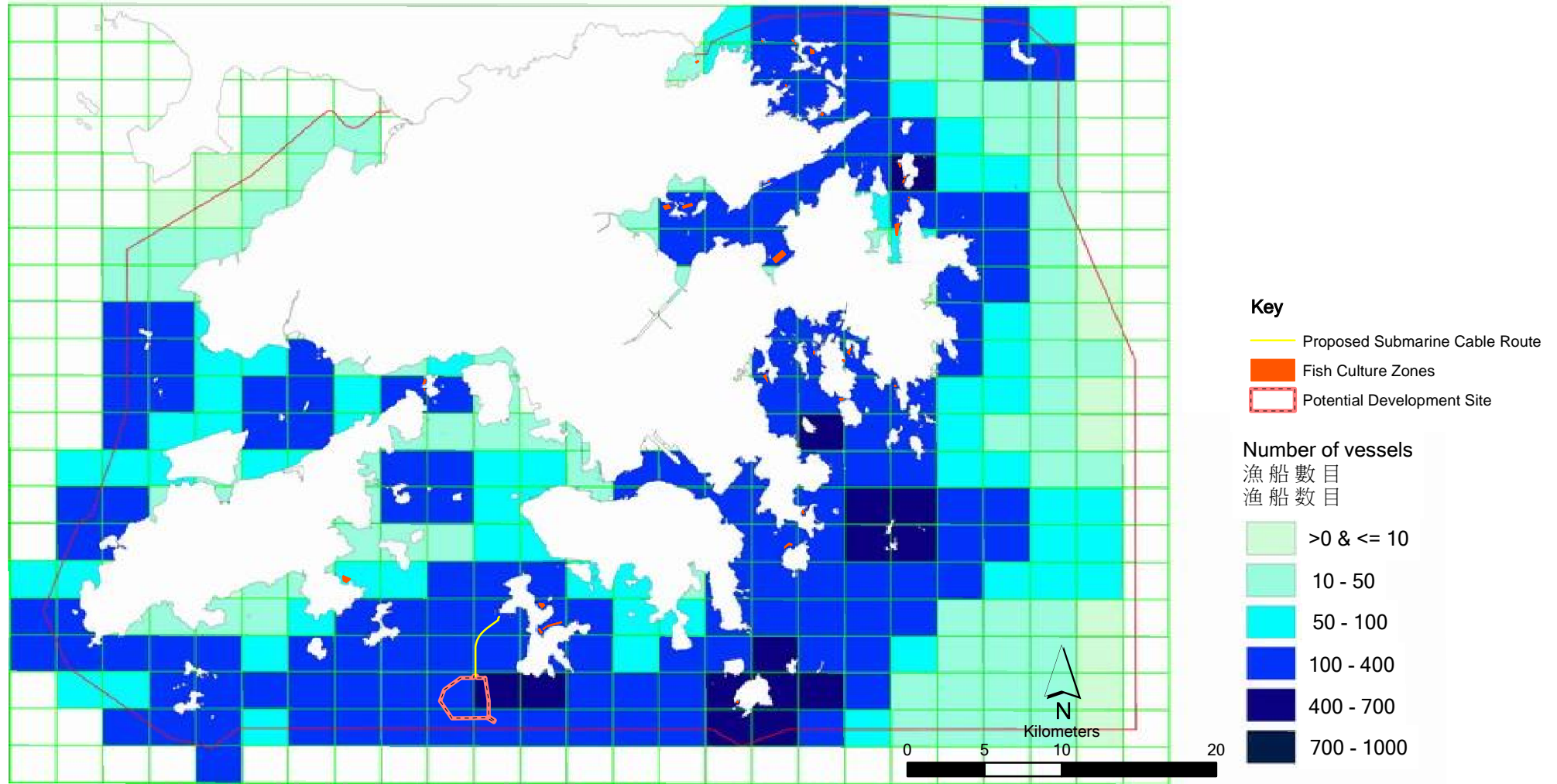


Figure 2.1

Distribution of Fishing Operations (All Vessels) in Hong Kong Waters
 as recorded by Agriculture, Fisheries and Conservation Department in Port Survey 2006

10%). The level of fishing activity in other areas at the wind farm site and along the transmission route is similar to that found in most nearshore zones to the south, west, and east of Hong Kong waters (see *Figure 2.1*). The Ninepin Island Group, Po Toi Island Group, Tap Mun and Shelter Island represent others areas in Hong Kong waters that show high levels of fishing vessel activity.

Vessels operating in the Project Area also include sampans (1 – 400 vessels), hang trawlers (10 – 50 vessels), gill netters (10 – 50 vessels), stern trawlers (1 – 50 vessels), pair trawlers (<10 vessels), long liners (1 – 50 vessels), hand lining (0 – 10 vessels) and purse seiners (1 – 50 vessels).

In addition, according to the 2006 Port Survey study, data on general marine traffic within the site supports the finding that fishing activity is greatest in the east and potentially the north east of the wind farm site ⁽¹⁾.

The use of these waters by trawling operations is also supported by the results of the geophysical surveys conducted as part of the site investigation and marine archaeological surveys works for the EIA Study of the Project ⁽²⁾. Numerous trawl scars within the study area are clearly evident from the results of these surveys.

In addition to the desktop review presented above, opportunistic vessel-based observations of active fishing vessels were made in the survey area during the bird and marine mammal surveys which were undertaken for the EIA Study of the Project ⁽³⁾. Data obtained from these surveys were collected to provide supplementary information on fishing operations in the area. Observational records were taken over a 10-month period from July to October 2008 and January to June 2009. A total of 6 different types of fishing vessel were recorded with a mean total number of ~10 vessels sighted in Study Area per day (*Table 2.1*). The results would suggest that fishing activity in the wind farm area was comparatively lower than areas to the north, west and east of the wind farm during the survey period (see *Figure 2.2*). The results from the vessel sighting records indicate that small P4s ⁽⁴⁾ undertaking hand lining or gill netting activities was the predominant type of vessels moving across the wind farm site and cable route during the period of observation, followed by shrimp trawling and stern trawling vessels. Greatest trawling activity seems to occur to the east of the wind farm site and around the south and east of Lamma Island.

Although the above information on fishing operations is based on opportunistic observational surveys, it is interesting to note some of the

(1) BMT Asia Pacific (2008) Technical Note to HKE.

(2) ERM (2010) Development of an Offshore Wind Farm in Hong Kong. EIA Report: Register No.: AEIAR-152/2010.

(3) ERM (2010) *Op. cit.*

(4) Defined as vessels are defined as those licensed to carry no more than four passengers

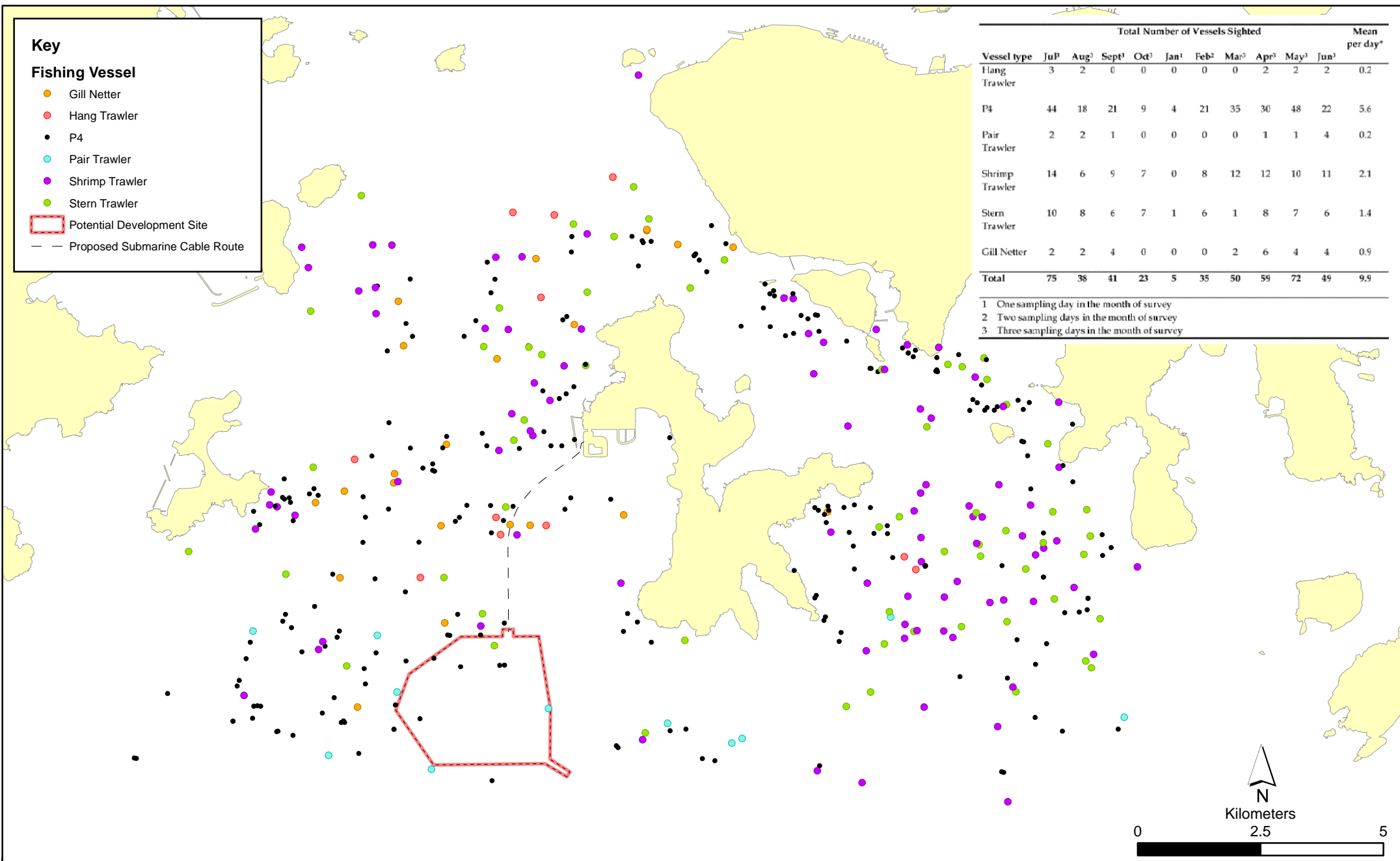


Figure 2.2

Fishing Vessel Sightings (July 08 - Oct 08; Jan 09 - Jun 09) 27 Survey Days in Total

differences between these surveys and the AFCD Port Survey findings. Of particular note are what appear to be lower levels of usage of these waters by trawling vessels and the high levels of small scale hand lining fisheries such as those observed on P4s. The findings from this newer data collected in 2008-09 may indicate that waters around the Study area are less intensively fished by certain gear types than that previously recorded by AFCD in 2005 during their Port Survey. However, caution should be added based on the limited dataset collected for the observational surveys.

On 31 December 2012, the trawling ban was put into effect and trawling operation is no longer allowed within Hong Kong waters. As such, fishing by trawlers is not expected during the future construction and operation of the wind farm.

Table 2.1 *Type of fishing vessels, total number of vessel sights for each month from July 2008 to June 2009 and the mean number of vessel sightings per day*

Vessel type	Total Number of Vessels Sighted										Mean per day*
	Jul ³	Aug ³	Sept ³	Oct ³	Jan ¹	Feb ²	Mar ³	Apr ³	May ³	Jun ³	
Hang Trawler	3	2	0	0	0	0	0	2	2	2	0.2
P4	44	18	21	9	4	21	35	30	48	22	5.6
Pair Trawler	2	2	1	0	0	0	0	1	1	4	0.2
Shrimp Trawler	14	6	9	7	0	8	12	12	10	11	2.1
Stern Trawler	10	8	6	7	1	6	1	8	7	6	1.4
Gill Netter	2	2	4	0	0	0	2	6	4	4	0.9
Total	75	38	41	23	5	35	50	59	72	49	9.9

- 1 One sampling day in the month of survey
 2 Two sampling days in the month of survey
 3 Three sampling days in the month of survey

Fisheries Production

The level of fisheries production in the waters around the Project site is presented in *Figure 2.3*. All data have been taken from the 2006 Port Survey Study.

Adult fish catches vary between 200 – 400 kg ha⁻¹ and 400 – 600 kg ha⁻¹ within and immediately adjacent to the wind farm area and cable route. Fisheries production to the east of the proposed wind farm site is again relatively high



Port Survey 2006
 Distribution of fisheries production (adult fish)
 Overall

捕魚作業及生產訪問調查 2006
 漁產分布(成魚)
 總計

捕鱼作业及生产访问调查 2006
 渔产分布(成鱼)
 总计

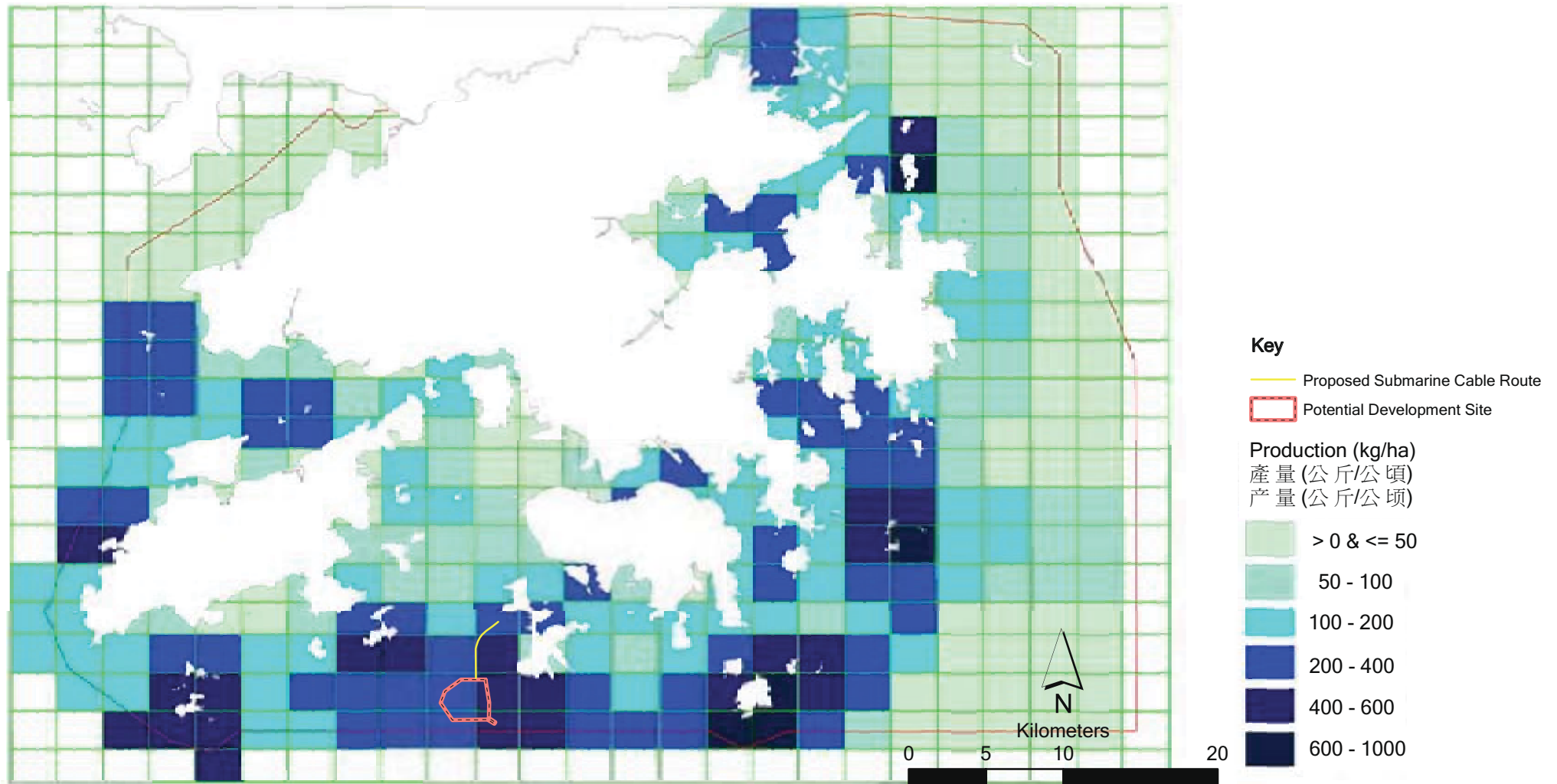


Figure 2.3

Distribution of Fish Production ('Adult' Fish) (kg ha^{-1}) in Hong Kong Waters
 as recorded by Agriculture, Fisheries and Conservation Department in Port Survey 2006

when compared with other waters of the Hong Kong. However, the data indicate that large-scale activities appear to extend around the south and west of Lamma Island with fishing areas of high catch value present outside of the wind farm site.

Fish Fry Production

As presented in *Figure 2.4*, there is no record of fish fry catches within the proposed wind farm and cable route. Inshore areas at around Lamma Island do, however, record fish fry production.

Catch Value

Based on the 2006 Port Survey Study, the value of catches from the waters around the proposed wind farm is presented in *Figure 2.5*. The overall catch value of both adult fish and fish fry recorded for the proposed wind farm ranges from HK\$2,000 – 5,000 ha⁻¹ to HK\$5,000 – 10,000 ha⁻¹. As for fisheries production, the value of catches to the east of the proposed wind farm site and along the cable route is relatively high. Again, the value of catches is also high outside of the wind farm around Lamma Island. Nevertheless, catch value may vary with concurrent fish prices fluctuations.

Fisheries Resources – Spawning and Nursery Areas

Spawning Area: In 1998, the southern waters of Hong Kong were identified as spawning grounds for commercial fisheries resources. *Johnius belengeri* (croaker), *Solenocera crassicornis* (mud shrimp) and *Metapenaeus affinis* (shrimp) were the key fish and crustacean species recorded ⁽¹⁾. The majority of commercial species recorded in Hong Kong were reported to aggregate and spawn in the open waters during the period from June to September ⁽²⁾.

The proposed wind farm is located within the Southern Waters fish spawning area. The area of the proposed wind farm encompasses 600 ha, which contributes to a small fraction (2.72%) of the identified spawning area (22,000 ha).

Nursery Area: Nursery areas in Hong Kong waters that are important for juveniles of a number of commercial fish and crustacean species have been previously identified. The nursery area extends across southern waters from Lantau Island to Lamma Island ⁽¹⁾. The waters near Lamma Island have been identified as an important habitat area for a number of commercial juvenile fish and crustacean species include *Metapenaeopsis barbata* (prawn), *Metapenaeopsis palmensis* (prawn), *Oratosquilla* spp. (mantis shrimp), *Oxyurichthys tentacularis* (goby), Sciaenid fry and Serranid fry. Juvenile fish species have been recorded in all seasons in the area. *Metapenaeopsis*

(1) ERM (1998). *Op. cit.*

(2) ERM (1998) *Op. cit.*

Port Survey 2006
 Distribution of fisheries production (fish fry)

捕魚作業及生產訪問調查 2006
 漁產分布(魚苗)

捕鱼作业及生产访问调查 2006
 渔产分布(鱼苗)

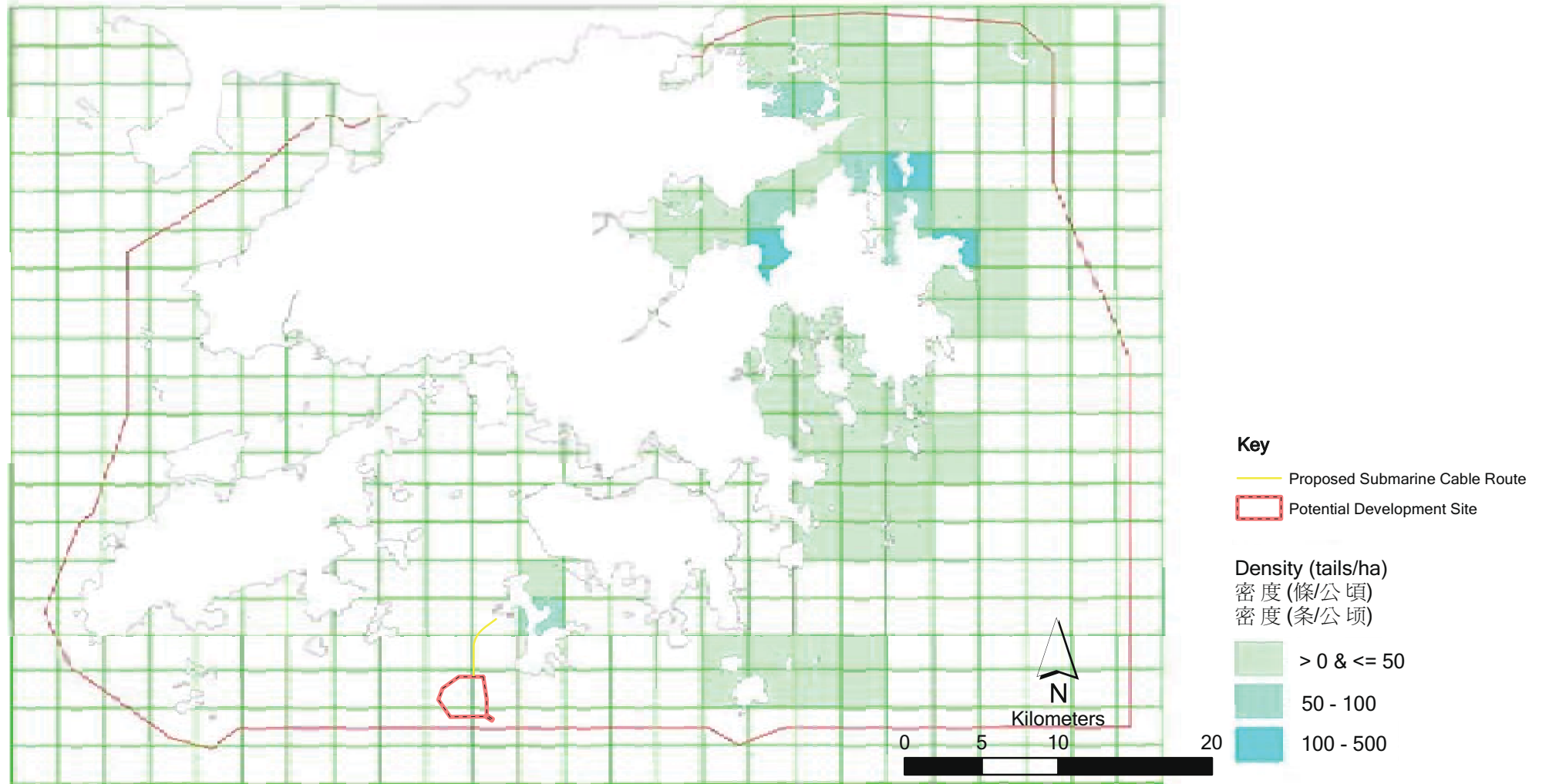


Figure 2.4

Distribution of Fish Fry Production (tails ha⁻¹) in Hong Kong Waters
 as recorded by Agriculture, Fisheries and Conservation Department in Port Survey 2006

Port Survey 2006
 Distribution of fisheries production (adult fish & fish fry)
 Overall

捕魚作業及生產訪問調查 2006
 漁產分布 (成魚及魚苗)
 總計

捕鱼作业及生产访问调查 2006
 渔产分布 (成鱼及鱼苗)
 总计

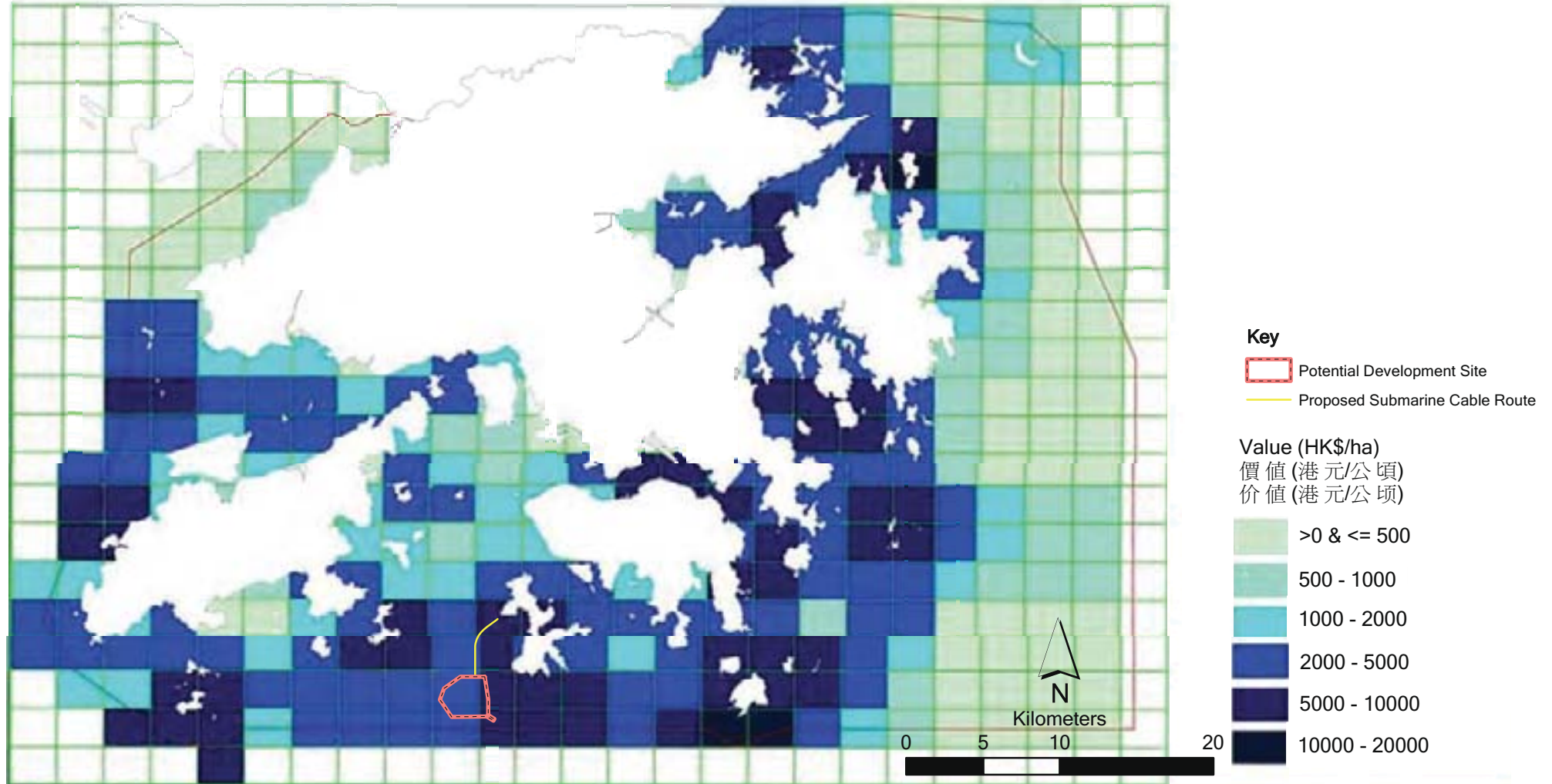


Figure 2.5

Distribution of Fisheries Production Value (Adult Fish and Fish Fry) in Hong Kong Waters as recorded by Agriculture, Fisheries and Conservation Department in Port Survey 2006

palmensis was dominant species during spring, summer and autumn, while *Thrissa kammalensis* and *Oxyurichthys tentacularis* were commonly found in winter. High abundance of *Squilla* fry has also been reported in Southern Lamma waters during the autumn. The proposed wind farm area coincides with a small fraction (2.72%) of the previously identified nursery grounds (22,000 ha).

Fisheries Importance

In the EIA Study of the Project, the importance of the fisheries resources within the Study Area was evaluated based on the baseline information provided above. The production of the fishing areas within and adjacent to the proposed wind farm are considered as medium to high when compared to other waters within Hong Kong.



3 OBJECTIVES OF THE FISHERIES ENHANCEMENT PLAN

3.1 GEOGRAPHICAL SCOPE OF THE FEP

The geographical scope of the fisheries enhancement plan is in the Southwestern Lamma Waters where the proposed wind farm located.

3.2 STRATEGIC FRAMEWORK APPROACH

Commitment to the enhancement of fisheries entails a long term programme and is viewed in this way as it will need to take into account the biological considerations of commercially important fish, invertebrate life cycles including growth and reproductive maturity. In addition, robust and scientifically rigorous baseline data on the fisheries resources, nature of the extractive activities and the resource users are required before full implementation of appropriate enhancement measures. Table 3.1 shows the framework structure with preliminary but indicative timing of the works.

Table 3.1 Strategic Framework for the Fisheries Enhancement Plan

FEP Components	Timeline		
	Pre-construction	Construction	Operation
Development of Enhancement and Management Measures	■		
Detailed Design and Baseline Monitoring	■		
Implementation of Recommended Measures		■	
Performance Evaluation			■

3.3 GOALS AND OBJECTIVES

The main goal of the FEP is to identify, explore and implement measures for enhancing the fisheries resources of the offshore wind farm area.

The key objectives of the FEP are as follows:

1. Conduct focused study and in consultation with the fishery sector and the AFCD to identify the best and practicable means to rehabilitate local fish stocks around the offshore wind farm area.
2. Undertake a comprehensive suite of baseline studies covering fisheries resources, ecological resources and socio-economic profiling of the resource users of the Southwestern Lamma waters with the aim of obtaining a comprehensive baseline status before implementation of the fisheries enhancement and management measures. The baseline information collected will then be used for evaluating the effectiveness of the fisheries enhancement and management measures during their implementation stage.

3. Implement the fisheries enhancement and management measures.
4. Implement and monitor the performance of the enhancement and management measures, e.g. deployment of ARs.

The above objectives for this FEP is considered as a programmatic component and discussed in detail in the following sections.

As part of the FRCC, a Fishing Operations Study has been undertaken with the following objectives:

- To determine whether fisheries, both commercial and recreational, would be manageable, permitted activities within the wind farm array during its operation through a review of international experiences on the operation of wind farms as well as the Marine Traffic Management Plan of the Project to acknowledge any considerations for overall vessel management.
- If deemed potentially manageable, to recommend measures for the management of fisheries activities (for both commercial and recreational) that may potentially be implemented during the operation of the Project. Development of the fisheries management measures has taken into account fisheries enhancement measures (eg AR deployment) recommended in *Section 5* to ensure that fishing activities within the wind farm, if permitted, will be sustainable and not counteracting the potential enhancement effects.

The following section summaries the feasibility of fishing operations during the operation of the wind farm and briefly describes the fisheries management measures that have been considered and eventually recommended under the FEP of the Project. For details regarding the rationale and development of the fishery management measures, readers are referred to the Fishing Operations Report ⁽¹⁾ which is prepared under a separate cover and accepted by AFCD on 6 February 2013.

4.1

FISHING OPERATIONS WITHIN THE OPERATING WIND FARM

Initial discussion between HK Electric and Marine Department on the Marine Traffic Management Plan of the Project preliminarily concluded that an Advisory Safety Zone will be instated around the 50m radius of each individual wind turbine, within which vessel approach is not encouraged from a safety point of view. This is a voluntary scheme and the project proponent will monitor the captioned Advisory Safety Zone by means of CCTV surveillance and boat patrol. The desktop review of fishing operations within overseas wind farms has indicated that similar safety exclusion zones of 50m radius have been implemented around turbines and/or project related structures of other offshore wind farms. Fishing vessels have been permitted to enter and operated within the wind farm boundaries during operation phase provided they do not enter the safety exclusion zones. In addition, results of the Marine Navigational Safety Risk Assessment (MNSRA) of the

(1) ERM (2012) Fishing Operations Report. Prepared for HKE under the Fisheries Review and Consultation Programme: Task Group 2 Fisheries Management.

Project ⁽¹⁾ indicate that unacceptable risk to fishing vessels are not expected to occur during operation of the Project. Fishing by hand lines, gill nets, long lines and purse seines, which have been identified as potential fishing gears that may be used within the operating wind farm, are considered as feasible assuming the operators can adjust the size of their gear types to adapt to the wind farm conditions. Based on the above consideration on international experiences and Marine Traffic Management Plan of the Project, it is considered that fishing operations is potentially manageable within the operating wind farm array in Southwestern waters of Lamma.

No other restrictions to fishing vessels and operations have been identified from the Marine Traffic Management Plan, instead, navigation aids and surveillance systems will be installed at the wind turbines and search and rescue capacity will be established to reduce the risk to navigation and respond to emergency situations. From the marine safety perspective, no additional management measures to fishing vessels, instead of those that would normally apply to all vessels, would be necessary during operation of the Project. It is anticipated that the above marine safety measures will affect the decision of individual fishing operators in deciding whether or not to fish within the wind farm array during its operation.

4.2 FISHERIES MANAGEMENT MEASURES

As presented in *Section 4.1* above, fishing operation is considered as potentially manageable within the operating wind farm array in Southwestern waters of Lamma. In order to ensure that the fishing operation will be sustainable and not counteracting the potential enhancement effects of the ARs deployed within the wind farm, two major types of fisheries management measures have been considered and consulted with the FRCC.

4.2.1 Proposed Fisheries Measures

The first type of fisheries management measures within the wind farm area that has been considered included:

- Mesh Size Regulations;
- Restrict Age / Size at First Capture;
- Restriction on the Use of Unselective Fishing Methods;
- Closed Season for Fishing; and
- Development of Recreational Fishing.

(1) BMT (2011) Marine Navigation Safety Risk Assessment. Final Report submitted to HK Electric.

All of the above measures were discussed with the *Fisheries Management Task Group* held on 12th October 2011. Comments raised by the Members of the Task Group to the above proposed fisheries measures are summarised below:

Mesh Size Regulations and Restrict Age/Size at First Capture

The members raised concerns on restricting the mesh size of their fishing gear and the age/size of fish at capture since certain target fish species are of small body sizes in nature, thus rendering it difficult to determine the minimum mesh size or minimum age/size of fish at fish capture.

Restriction on the Use of Unselective Fishing Methods

Since some gears used by the fishermen are unselective in nature, the group held reservation towards the restriction on the use of this type of gear within the wind farm array.

Seasonal Closure of Fishing

The members raised their concerns on the loss of income of fishermen if they are not allowed to operate during a closed season and thus did not support this option in general.

Development of Recreational Fishing

Some FRCC members expressed supporting views to this option. It is suggested to further discuss this option, if deemed necessary, after the implementation and review of the effectiveness of the AR programme of the Project.

Generally, the members held reservation towards some of the above proposed measures as these measures may affect the livelihood of fishermen and are considered difficult to implement.

4.2.2 Management of Fisheries Enhancement Measures

Another type of fisheries management measure that has been considered is related to the management of fishing at the ARs deployed within the wind farm waters (ie fisheries enhancement measure of the Project).

Past experience in Hong Kong has shown that unless fishing is regulated, aggregation of fish on ARs can lead to overexploitation ⁽¹⁾. The deployment of ARs may enhance the fisheries resources but ARs will also aggregate stocks making them potentially easier to catch. ARs will not be fishable by trawlers or purse seine fishermen that operate deep nets. These groups of fishermen however account for only a limited number of vessels in the fleet. The remainder of the fleet, particularly small vessels such as P4 and mixed vessel

(1) Morton, B (1996) Marine Pollution Bulletin, July 1996 - Editorial.

operators, will potentially be able to fish the reefs and would lead to overexploitation of fisheries resources as they are highly dependent on Hong Kong waters. Also, the prevalent use of gill nets and cage traps by the small vessels in the Hong Kong fleet could have serious impacts on fish stocks at ARs if no fishing controls are introduced. Therefore, the artificial reefs require certain degree of management control to ensure they provide the desired outcomes for both the biological resources and users.

International experience has shown that the no-take ARs are commonly considered to be the most successful in enhancing fisheries production. Therefore, for the purposes of the Southwest Lamma Wind Farm, it is recommended that Voluntary No-Take Zone be established within which ARs should be deployed. The Voluntary No-Take Zone will be located within the Advisory Safety Zone in which all vessels, including fishing vessels, are not encouraged to enter due to marine safety concern. In addition, under the Marine Traffic Plan of the Project ⁽¹⁾, it is proposed that surveillance systems will be provided to monitor vessel activities within the operating wind farm array measures and communications with vessels will be conducted through VHF radio and loudspeakers to provide guidance or warnings to vessels (e.g. when they enter the Advisory Safety Zone) if necessary. The implementation of these potential marine traffic management measures would reduce the likelihood of fishing vessel entering the Voluntary No-Take Zone, consequently reducing the level of fishery disturbance at the ARs deployed within these zones. With the potential reduction in fishery disturbance, it is expected that the implementation of Voluntary No-Take Zone would lead to enhancement of fishery resources at the ARs and this measure is thus recommended for the Project.

The implementation of Voluntary No-Take Zone as part of the AR deployment programme was discussed with the *Fisheries Management Task Group* held on 12th October 2011. The members recognized the proposed design which includes fishable installations with non-fishable areas, with the idea that the non-fishable ARs will provide enhancement to balance the take at the fishable ARs.

4.3

PREFERRED FISHERIES MANAGEMENT MEASURES

Findings from the consultation exercise with the *Fisheries Management Task Group* which comprised representatives from key fishermen associations indicated that members held reservation towards some proposed measures. The *Task Group* recommended the FRCC to focus on the development of options related to AR deployment and fisheries management measure related to this aspect (ie implementation of the Voluntary No-Take Zone). Therefore, under the FEP the implementation of Voluntary No-Take Zone is being

(1) BMT (2011) *Op. cit.*

recommended as the fisheries management measure during the Project's operation which was eventually endorsed by the FRCC during the 2nd FRCC meeting held in July 2012.



The purpose of AR deployment is to enhance the fisheries resources of the wind farm array, thereby meeting the overall requirement of needing to design a FEP as per the EP condition for the Project. Through a series of FRCC consultation meetings held between May 2011 and July 2012, opinions of the fisheries sector and AFCD were received and taken into account to establish the AR design for the Project. Three conceptual AR options (Options 1, 2 and 3) were developed initially and presented to the AR Task Group members during the 1st AR Task Group meeting held in October 2011. Concerns over placement and design of AR were discussed. Based on these discussions, a preferred option has been developed which was subsequently agreed with the AR and FM Task Groups during the 2nd Task Group meeting held in February 2012. The preferred option was eventually agreed by the AFCD and the FRCC during the 2nd FRCC meeting held in July 2012. The Fisheries Review and Consultation Committee (FRCC) Study Report was subsequently endorsed by the AFCD on 19 April 2013 in which the preferred option will be implemented as fisheries enhancement measure of the Project.

Details regarding the development of the preferred option are presented in the Artificial Reefs Study Report ⁽¹⁾ which is prepared under a separate cover and accepted by AFCD on 6 February 2012. The preferred AR options as fisheries enhancement measures for the Project are described below.

5.1

ARTIFICIAL REEF AS FISHERIES ENHANCEMENT MEASURE

The key design principles of the preferred option, as agreed in the FRCC consultation exercise, are as follows:

- Artificial reefs will be deployed within the wind farm array and outside of the Advisory Safety Zone (ASZ) ⁽²⁾. These will be fishable artificial reefs;
- Scour protection will be installed around the turbines within the Advisory Safety Zone. This will be non-fishable seabed relief with management requirements imposed; and
- Trial artificial reefs/seafloor habitat will also be deployed within the Advisory Safety Zone. These will be non-fishable reefs protected by the recommendations imposed within the Advisory Safety Zone relating to vessel access.

(1) ERM (2012) Artificial Reefs Study Report. Prepared for HKE under the Fisheries Review and Consultation Programme: Task Group 1 Artificial Reefs.

(2) Please refer to *Section 5* for detailed discussion of the ASZ as fishery management measure under the FEP of the Project.

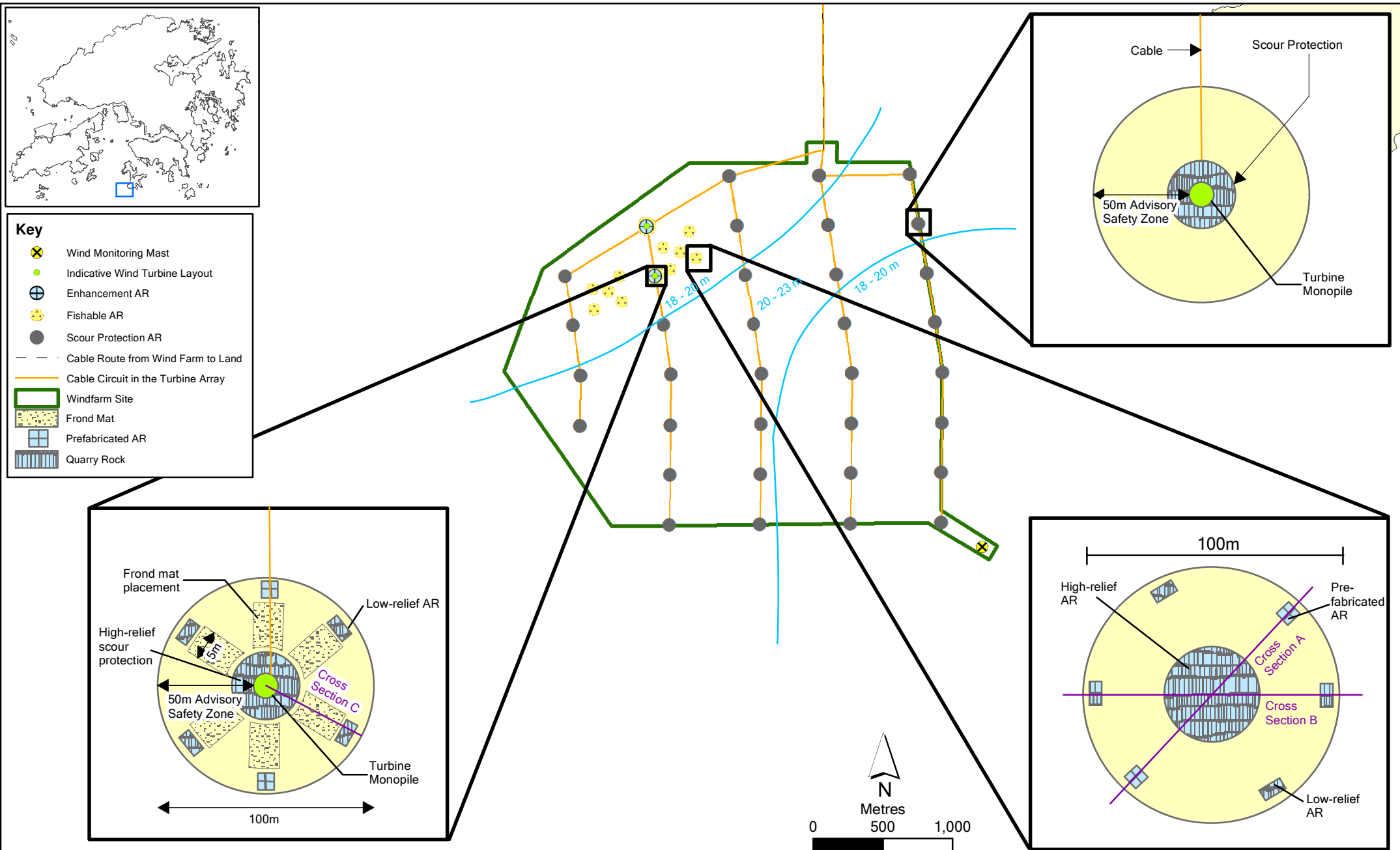


Figure 5.1

Plan View of Preferred Option

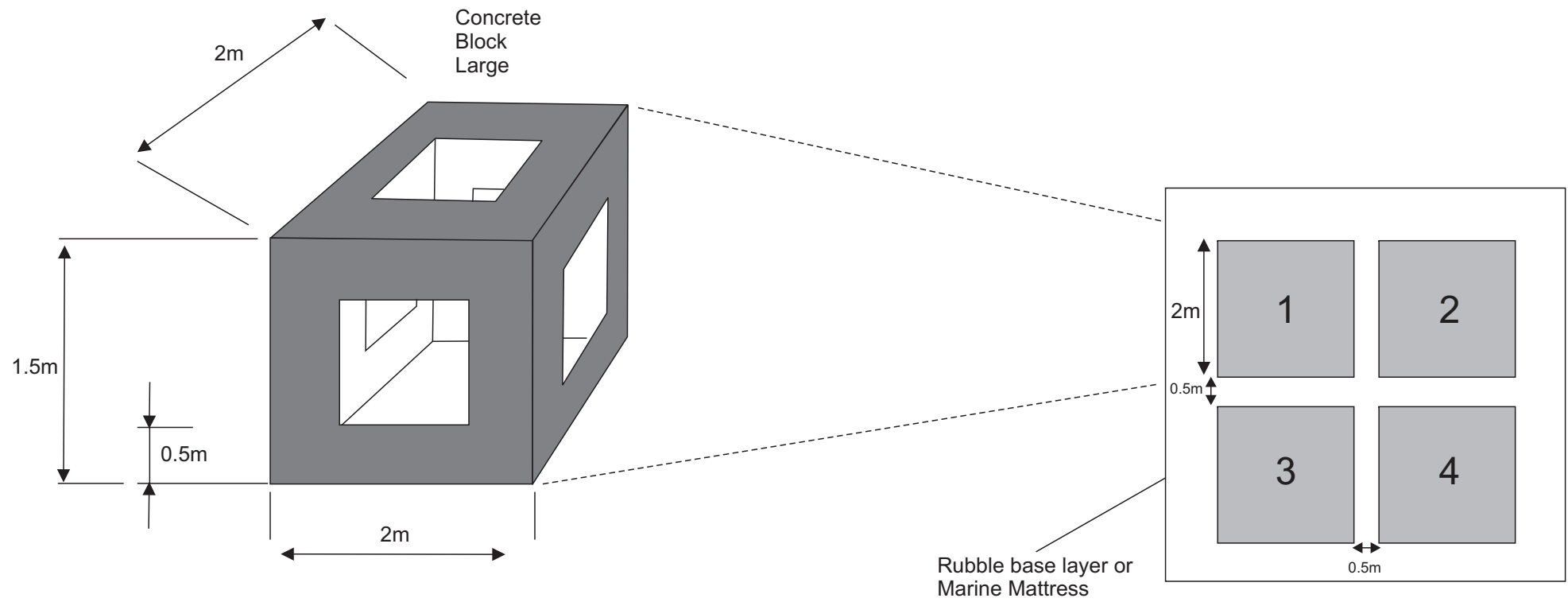
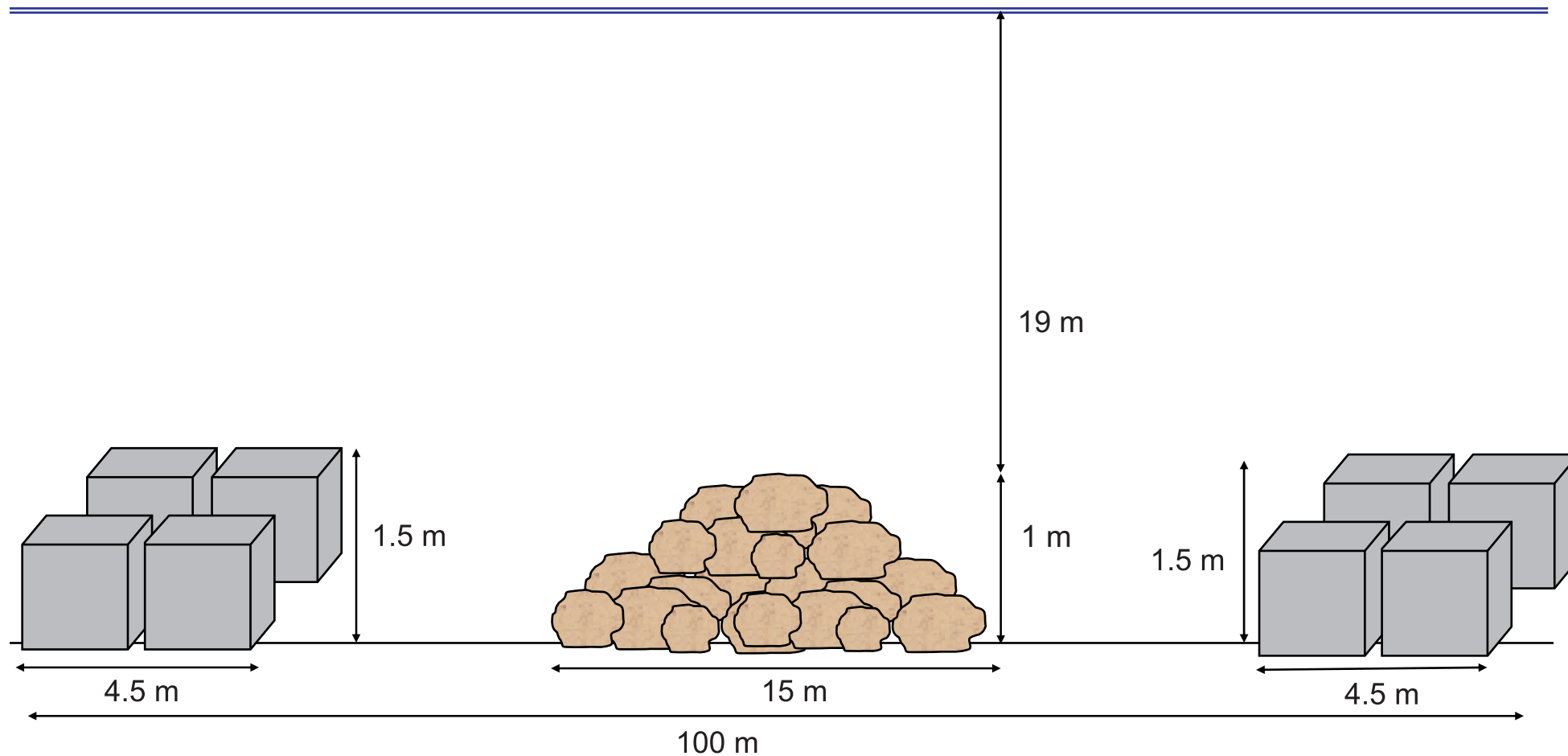


Figure 5.2

Fishable Artificial Reefs Outside Advisory Safety Zone



(Not to Scale)

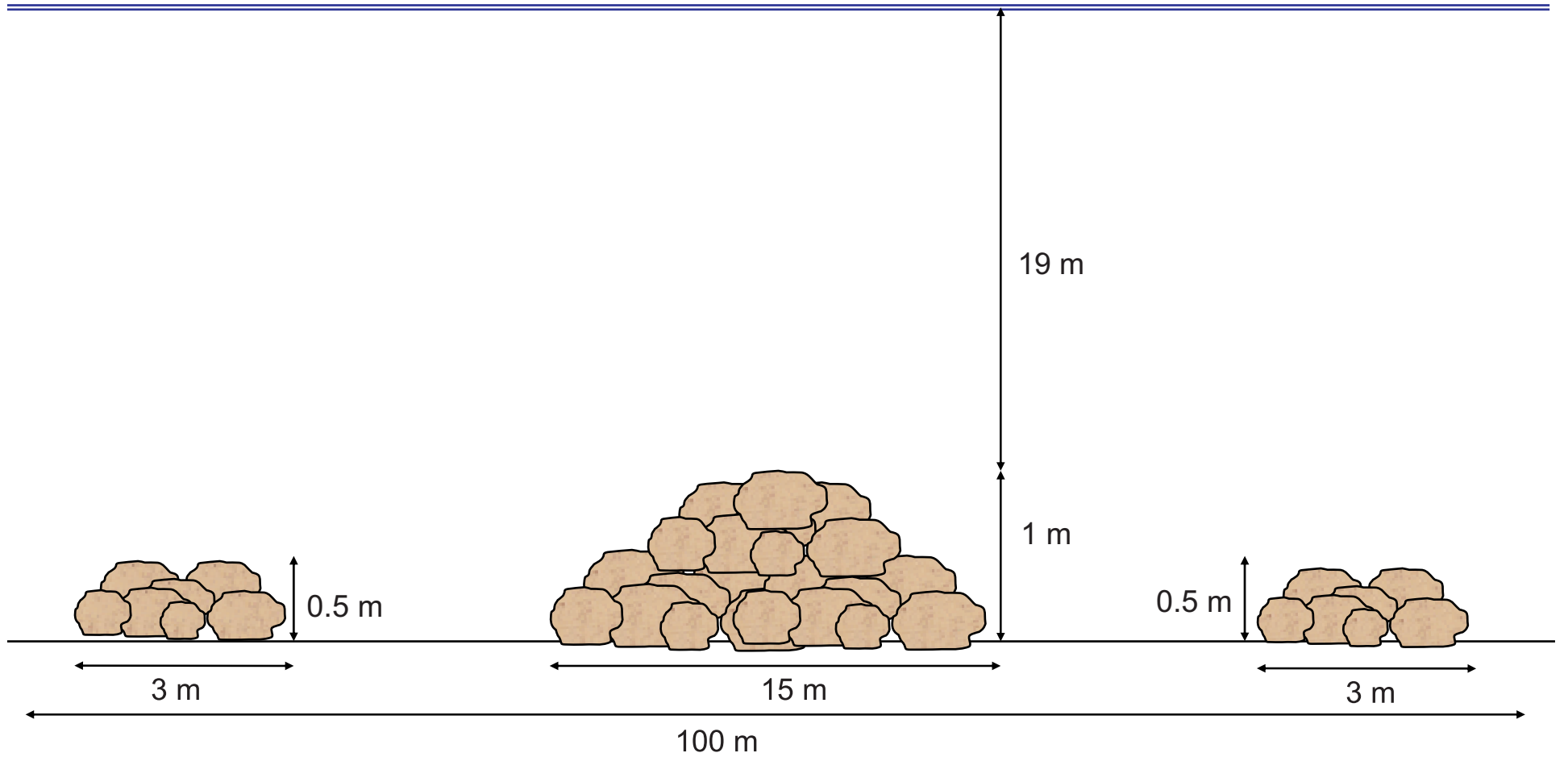
Figure 5.3

Cross-section A, Fishable Artificial Reefs

FILE: 0169904d
DATE: 13/12/2013

Environmental
Resources
Management





(Not to Scale)

Figure 5.4

Cross-section B, Fishable Artificial Reefs

FILE: 0169904c
DATE: 13/12/2013

Environmental
Resources
Management



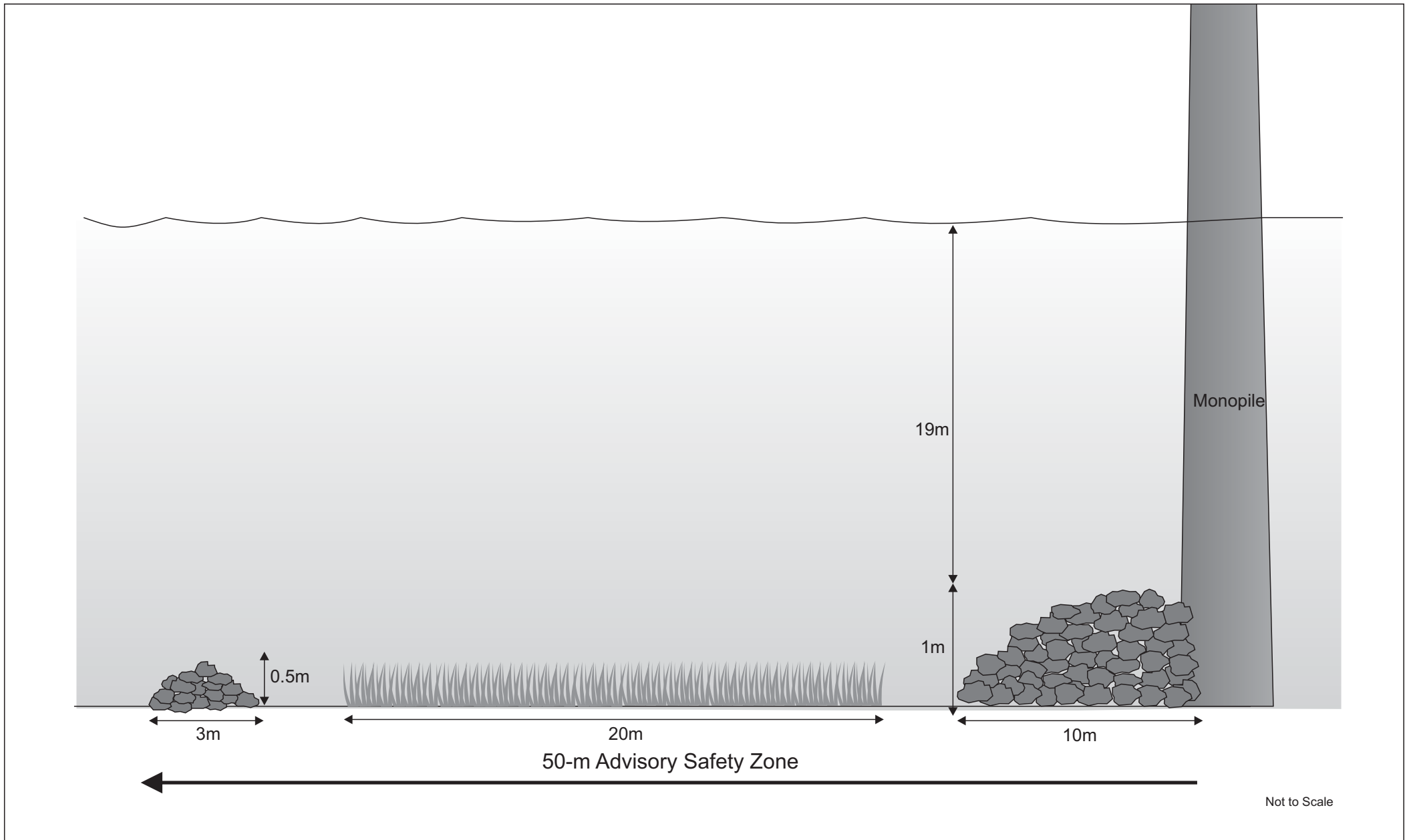


Figure 5.5

Cross-section C, Fisheries Enhancement AR inside Advisory Safety Zone

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DATE: 13/12/2013

Environmental
Resources
Management



The preferred option was developed on the basis of the key design principles presented above. The three main components of the preferred option are 1) scour protection alone, 2) scour protection with artificial reefs/enhancement inside the Advisory Safety Zone, and 3) artificial reefs outside the Advisory Safety Zone. The preliminary layout of the preferred AR option is presented in *Figure 5.1*. This preliminary AR layout is established based on the conceptual arrangement of turbines within the wind farm. As such, the AR layout should be reviewed when final arrangement of turbines is available.

Firstly, scour protection will be implemented around every turbine monopile. It is proposed that large quarry rock be placed around each monopile in a pyramid formation at approximately 1m in height. Exact volume and height of material placed will be determined by subsequent engineering. The objective of this component is to place material that acts as scour protection around the bases of each monopile while providing protected habitat for larger fish species (*Figure 5.1*).

Secondly, additional enhancement features will be added within the Advisory Safety Zones of monopiles. This enhancement design will be implemented as an experimental trial around one or two monopiles, and includes the placement of frond mats and low-relief AR structures within the Advisory Safety Zones around the monopile(s) in the shallowest portions of the array (ie northwest portion). This configuration was chosen as it may have the potential for the highest success of attracting juvenile fish. The low-relief structures are proposed to be made of either 1) smaller-diameter quarry rock, or 2) larger quarry rock. This latter design would be similar to what will be used around the monopiles but in a single layer so as to create low-relief reef that provides additional juvenile fish habitat (*Figures 5.1 and 5.5*). The quarry rock surrounding each monopile, as well as the additional enhancement described here, falls within the 50-m Advisory Safety Zone. This area will also serve as a Voluntary No-Take Zone and is restricted from fishing access.

The third component includes the placement of a number of fishable AR structures placed outside the Advisory Safety Zone (ie Voluntary No-Take Zone) among the enhanced monopile configurations in the northwest portion of the turbine array. These structures are proposed as a combination of pre-fabricated concrete units, high-relief quarry rock piles, and low-relief quarry rock piles, and are intended to interact with the other enhancement structures to provide fisheries connectivity while also providing fishable areas within the wind farm array (*Figures 5.1 – 5.4*). Placement will avoid existing cables with enough buffer that they will not be impacted by unanticipated scour effects or shifting of AR material. Similarly, these ARs will be placed far enough from turbine monopiles that work vessels requiring access to the monopiles will not be impeded. Water depth over each proposed AR will also provide sufficient draft for even large vessels travelling through the area.

It should be noted that the proposed preliminary design is subject to change during the detail design phase considering any further relevant data collected such as geophysical and geotechnical data. Where practicable, possibility of deploying ARs of higher profile or different height coverage shall be considered subject to consideration on key factors such as impact to marine safety, engineering design and cost effectiveness, etc.

5.2 *ARTIFICIAL REEF PROGRAMME MONITORING PLAN*

Following the ARs deployment, it would be necessary to determine the effectiveness of the ARs in enhancing fisheries resources of the wind farm area. The following four monitoring components are proposed under the AR Programme Monitoring Plan:

1. Fisheries Monitoring;
2. Ecological Monitoring;
3. Structural Monitoring; and
4. Socio-economic Monitoring.

The Artificial Reef Programme Monitoring Plan was submitted and accepted by the AFCD on 23 December 2013. Readers are referred to the Artificial Reef Programme Monitoring Plan ⁽¹⁾ for details regarding the methodology of the above monitoring components while their brief descriptions are presented below. The performance of the monitoring surveys would be reviewed regularly.

5.2.1 *Fisheries Monitoring*

Acoustic Fisheries Survey

The survey would involve the use of hydro-acoustic equipment and echo integration techniques to map fish distribution in survey areas before and after deployment of ARs. Although this type of sampling has not been conducted before in Hong Kong and thus no comparable historic data exists, studies have shown that this method has been successful in quantifying densities of demersal and pelagic fish ⁽²⁾ ⁽³⁾. As catch methods can provide information on species utilizing the area but may not accurately determine fish abundance, a combination of different techniques may be the best

- (1) ERM (2013) Artificial Reef Programme Monitoring Plan. Prepared for HKE under the Fisheries Review and Consultation Programme.
- (2) Loggerwell, E and Rand, K (2008) Beaufort Sea Marine Fish Monitoring 2008: Pilot Survey and Test Hypotheses. Final Report of NOAA NMFS, prepared for BOEMRE.
- (3) Emmerich, M, IP Helland, S BUSch, S Schiller and T Mehner (2010) Hydroacoustic estimates of fish in comparison with stratified pelagic trawl sampling in two deep, coregonid-dominated lakes. Fish Res 105: 178-186



approach to gain a true picture of fish stocks ⁽¹⁾. Thus, it is recommended to explore the feasibility of acoustic monitoring in the survey area which may provide critical supplemental information in determining whether the ARs are functioning to enhance resources, to aggregate them or to seed areas outside the wind farm or AR deployment area.

Juvenile Fisheries Resources

The findings of the EIA noted that the southern waters of Hong Kong had been identified as an area supporting spawning of commercial fisheries. Waters closer to the inshore areas were also noted as potentially supporting juvenile fish that then may seed into the wind farm array. It is thus recommended that, in order to quantify the production of juveniles in the area, ichthyoplankton trawls ⁽²⁾ should be undertaken for ichthyoplankton and zooplankton surveys, crustacean and fish post-larval surveys as well as diurnal/nocturnal sampling of juvenile fisheries resources at discrete depth within the windfarm array as well as outside the array in the surrounding area for comparison. This method has historically been used in the Hong Kong area and thus historic data for comparison is available. In particular, a study on fisheries resources and operations was conducted which compared several methods for fish catch in Hong Kong waters, including the area around south Lamma, and can be used for comparison to this study ⁽³⁾.

Catch Per Unit Effort (CPUE) Surveys

Surveys using hand line and cage traps are recommended to be conducted within the no-take areas around the ARs and along shores along the south Lamma coast for comparison. These surveys will provide information as to how the AR is enhancing fisheries resources in comparison with natural reef under fishing controls and under an open access system. Cage traps have been historically used in Hong Kong and data are available for comparison ⁽⁴⁾.

5.2.2 *Ecological Monitoring*

The following components would be recommended as an optional additional ecological monitoring programme for the ARs.

Soft Benthos Infaunal Assemblages

Many of the high value fish species in this area of Hong Kong feed on organisms associated with soft bottom sediments. The effect of AR deployment on the abundance of these prey items is likely to have

- (1) Kubecka, J, E Hohaurova, J Matena, J Peterka, US Amarasinghe, SA Bonar, J Hateley, P Hickley et al (2008) The true picture of a lake or reservoir fish stock: a review of needs and progress. *Fish Res* 96: 204-211
- (2) In accordance with Fisheries Protection Ordinance (Cap. 171), a research fishing permit shall be applied for conducting the ichthyoplankton trawl survey.
- (3) ERM (1998) Fisheries Resources and Fishing Operations in Hong Kong Waters. Report to AFCD, March 7, 1998.
- (4) ERM (1998) Ibid



consequences on the stocks of predator species (e.g. croakers). The results of this assessment should be compared with details gathered as part of the fisheries surveys to determine if there is a relationship between enhancement of infaunal organisms and enhancement of fisheries resources.

Hard Surface Epibenthic Assemblages

Monitoring of colonisation onto the reef structures is important to evaluate how effective the ARs are at providing food for juvenile fisheries resources and to compare the nature of the colonised assemblages with those on natural rocky reefs in Hong Kong. If a variety of structures are being used, comparisons can be made to determine the success of the different material at promoting colonisation by epifauna.

5.2.3 Structural Monitoring

Potential issues associated with the physical stability of ARs (such as reef subsidence and burial) are required to be assessed after the deployment of ARs through structural monitoring. Structural monitoring of ARs should be undertaken simultaneously with the hard surface epibenthic assemblages monitoring to determine any observable subsidence of the AR structures. During the monitoring, the height of the six types of AR (including the large quarry rock around the scour protection of the monopile, frond mat and low relief ARs within the Advisory Safety Zone, and the pre-fabricated concrete units, high-relief quarry rock piles, and low-relief quarry rock piles outside the Advisory Safety Zone) above the seabed should be measured at each survey station to provide qualitative information on any settlement of different types of ARs by comparing to the designed height. A total of 12 AR units should be measured, which should comprise duplicate measurements for each of the six types of AR. Photos will be taken for each of the AR units measured in order to show their general conditions.

5.2.4 Socio-Economic Monitoring

While economic returns will always be the main concern, people involved in fishing are also concerned about issues such as "sense of ownership", "perception of fairness in management" and "satisfaction with the AR system". These concepts are more difficult to measure than economic returns. Economic data on catch size and fishing effort can be gathered using interview questionnaires designed to be compatible with those currently in use by AFCD. These surveys should be carried out before and during implementation of ARs and monitoring programmes.

5.2.5 Monitoring Schedule

The above monitoring, except for structural monitoring and hard surface epibenthic assemblage monitoring, which only cover the post-deployment phase, will cover both the baseline (pre-deployment) and post-deployment



phases of the AR programme to monitor the AR performance and so that adaptive management practices can be identified and implemented to improve performance if needed. The tentative monitoring programme is presented in *Table 5.1* below.

After one year of post-deployment monitoring, the monitoring programme should be reviewed to determine whether any revisions can be made to the monitoring programme to improve its cost-effectiveness in evaluating the enhancement effects of the ARs. The review should also consider whether the whole monitoring programme should be continued based on an evaluation of the AR performance. Should the ARs be deemed effective in enhancing the fisheries resources, it may be considered suitable to reduce the monitoring frequency or dis-continue the monitoring programme.



Table 5.1 Tentative Monitoring Programme Before and After the Deployment of ARs

Monitoring	Survey components	Number of Survey Locations per Survey	Total Number of Samples per Survey	Monitoring Frequency	
				Baseline	Post Deployment
Fisheries Monitoring	Acoustic Fisheries Survey	12	12	Once per wet season and once per dry season. A total of two (2) monitoring surveys within 12 months prior to commencement of Project construction.	Quarterly Monitoring. A total of four (4) monitoring surveys after deployment of the ARs.
	Juvenile Fisheries Resource Survey				
	(i) Ichthyoplankton and Zooplankton Surveys	8	16	Once per wet season and once per dry season. A total of two (2) monitoring surveys within 12 months prior to commencement of Project construction.	Quarterly Monitoring. A total of four (4) monitoring surveys after deployment of the ARs.
	(ii) Crustacean and Fish Post-Larval Surveys	8	16	Once per wet season and once per dry season. A total of two (2) monitoring surveys within 12 months prior to commencement of Project construction.	Quarterly Monitoring. A total of four (4) monitoring surveys after deployment of the ARs.
	(iii) Diurnal / Nocturnal Sampling at discrete depth	3	48	Once per wet season and once per dry season. A total of two (2) monitoring surveys within 12 months prior to commencement of Project construction.	Once per wet season and once per dry season. A total of two (2) monitoring surveys after deployment of the ARs.
	CPUE Survey				
	(i) Cage Trapping Survey	12	48	Once per wet season and once per dry season. A total of two (2) monitoring surveys within 12 months prior to commencement of Project construction.	Quarterly Monitoring. A total of four (4) monitoring surveys after deployment of the ARs.
	(ii) Hand Lining Survey	12	Sampling by 5 fishers at each location	Once per wet season and once per dry season. A total of two (2) monitoring surveys within 12 months prior to commencement of Project construction.	Quarterly Monitoring. A total of four (4) monitoring surveys after deployment of the ARs.

Monitoring	Survey components	Number of Survey Locations per Survey	Total Number of Samples per Survey	Monitoring Frequency	
				Baseline	Post Deployment
Ecological Monitoring	Soft Benthos Infaunal Assemblage Survey	11	22	Once per wet season and once per dry season. A total of two (2) monitoring surveys within 12 months prior to commencement of Project construction.	Once per wet season and once per dry season. A total of two (2) monitoring surveys after deployment of the ARs.
	Hard Surface Epibenthic Assemblage Survey	9	90	Not applicable	Two (2) surveys, one at 6 months and one at 1 year after deployment of the ARs.
Structural Monitoring	Structural Monitoring Survey	6	12	Not applicable	Two (2) surveys, one at 6 months and one at 1 year after deployment of the ARs. To be conducted simultaneously with the Hard Surface Epibenthic Assemblages Survey.
Social-economic Monitoring	Social-economic Monitoring Survey	Not applicable	Not applicable	Two (2) surveys, one at 6 months and one at 1 year prior to commencement of Project construction.	Two (2) surveys, one at 6 months and one at 1 year after deployment of the ARs.

This document presents details on the proposed fisheries enhancement measures that HK Electric will be implemented as part of the Fisheries Enhancement Plan (FEP) in the Southwest Lamma Waters where the offshore wind farm is to be located.

The proposed fisheries enhancement measures, as endorsed by FRCC and AFCD previously, are primarily deployment of ARs. The AR options was to include high-relief structures around each of the monopiles within the Advisory Safety Zone (ASZ), providing both fishery habitat and scour protection; high- and low-relief structures made from boulders or materials of opportunity as well as pre-fabricated concrete units outside the ASZ; and a trial design incorporating all artificial reef material and placement of frond mats around 1 - 2 monopiles within the ASZ to determine if this combination of habitat types will produce higher abundance and biodiversity of fishes while providing connectivity of various life-stages. In order to allow for the best potential benefits of deploying ARs to be realised, it is recommended that the 50 m ASZ within which vessel access is not encouraged (ie including fishing vessels) also doubles as a Voluntary No-Take Zone. This would decrease the potential for disturbance from fishing activities too close to the ARs, with the aim of enhancing fisheries production. The preferred AR option and the concept of Voluntary No-Take Zone were agreed by the two Task Groups in February 2012 and eventually endorsed by the FRCC and AFCD in July 2012.

It should be noted that the proposed preliminary design of artificial reef is subjected to change. Where practicable, possibility of deploying ARs of higher profile and/or different height coverage shall be considered in view of the key factors, such as impact to marine safety, engineering design and cost effectiveness etc., to enhance AR habitat diversity.

In order to determine the effectiveness of the AR deployment in enhancing fisheries resources of the wind farm area, the following four monitoring components are proposed in the Artificial Reef Programme Monitoring Plan which is accepted by the AFCD on 23 December 2013:

1. Fisheries Monitoring;
2. Ecological Monitoring;
3. Structural Monitoring; and
4. Socio-economic Monitoring.

The above monitoring, except for structural monitoring and hard surface epibenthic assemblage monitoring, which only cover the post-deployment

phase, will cover both the baseline (pre-deployment) and post-deployment phases of the AR programme to monitor the AR performance and so that adaptive management practices can be identified and implemented to improve performance if needed.

It should be noted that this FEP is expected to be a living document that will be updated over time as the plan is implemented. There may in future be further Working Papers and Technical Notes that accompany this FEP if it is considered necessary.