環境保護署
Environmental Protection Department
The Government of the Hong Kong Special Administrative Region

Agreement No. CE 14/2012 (EP)

Provision of Compensatory Marine Park for Integrated Waste Management Facilities at an Artificial Island near Shek Kwu Chau – Investigation

Final Detailed Design of Marine Park

August 2018

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Final Detailed Design of Marine Park

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Summary:

This document presents the *Final Detailed Design of Marine Park* for the EPD consultancy (*Agreement No. CE 14/2012(EP))* Provision of Compensatory Marine Park for Integrated Waste Management Facilities at an Artificial Island near Shek Kwu Chau – Investigation.

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Approved by:

Craig A Reid
Partner

Revision	Description	By	Checked	Approved	Date
2	Final Detailed Design of Marine Park	CY	Var	CAR	14/8/18
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1 INTRODUCTION

The **Environmental Protection Department** (EPD) has commissioned **ERM-Hong Kong, Limited** (ERM) to undertake "**Agreement No. CE 14/2012 (EP) Provision of Compensatory Marine Park for Integrated Waste Management Facilities at an Artificial Island near Shek Kwu Chau – Investigation**". The Agreement commenced on 15 June 2015.

1.1 BACKGROUND TO THE STUDY

In December 2005, the Government published *A Policy Framework for the Management of Municipal Solid Waste in Hong Kong (2005-2014)* ("Policy Framework"), setting out policy tools and initiatives to be implemented for the sustainable management of municipal solid waste in Hong Kong. The Policy Framework suggested, amongst other measures, the implementation of the integrated waste management facilities (IWMF) to treat municipal solid waste so as to reduce landfill disposal and recover energy from waste.

In 2013, the Government having reviewed the action agenda outlined in the *Hong Kong Blueprint for Sustainable Use of Resources (2013 – 2022)* announced a comprehensive waste management strategy and the 10 years' action blueprint to tackle the imminent waste problem. Amongst others, the Government would develop modern facilities to treat municipal solid waste, including the IWMF.

The Environmental Impact Assessment (EIA) Report for the development of the IWMF Phase 1 (1) was completed in 2011 and subsequently approved by the Environmental Impact Assessment Ordinance (EIAO) authority on 17 January 2012 (Environmental Permit (EP): *EP-429/2012*, issued on 19 January 2012). Taking into account the EIA results, the overall spatial distribution of waste management facilities in Hong Kong, environmental factors and transport efficiency, the Government has chosen an artificial island near Shek Kwu Chau as the site for the IWMF Phase 1 for treating a total of 3,000 tonnes of municipal solid waste each day.

The EIA Report identified that the formation of the artificial island would require about 11.8 hectares of reclamation and construction of 4.1 hectares of breakwater which would lead to a permanent loss of 31 hectares of important marine habitat for Finless Porpoise (FP).

To mitigate the loss, the EIA Report recommended the project proponent to seek to designate a marine park with an area of at least 700 hectares in the waters between Soko Islands and Shek Kwu Chau, in accordance with the statutory process stipulated in the Marine Parks Ordinance with a schedule to tie in with the operation of the IWMF Phase 1 project. In addition to the

(1) AECOM (2011) Engineering Investigation and Environmental Studies for Integrated Waste Management Facilities Phase 1 – Feasibility Study, ENVIRONMENTAL IMPACT ASSESSMENT REPORT (Nov.2011).

compensatory marine park (MP) for FP, the EIA Report identified the deployment of artificial reefs (ARs) and the release of fish fry as potential enhancement measures for the marine habitats. In accordance with the *EP Condition 2.8*, the designation of the compensatory MP shall immediately follow the completion of the construction works of the IWMF Phase 1.

1.2 *PURPOSE & OBJECTIVES OF THE DETAILED DESIGN OF MARINE PARK*

In accordance with *Clause 5.18* of the Brief of this Agreement, this *Detailed Design of Marine Park* (the "Assignment") shall contain the proposed location and size of the proposed marine park, deployment of ARs, release of fish fry, management plan and construction programme along with the implementation programme for the designation of the MP in accordance with the statutory process stipulated in the Marine Parks Ordinance to tie in with the operation of IWMF Phase 1 project, for the submission of detailed design of marine park to the Director of Environmental Protection (DEP) in accordance with the EP condition of the IWMF Phase 1 project.

The specific objectives and tasks for the *Detailed Design of Marine Park* can be summarised as follows:

- Identify a suitable site within the Marine Park Study Area (MPSA) for the development of the compensatory MP;
- Derive the appropriate size and boundary of the compensatory MP in the MPSA by taking cognizance of all the information collated and reviewed in this Study, including but not limited to the pros and cons of integrating with the proposed Soko Islands Marine Park (SIMP), the opportunities and constraints of all existing and planned uses of the waters in the MPSA as well as the consideration of maximizing coverage of other significant or representative ecological resources in addition to FP;
- Identify, evaluate and design suitable operation and management plan, and enhancement measures (including deployment of ARs within the marine park and release of fish fry at the reefs) for the MP, and design and specify the associated ecological, fisheries and environmental monitoring and audit requirements necessary for the management of the MP and assessment on the effectiveness of the enhancement measures; and
- Prepare construction programme along with the implementation programme for the designation of the MP and recommended enhancement measures.

1.3 *STRUCTURE OF THE DETAILED DESIGN OF MARINE PARK*

Following this introductory section, the remainder of this *Detailed Design of Marine Park* is arranged as follows:

- *Section 2* describes the key considerations in deriving the proposed boundary for the compensatory MP and summarizes the constraints and opportunities within the MPSA. The proposed boundary of the compensatory MP is then developed in this section based on the key considerations, constraints and opportunities identified as well as the results from stakeholder consultation. The compensatory MP will be integrated with the proposed SIMP to form the proposed South Lantau Marine Park (SLMP);

- *Section 3* outlines the management plan and proposed enhancement measures for the proposed SLMP;

- *Section 4* presents the implementation schedule for the SLMP and enhancement measures; and

- *Section 5* summarises the findings and recommendations of this *Detailed Design of Marine Park*.

2 KEY CONSIDERATIONS OF THE MARINE PARK DESIGN

A set of key considerations were derived to form the basis for the marine park detailed design. The process for deriving the key considerations has involved a review of the following:

- Relevant findings / requirements from the EIA Study and EP of the IWMF Phase 1 project on this compensatory MP;
- Criteria adopted locally in Hong Kong and overseas on marine protected area (MPA) design;
- Published research and practical management experience in MPA; and
- Feedback from stakeholder consultation

As presented in the EIA Study (Register No.: AEIAR-163/2012) and subsequently carried forward as an EP (EP-429/2012) condition for the IWMF Phase 1 project development, the principal objective of the compensatory MP is to conserve the FP habitats between the waters of Shek Kwu Chau and Soko Islands as a mean to compensate for the habitat loss arising from the construction of the IWMF Phase 1 at an artificial island near Shek Kwu Chau. While the primary objective of the compensatory MP is to protect and conserve FP habitats, it is important to note that the proposed MP design should also consider to minimize any potential impact on existing marine users and will cater for ongoing use of the marine environment.

In connection to the above, six key considerations are scrutinized in delineating the boundary of the compensatory MP, including:

1. Importance of the FP Habitat - the principal objective of the compensatory MP is to protect and conserve FP habitats. As such, importance of the selected MP area as FP habitats is the first consideration in the derivation of marine park boundary. For this aspect, reference was made to the Porpoise Habitat Index (PHI), which is developed to rate and identify important FP habitats, in delineating the MP boundary;

2. Fisheries Resources - as FP and other marine organisms rely heavily on fish as food sources in marine ecosystems, fisheries resources is another key aspect that has been considered for the development of the MP design in order to achieve the conservation purpose of the compensatory MP.

3. Management and Enforcement – the design should ensure that the selected location of the MP can allow effective management and enforcement by different Government authorities under the Marine Parks Ordinance.

4. Size - a sizeable MP is essential in terms of self-sustaining and retention of marine fauna. It is also particularly important for the MP to conserve large predatory species which has a relatively larger range, including FP.

As such, size would be an important factor to consider and the compensatory MP should be at least 700 ha in size according to the requirements of the EIA Study and EP (*EP Condition 2.8(i)*) of the IWMF Phase 1 project;

5. Compatibility with Existing and Planned/ Potential Uses - while the primary objective of the MP is for conserving FP, it is acknowledged that the MP design should aim to minimize any potential impact on existing marine users and will cater for ongoing use of the marine environment. Thus, constraint mapping on marine traffic and existing and planned/ potential facilities/ developments within the MPSA have been adopted in deriving the MP boundary; and

6. Views of Stakeholders – first and second rounds of stakeholder consultation were conducted during May to November 2016 and April to November 2017, respectively, to consult stakeholders on the proposed boundary, management plan as well as artificial reef and fish restocking programmes of the compensatory MP. Views of stakeholders have been taken into consideration in finalising the above.

The above key considerations are not meant to be exhaustive but represent a foundation for delineating MP boundary *(Figure 2.1*). Details of each key consideration are presented *in Section 2.1 – 2.6*.

2.1 IMPORTANCE OF FP HABITAT - PORPOISE HABITAT INDEX (PHI)

According to the findings in the approved EIA Report [(1)], the proposed works area for the IWMF Phase 1 is of high ecological value as it is identified as an important habitat for FP. To minimize the impacts due to the loss of 31 ha of marine habitat of FP as a result of the reclamation and breakwater construction at the southwestern waters of Shek Kwu Chau, compensatory measure through establishment of a MP is therefore required. The principal objective of the compensatory MP is thus to encompass and conserve major FP habitats in order to mitigate the loss caused by the IWMF Phase 1 project.

For cetaceans, the most difficult aspect of creating good MPAs is to define and identify their critical habitats, which would serve as crucial information to set up core areas within an MPA for better management [(2)]. In general, critical habitat should be specifically linked with the concept of high-quality habitat, and this habitat should have the ability to provide necessary resources for the persistence of a species or population [(3)]. The critical habitats should be

(1) AECOM (2012) Agreement No. CE 29/2008 (EP) Engineering Investigation and Environmental Studies for Integrated Waste Management Facilities Phase 1 – Feasibility Study. Environmental Impact Assessment Report. Approved with conditions on 17 January 2012.

(2) Hoyt E (2005) Marine Protected Areas for Whales, Dolphins and Porpoises: A world handbook for cetacean habitat conservation. Earthscan, London and Washington, DC.

(3) Hall, L. S., Krausman, P. R. and Morrison ML (1997) The habitat concept and a plea for standard terminology. Wildlife Society Bulletin 25: 173-182.

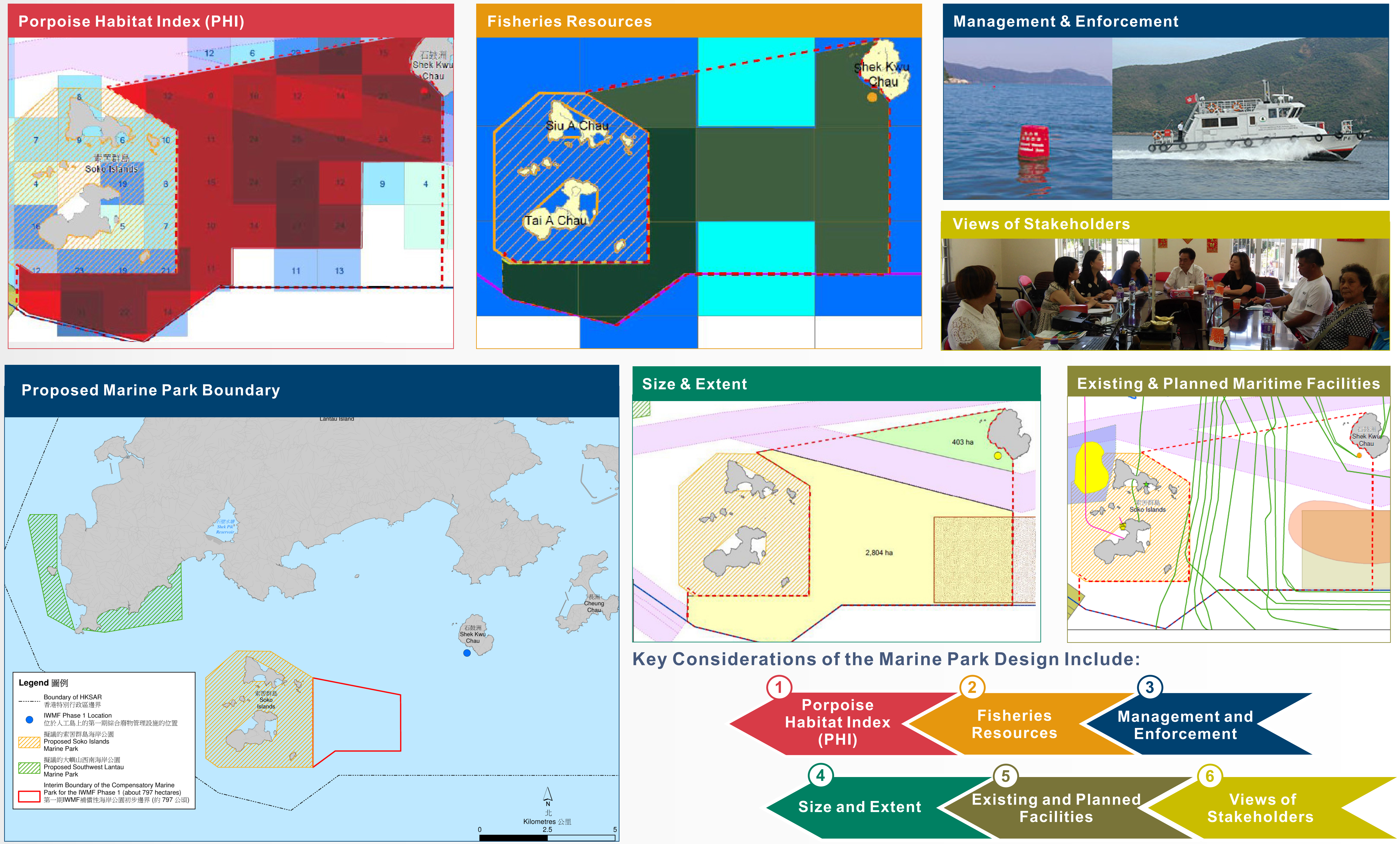

Figure 2.1

Key Considerations of the Marine Park Design

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assessed quantitatively whenever possible in order to ensure the efficacy of reserves that are specifically designed for protection of cetacean habitats [1].

To identify the critical habitat of FP and subsequently inform the MP design to include those habitats as much as practicable and possible, findings from AFCD's long-term marine mammal monitoring and other best available desktop information of marine mammal distribution in the MPSA were thoroughly reviewed under this Agreement. Key relevant findings for the derivation of the MP design are presented below.

2.1.1 *Establishing PHI to Delineate Compensatory Marine Park Boundary*

A habitat rating system for marine mammals has been established to locate the priority habitats of *Sousa chinensis* (a.k.a. Chinese White Dolphins) in Hong Kong [2], with an objective to set up MPAs for conserving their important habitats. Such system has also been applied to delineate the boundary for the recently designated The Brothers Marine Park (BMP) as a habitat compensation measure for the construction of the Hong Kong Boundary Crossing Facilities, and more recently for the proposed Southwest Lantau Marine Park (SWLMP) as well as Soko Islands Marine Park (SIMP).

This Assignment also adopted the same methodology to establish the habitat rating system by deducing a PHI, which in turn can be used to identify important FP habitats within the MPSA between Shek Kwu Chau and the Soko Islands and subsequently be considered for delineating the boundary of the compensatory MP. The approach to establish the porpoise habitat rating system is based on the site selection process proposed by Salm and Price (1995) [3], in which a number of selected criteria are scored, and the total scores are used to identify areas of importance to the FPs in South Lantau waters, where the MPSA is situated.

2.1.2 *Methodology to Establish Porpoise Habitat Index*

To develop the PHI, the adopted approach to utilize quantitative data on various aspects of FP habitat use was similar to the ones for establishing dolphin habitat index, but with a different set of scoring criteria due to several reasons.

FPs are very shy and elusive, and their calves and engaged activities are difficult to be observed at sea and identified consistently. In addition, photo-identification work cannot be conducted on FPs due to their lack of natural marking and elusive behaviour. Therefore, several criteria considered under the dolphin habitat index, including the sighting density (i.e. Porpoise Sighting per Survey Effort, SPSE) for feeding and socializing activities and

(1) Hoyt E (2005) *Op.cit*.

(2) Hung SKY (2008) Habitat use of Indo-Pacific humpback dolphins (*Sousa chinensis*) in Hong Kong. Ph.D dissertation. University of Hong Kong, Hong Kong, 266p.

(3) Salm RV and Price A (1995) Selection of marine protected areas. Marine Protected Areas: Principles and Techniques for Management. Chapman and Hall, London. Edited by Gubbay S: 15 -31.

porpoise density (i.e. Number of Porpoise per Survey Effort, DPSE) for young calves and individual core areas, cannot be used under the PHI.

Another important consideration when establishing the PHI was their distinct seasonal occurrence in Hong Kong. As a result, the criteria evaluated for their habitat use should be stratified into dry season (December-May) and wet season (June-November), which was commonly done in assessing FP habitat use in the past (1) (2) (3) (4).

After careful consideration of different options, a total of eight scoring criteria were derived to identify important FP habitats (*Figure 2.2*), which included:

- No. of on-effort porpoise sightings per 100 units of survey effort (SPSE) in the wet season (June-July);
- SPSE in the dry season (December-May);
- No. of porpoise from on-effort sightings per 100 units of survey effort (DPSE) in the wet season;
- No. of porpoise from on-effort sightings per 100 units of survey effort in the dry season;
- No. of years (maximum 10) with on-effort porpoise sightings made within the grid in the wet season;
- No. of years (maximum 10) with on-effort porpoise sightings made within the grid in the dry season;
- Mean group size of porpoises in the wet season; and
- Mean group size of porpoises in the dry season.

(1) Hung SKY (2005). Monitoring of finless porpoise (*Neophocaena phocaenoides*) in Hong Kong waters: final report (2003-05). An unpublished report submitted to the Agriculture, Fisheries and Conservation Department of Hong Kong SAR Government, 95 pp.

(2) Hung SKY (2008). *Op. cit.*

(3) Hung SKY (2014) Monitoring of Marine Mammals in Hong Kong waters – data collection: final report (2013-14). An unpublished report submitted to the Agriculture, Fisheries and Conservation Department of Hong Kong SAR Government, 231 pp.

(4) Hung SKY (2015) Monitoring of Marine Mammals in Hong Kong waters – data collection: final report (2014-15). An unpublished report submitted to the Agriculture, Fisheries and Conservation Department of Hong Kong SAR Government, 198 pp.

Figure 2.2 ***Eight Selection Criteria for Each 1 km² Grid in Assessment of Habitat Ratings for Finless Porpoises with Associated Total Scores***

Criteria\Score	1	2	3	4	5
1-2. SPSE (wet/dry season)	0.1-5.0	5.1-10.0	10.1-15.0	15.1-20.0	>20.0
3-4. DPSE (wet/dry season)	0.1-20.0	20.1-40.0	40.1-60.0	61.0-80.0	>80.0
5-6. Interannual (wet/dry season)	1	2	3-4	5-6	7-10
7-8. Mean Group Size (wet/dry season)	0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	>4.0

Total Score	Habitat Rating
1-5	Marginal
6-10	Average
11-15	Above Average
16-25	Important
26-40	Critical

Scoring criteria for each 1 km² grid

1-2. SPSE: No. of on-effort porpoise sightings per 100 units of survey effort during wet and dry seasons respectively

3-4. DPSE: No. of porpoises from on-effort sightings per 100 units of survey effort during wet and dry seasons respectively

5-6. Interannual: No. of years (maximum: 10) with on-effort porpoise sightings made within that grid during wet and dry seasons respectively

7-8. Mean Group Size: Mean group size of poproises during wet and dry seasons respectively

Each of the scoring criteria listed in *Figure 2.2* for the porpoise habitat rating systems was assessed amongst each 1-km² grid within South Lantau waters, and a score of 1 (least important) to 5 (very important) was given for each criterion to develop the PHI and assess the relative importance of each grid area to the FP.

After summing up the scores from the eight criteria, the habitat rating of each grid in South Lantau waters was assessed based on the total overall score, with the maximum total score of 40. For example, porpoise habitats were rated as "marginal" for grids with total scores of 5 or below as shown in *Figure 2.2*. The grids with total scores of 16-25 and 26-40 were rated as "important" and "critical" FP habitats, respectively.

2.1.3 *Habitat Ratings in MPSA*

The 10-year marine mammal data collected between 2005 and 2014 were adopted for deriving the habitat ratings (i.e. PHI) in MPSA as well as in South Lantau waters. After summing up the scores from each of the eight scoring criteria, porpoise habitat ratings were given to all 135 grids in South Lantau waters (*Figure 2.3*).

As shown in *Figure 2.3*, 45 grids out of the 135 grids rated as above average, critical and important habitats were clustered at the southern side of the Soko Islands and Shek Kwu Chau, between the Soko Islands and Shek Kwu Chau, and also between Shek Kwu Chau and Cheung Chau. Notably, most of these priority porpoise habitats (35 out of 45 grids) were within either the MPSA or the proposed SIMP.

Within the MPSA, 19 grids were identified as important and critical habitats for FPs (scores of 16 or above), and another 14 grids were identified as above average porpoise habitats (*Figure 2.3*). Nine grids were identified as either average or marginal porpoise habitat or with no habitat rating at all within the MPSA, which were mainly distributed at the southeastern corner of the MPSA (*Figure 2.3*).

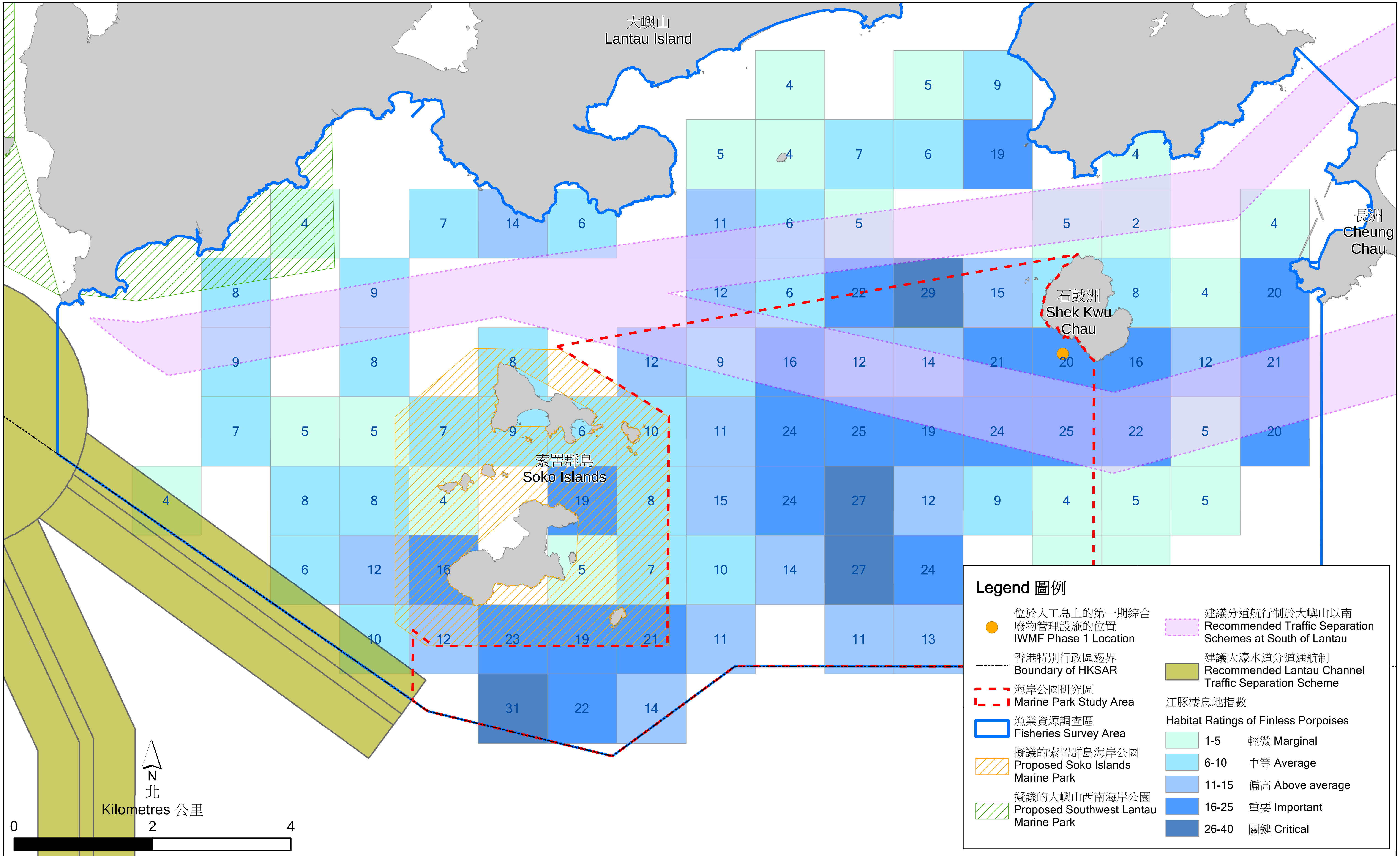

圖 2.3
Figure 2.3

Habitat ratings of finless porpoises in the South Lantau Waters between 2005 and 2014

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Based on the porpoise habitat ratings, this detailed design would aim at covering as many grids with PHI ≥ 11 (i.e. above average) as possible in delineating the boundary for the compensatory MP as these grids are rated as important habitat for conservation of FPs (i.e. with habitat rating of "above average or higher) (*Figure 2.3*).

2.2 FISHERIES RESOURCES

Besides the consideration of the PHI which reflects the importance of an area as FP habitat, it is also necessary to take fisheries resources into account when developing the MP design as FPs rely heavily on fish as food sources. In addition, permanent loss of 31 ha of fishing ground and 15.9 ha of previously identified fisheries spawning and nursery grounds are expected to arise due to the IWMF Phase 1 project. As such, in accordance with the approved EIA Report and *EP Conditions 2.8*, deployment of ARs and release of fish fry at the proposed ARs are required as enhancement measures for both FP habitats and fisheries resources.

The relevant information on fisheries characteristics and fisheries resources in the MPSA and its vicinity has been reviewed. In essence, sampan is the major fishing vessel operating in this water with high catch of scads and mullet. Pelagic, benthopelagic and demersal species commonly found in elsewhere in Hong Kong waters can be expected in waters within the MPSA. Overall, the water in MPSA and its vicinity is considered to support moderate to high level of fisheries production, particularly nearby Soko Islands. As depicted in *Figures 2.4 – 2.6*, the grids with high fisheries production and fishing operations in the MPSA are located adjacent to the east and south of Soko Islands (fisheries production of adult fish = 400 – 600 kg ha^{-1}; fishing operations = 100 – 400 vessels), followed by the grids to the south of Shek Kwu Chau and north of Siu A Chau (fisheries production of adult fish = 200 - 400 kg ha^{-1}; fishing operations = 100 – 400 vessels). The southern Lantau waters were identified as fish and crustacean spawning and nursery grounds (*Figure 2.7*). The spawning and nursery grounds extend from Fan Lau Kok all the way east pass Soko Islands and beyond to the eastern waters of Hong Kong. The MPSA is almost completely within the spawning and nursery grounds. However, fish fry production is generally low in the identified spawning /nursery grounds for commercial fisheries of the southern waters of Hong Kong (*Figure 2.5*).

In addition to the desktop review, fisheries resources surveys (see *Figure 2.8*) were undertaken from September 2015 to August 2016 under the current Assignment to provide the latest information on species composition, diversity, abundance, size, biomass, estimated commercial value, distribution of fish stock, significant fishing grounds, fish spawning grounds and sites of fisheries importance in the Fisheries Survey Area (FSA) (Southern waters from Fan Lau to west of Cheung Chau).

During the adult and juvenile surveys, a total of 118 species (45 families) and 42 species (22 families) were recorded, respectively. *Table 2.1* presents the

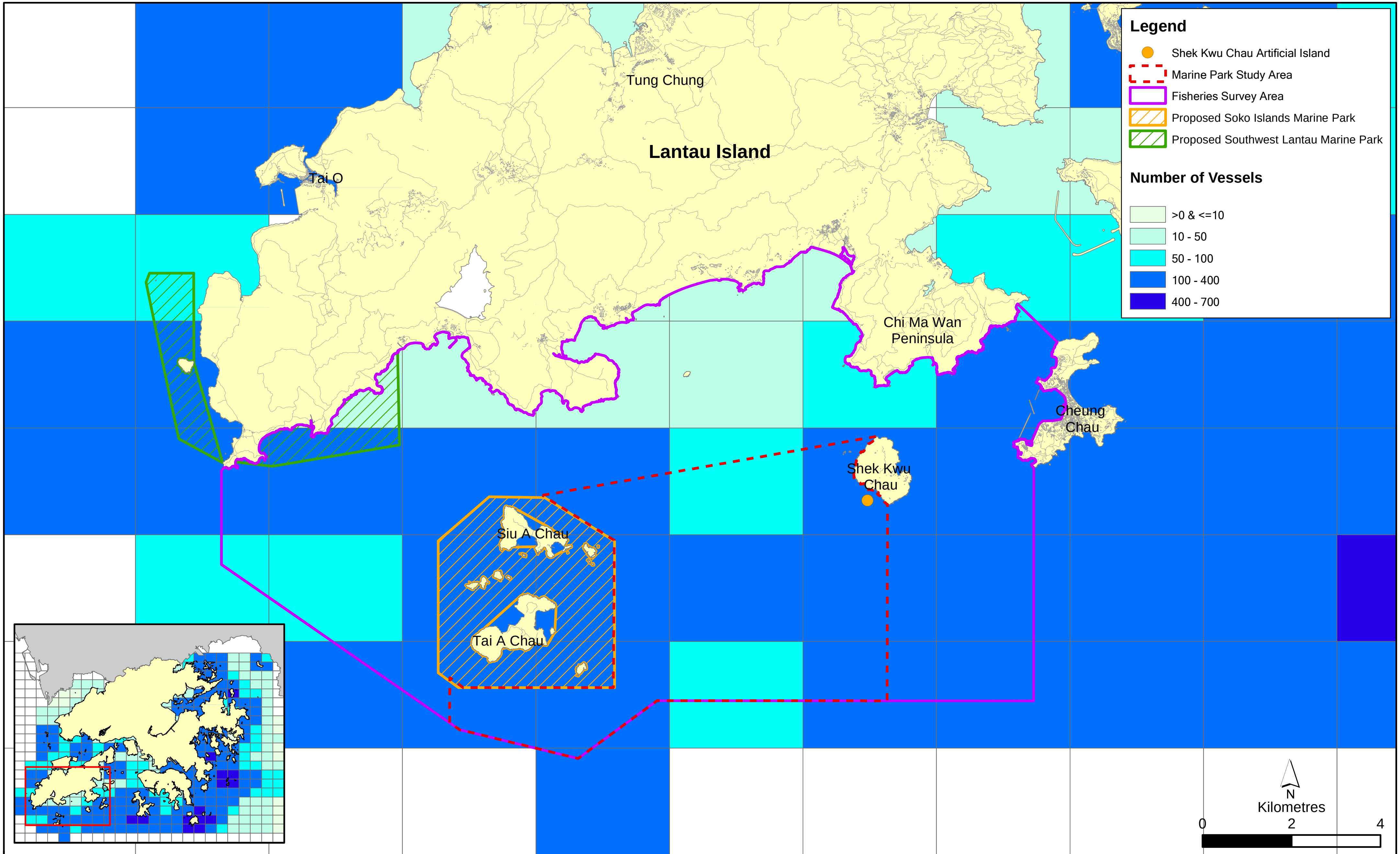

Figure 2.4

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

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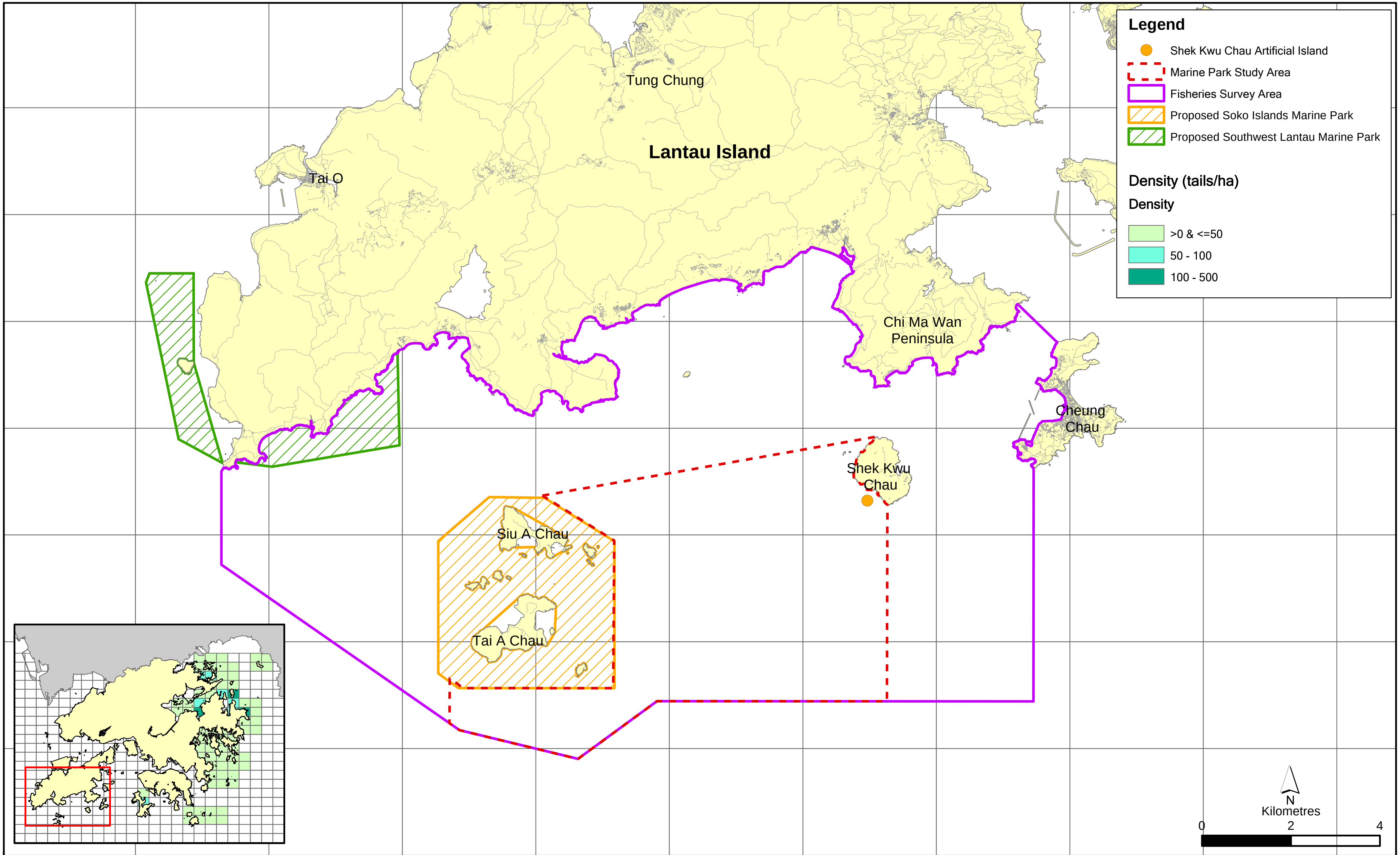

Figure 2.5

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

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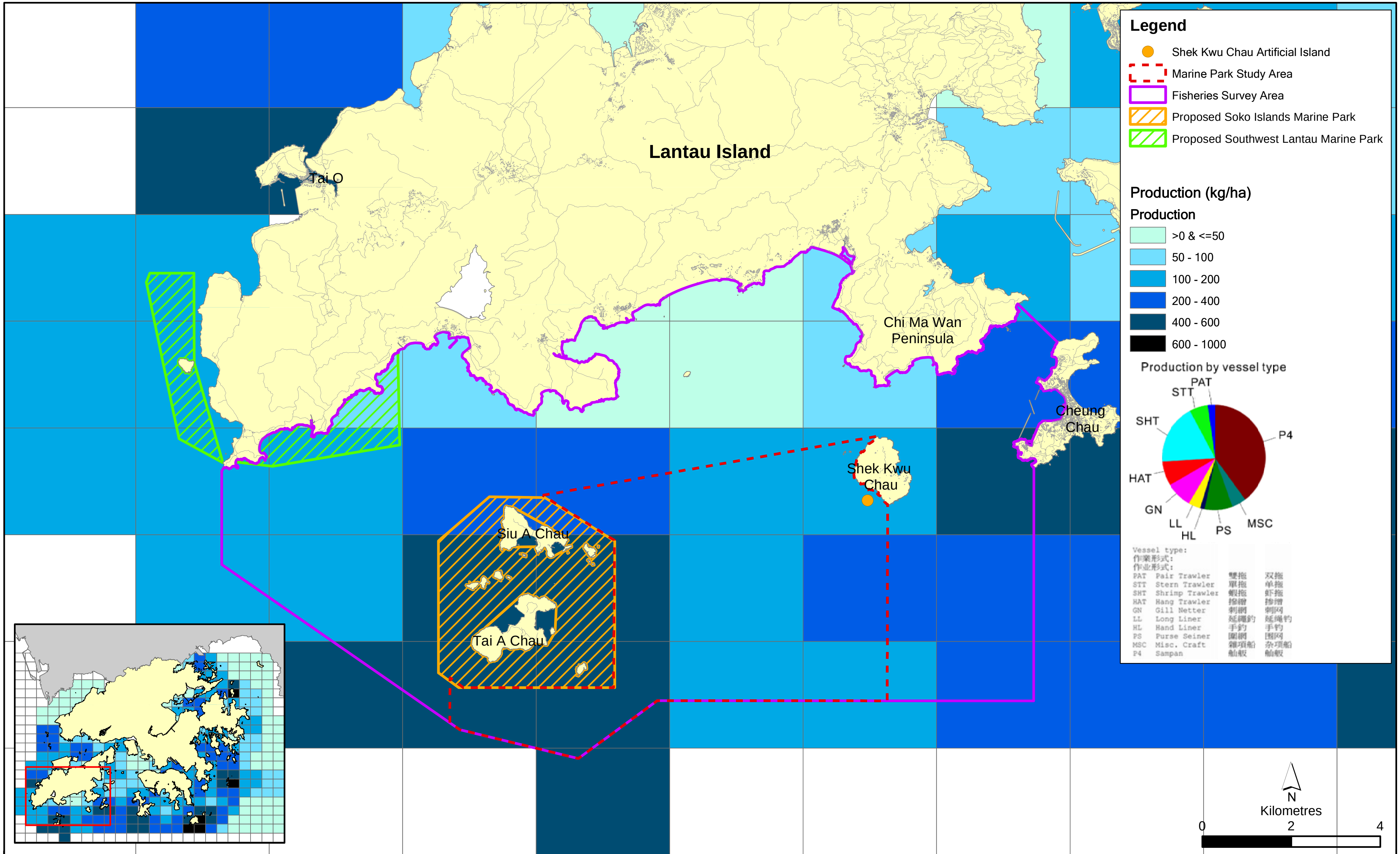

Figure 2.6

Distribution of Fishing Production (Adult Fish) in terms of Weight(kg/ha) in Hong Kong Water as recorded by Agriculture, Fisheries and Conservation Department in Port Survey 2006

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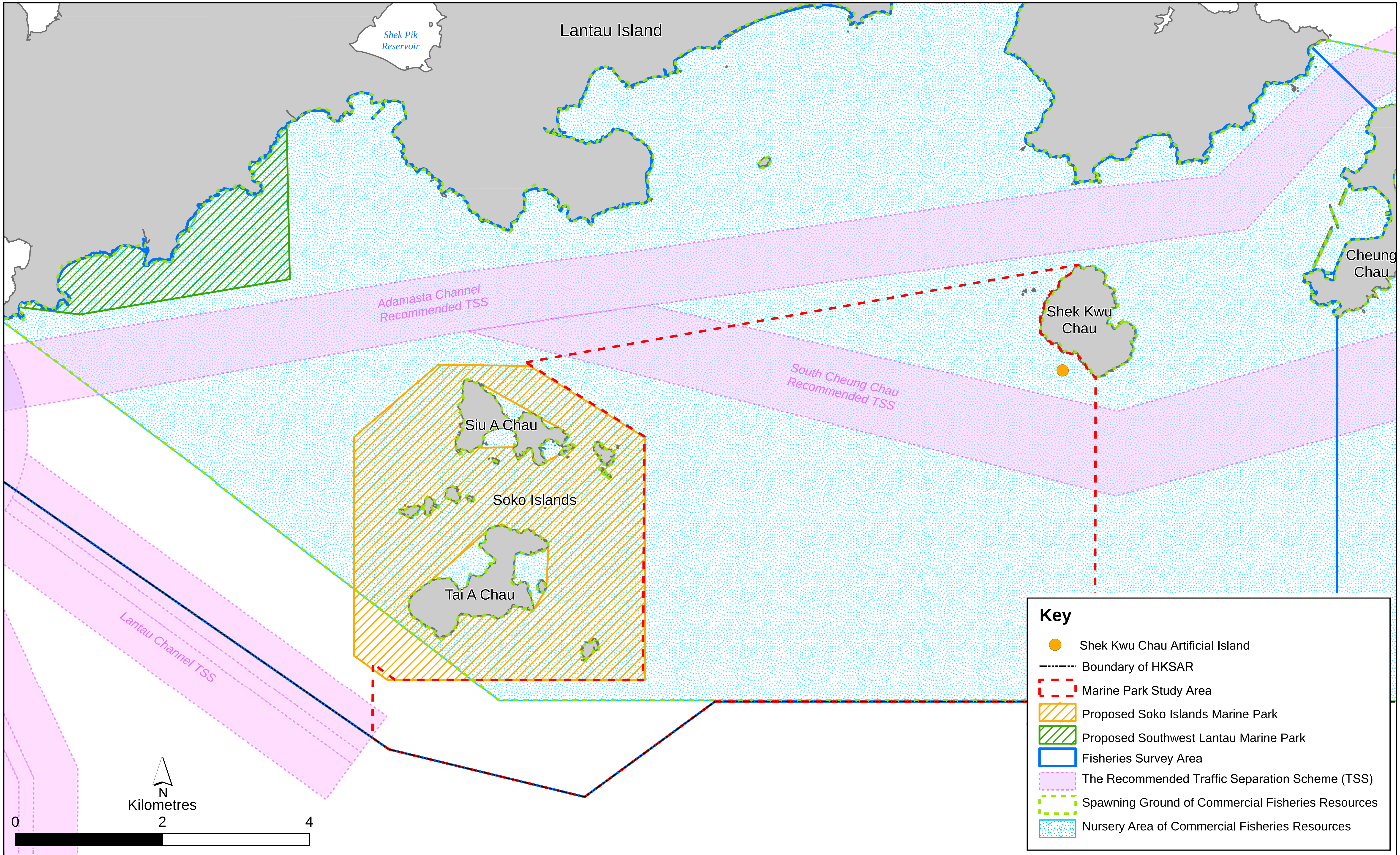

Figure 2.7

Spawning and Nursery Grounds

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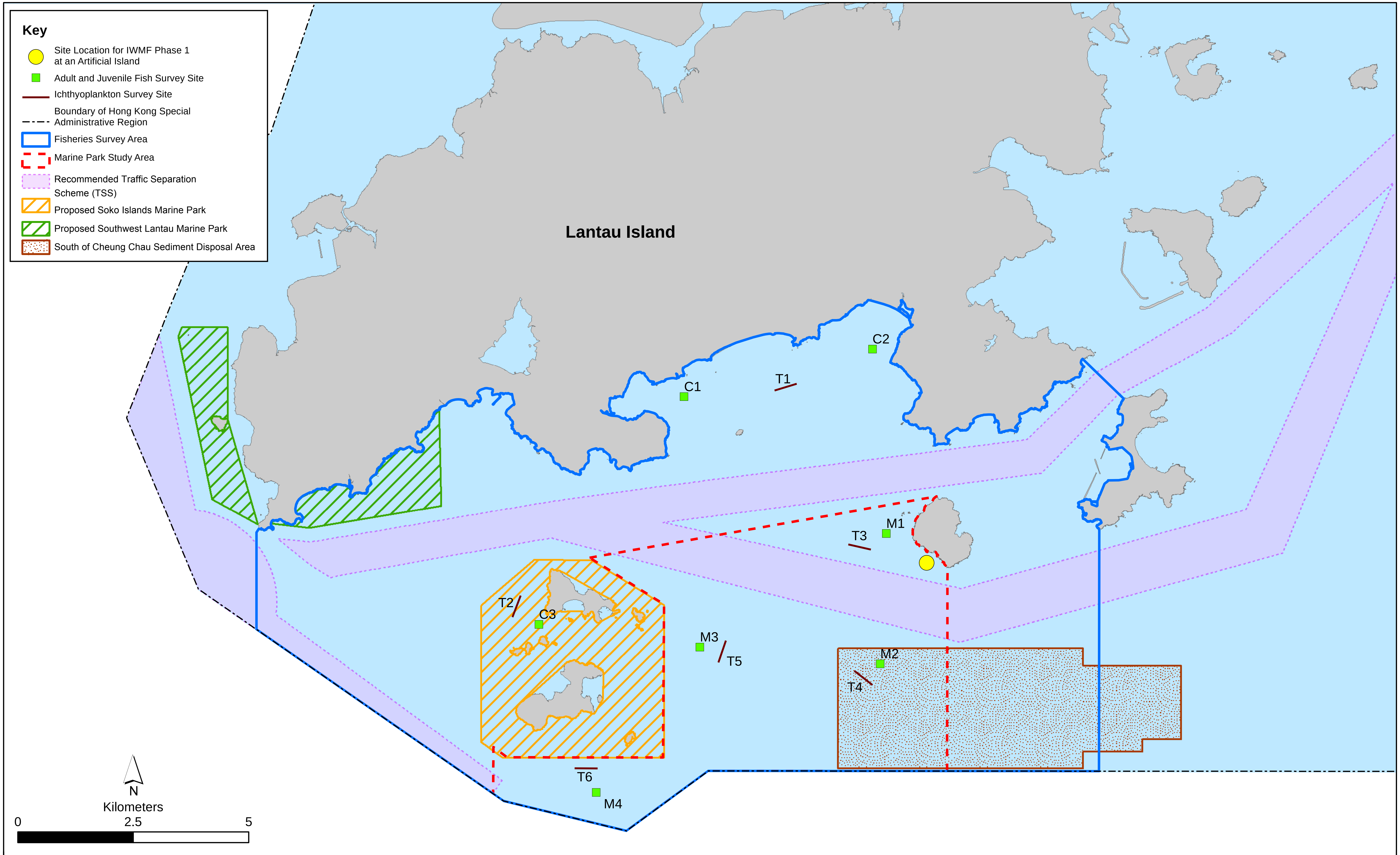

Figure 2.8

Survey Locations of Fisheries Resources Study

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dominant species recorded in terms of abundance and biomass. The dominant species recorded during the adult fish survey, in terms of abundance were *Sebastiscus marmoratus* (rockfish), *Evynnis cardinalis* (seabream), *Lagochephalus wheeleri* (pufferfish), *Epinephelus awoara* (grouper) and *Johnius trewavasae* (croaker). In terms of biomass, *Lagocephalus wheeleri* (pufferfish), *Pisdonophis cancrivorus* (snake-eel), *Gymnura japonica* (butterfly ray), *Muraenesox cinereus* (eel) and *Sebastiscus marmoratus* (rockfish) were the dominant species recorded during the adult fish surveys. The total biomass of fish recorded during the adult fish survey were similar in south Lantau water in all seasons. Higher abundance of fish were recorded in the waters south of Soko Islands and waters off the coast of Tong Fuk in the dry season, however, the abundance of fish recorded during other seasons (wet season and transitional seasons) were similar amongst sites.

The dominant fish species recorded in the juvenile fish survey, in terms of abundance, were *Thryssa mystax* and *Stolphorus commersonni* (anchovies), *Siganus fuscenscens* (rabbit fish), *Sardinella aurita* (sardine) and *Leiognathus brevieostris* (ponyfish) (*Table 2.1*). In terms of biomass, the dominant juvenile fish species included *Siganus fuscescens* (rabbit fish), *Sardinella aurita* (sardine), *Thryssa mystax* and *Stolephorus commersonnii* (anchovies) and *Nuchequula nuchalis* (ponyfish) (*Table 2.1*). During the juvenile fish survey, highest number of fish were recorded in the waters of Pui O (~8,800) and west of Shek Kwu Chau (~2,500) while the lowest number of fish was recorded near Siu A Chau (~50). The number of fish recorded during the wet season was much higher than that recorded in the dry season.

Table 2.1 Dominant Species Recorded in Adult and Juvenile Fish Surveys

	Family	Species	Abundance (number)	Family	Species	Biomass (kg)
Adult Fish Survey						
1	Sebastidae	*Sebastiscus marmoratus*	295	Tetraodontidae	*Lagocephalus wheeleri*	20.29
2	Sparidae	*Evynnis cardinalis*	282	Ophichthidae	*Pisodonophis cancrivorus*	19.54
3	Tetraodontidae	*Lagocephalus wheeleri*	166	Gymnuridae	*Gymnura japonica*	17.00
4	Serranidae	*Epinephelus awoara*	154	Muraenesocidae	*Muraenesox cinereus*	13.12
5	Sciaenidae	*Johnius trewavasae*	115	Sebastidae	*Sebastiscus marmoratus*	12.11
Juvenile Fish Survey						
1	Engraulidae	*Thryssa mystax*	8893	Siganidae	*Siganus fuscescens*	4.49
2	Siganidae	*Siganus fuscescens*	2189	Clupeidae	*Sardinella aurita*	4.32
3	Engraulidae	*Stolephorus commersonnii*	1070	Engraulidae	*Thryssa mystax*	3.04
4	Clupeidae	*Sardinella aurita*	805	Engraulidae	*Stolephorus commersonnii*	1.80
5	Leiognathidae	*Leiognathus brevirostris*	216	Leiognathidae	*Nuchequula nuchalis*	0.72

The survey results confirmed that the areas in South Lantau waters support a moderate diversity of fish species, and fisheries resources were generally similar within the FSA, except for the higher abundance of adult fish recorded during the dry season in the waters south of Soko Islands and waters off the coast of Tong Fuk and higher abundance of juvenile fish in waters off the coast of Pui O and west of Shek Kwu Chau. Therefore, the fisheries importance in terms of adult and juvenile fish is considered generally similar throughout the whole FSA, including the MPSA.

The fisheries resources surveys also confirmed the FSA, including the MPSA, as important fisheries spawning and nursery ground with Sparidae sp., *Acanthopagrus schlegelii, Solea ovata* and *Platycephalus indicus* recorded during the ichthyoplankton survey from September 2015 to August 2016. During the ichthyoplankton survey, a total of 69 species (32 families) of fish larvae and 39 species (21 families) of fish egg were recorded. The most dominant species of fish larvae and egg recorded are presented in *Table 2.2*. Abundance of fish larvae and egg in the FSA was much higher in the wet season than the dry season. The survey results showed that during the wet season the abundance of fish eggs and larvae were higher in the west of Shek Kwu Chau. This indicates that the west of Shek Kwu Chau is potentially an area of relatively higher importance as fisheries spawning and nursery grounds.

Table 2.2 ***Dominant Species Recorded in Ichthyoplankton Survey***

Fish Larvae		Fish Egg	
Species	**Mean abundance (individuals/ 1,000m³)**	**Species**	**Mean abundance (eggs/ 1,000m³)**
Engraulis japonicus	4,952.95	*Konosirus punctatus*	243,252.73
Gobiidae spp	886.59	Engraulidae sp.	19,693.99
Sardinella melanura	758.81	*Photopectoralis bindus*	12,321.06
Omobranchus punctatus	560.10	*Polydactylus sextarius*	9,396.42
Ambassis sp.	370.09	*Engraulis japonicus*	2,300.59

MPs could help protect fisheries resources as fishing activities within MPs are controlled under the Marine Parks Ordinance and its Regulation (Cap 476 & Cap 476A). As a result, MPs serve as shelter to harbour fish population and restore fisheries resources. Fish is also an important prey in FP's diet. As presented in *Figure 2.1*, the substantial overlap of FPs habitats and area with high fisheries production indicated FPs also relies on area of high fisheries production. Measures to protect and enhance fisheries resources would be beneficial to FP conservation in terms of habitat use and prey availability. Therefore, the MP boundary should aim to encompass areas with high fisheries production, namely the area to the east and to the south of Soko Islands as indicated in *Figure 2.1*. In addition, enhancement measures in relation to deployment of ARs and release of fish fry would enable the restoration and sustainable local use of these valuable fisheries resources. Results of the current fisheries resources survey have also been taken into consideration in delineating the MP boundary.

2.3 *MANAGEMENT & ENFORCEMENT*

The compensatory MP should be designed to facilitate compliance and enforcement which are critical for its success. Whenever possible, the boundaries should be easily manageable by the authorities to carry out patrol activities and readily recognizable by public.

AFCD will be the key government department responsible for the operation, management and law enforcement of the marine park after its designation under the Marine Parks Ordinance (Cap 476). Other departments, such as the Marine Department and the Marine Police will also be involved in enforcement within the areas under their respective jurisdictions. Considering the management and enforcement aspects, area to the south of Soko Islands is relatively remote and in close proximity to the Boundary of the HKSAR. This would induce enforcement challenges of the compensatory MP if the MP included that area. The area to the south of Soko Islands is thus not recommended to be included as part of the proposed boundary of the compensatory MP. On the contrary, by positioning the compensatory MP adjacent to the east of the proposed SIMP, the integrated MP management would optimize future management and enforcement of the marine parks through harmonized legislations between the two marine parks and sharing benefits/ infrastructures. Therefore, for the compensatory MP it is recommended to seek for integration of its layout with the proposed SIMP eastern boundary.

2.4 *SIZE & EXTENT OF THE COMPENSATORY MARINE PARK*

In accordance with *EP Condition 2.8(i)*, the proposed MP shall encompass at least 700 ha between the waters of Shek Kwu Chau and Soko Islands for the conservation of FPs. Based on the reviewed information and discussion in *Section 2.2* above, the area with relatively higher importance to FPs is located to the south of Shek Kwu Chau and this area is considered as the core area to draw up the proposed MP boundary. Although moderate FPs rating is also recorded to the west of Shek Kwu Chau, in that area there exists two recommended traffic separation schemes (TSS) (please also refer to *Section 2.5* below for more detailed discussion of the TSS). It would induce primary conflict with existing marine users if the proposed MP encroaches into these recommended TSS. In comparison to the Adamasta Channel Recommended TSS, the South of Cheung Chau Recommended TSS is not transited as frequently on a regular basis by fast ferries or other crafts, however, it serves as an alternative vessel route with approximately 3-5 daily transit by small crafts and a maximum of 5 daily transits by rivertrade vessels. Therefore, it is still considered necessary for the MP to avoid encroaching into the South of Cheung Chau Recommended TSS. To avoid overlapping with the TSS, waters to the west of Shek Kwu Chau, which encompass an area of 403 ha (*Figure 2.9*), cannot fulfill the size requirement stipulated in *EP Condition 2.8(i)* (i.e. at least 700 ha) if being designated as the compensatory MP. Waters to the west of Shek Kwu Chau will thus not be considered in the MP design. On the contrary, the remaining waters to the east of Soko Islands encompass an area of 2,804 ha, in which the South of Cheung Chau Sediment Disposal Area with an area of approximately 558 ha is located within the MPSA (*Figure 2.9*). By avoiding the area of the existing South of Cheung Chau Sediment Disposal Area, the remaining area of the MPSA adjacent to the east of Soko Islands is 2,246 ha which could provide adequate coverage of at least 700 ha for the compensatory MP to comply with *EP Condition 2.8(i)*.

Considering the above, it is recommended to locate the compensatory MP in waters to the east of Soko Islands. This is also in line with the recommended approach of positioning the compensatory MP adjacent to the east of the proposed SIMP as described in *Section 2.3* above for better integrated management of the compensatory MP and the SIMP. An additional benefit of this integration is that the ecological connectivity and linkage in marine resources in this water of Hong Kong can be maximized, which in turn protects a greater fraction of species by accommodating wider movement of different species. The combined design would provide an effective corridor and sufficient space for mobile species to propagate among the marine parks in an ecological context.

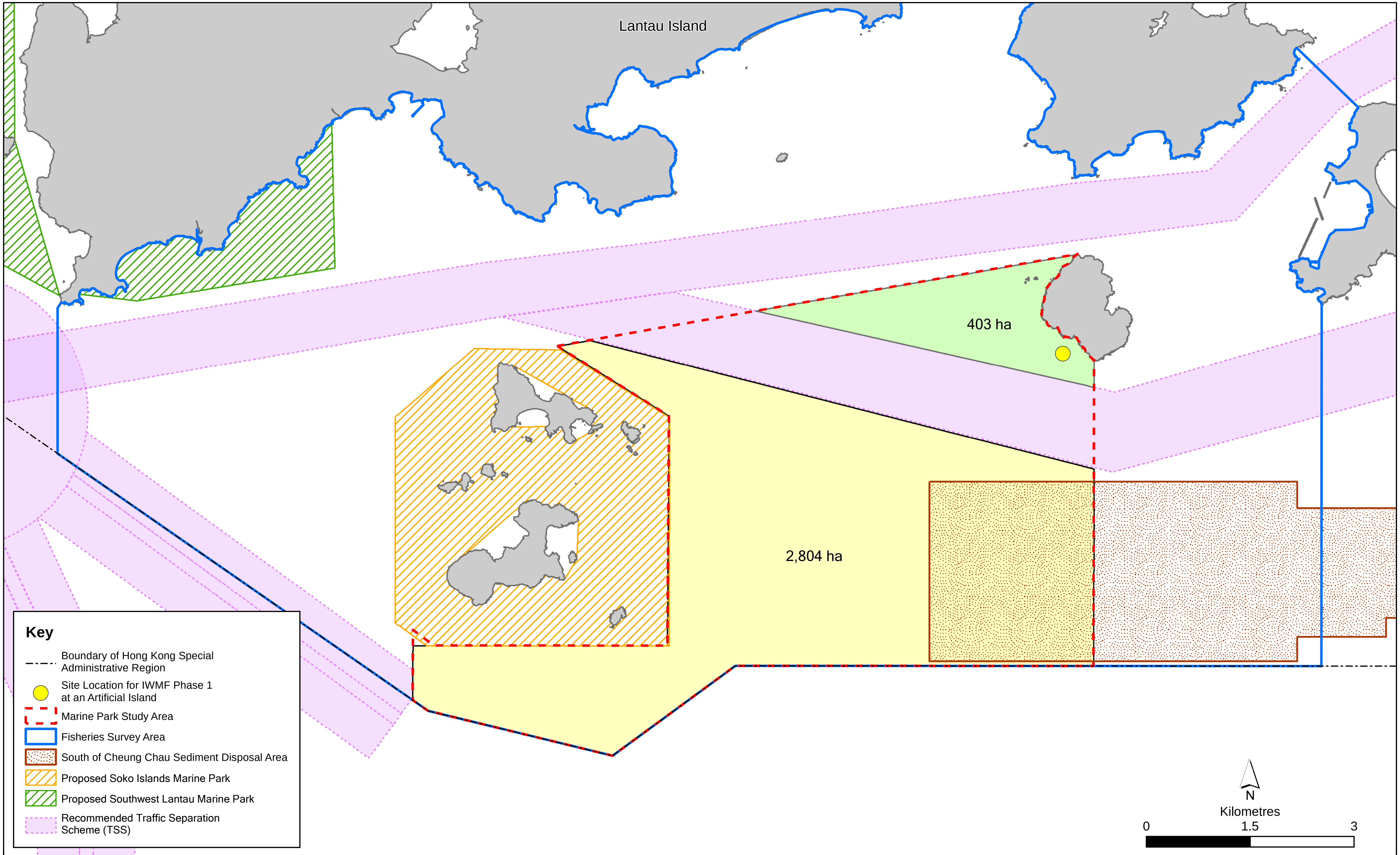

Figure 2.9

Key Consideration - Size and Extent

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2.5 *KEY MARINE TRAFFICS, EXISTING & PLANNED/ POTENTIAL MARINE FACILITIES/ DEVELOPMENTS*

One of the key considerations in the marine park design is to allow greater flexibility to create protected habitats that are large enough to protect viable ecosystems but that minimize impacts on marine users. To address this consideration, a Marine Traffic Impact Assessment (MTIA) has been carried out under this Agreement to characterize the marine traffic activities of the MPSA. Key results of MTIA are summarized below.

2.5.1 *Review of Existing and Planned/ Potential Marine Facilities/ Developments & Infrastructures*

Three traffic separation schemes and/or fairways run through the MPSA and its vicinity, namely Lantau Channel TSS, Adamasta Channel Recommended TSS and South of Cheung Chau Recommended TSS. In addition, there are three landings (IP021, IP022 and IP033) on Tai A Chau which are maintained by CEDD, however, these landings are seldom used with no regular passenger vessel services. Although the Shek Kwu Chau pier is located on the east side of the island, it is outside the MPSA and there are no other active piers, berths or landings within the MPSA.

Identified existing and planned/ potential marine facilities/ developments within MPSA and its vicinity are summarized in *Table 2.3* below and illustrated on *Figure 2.10*.

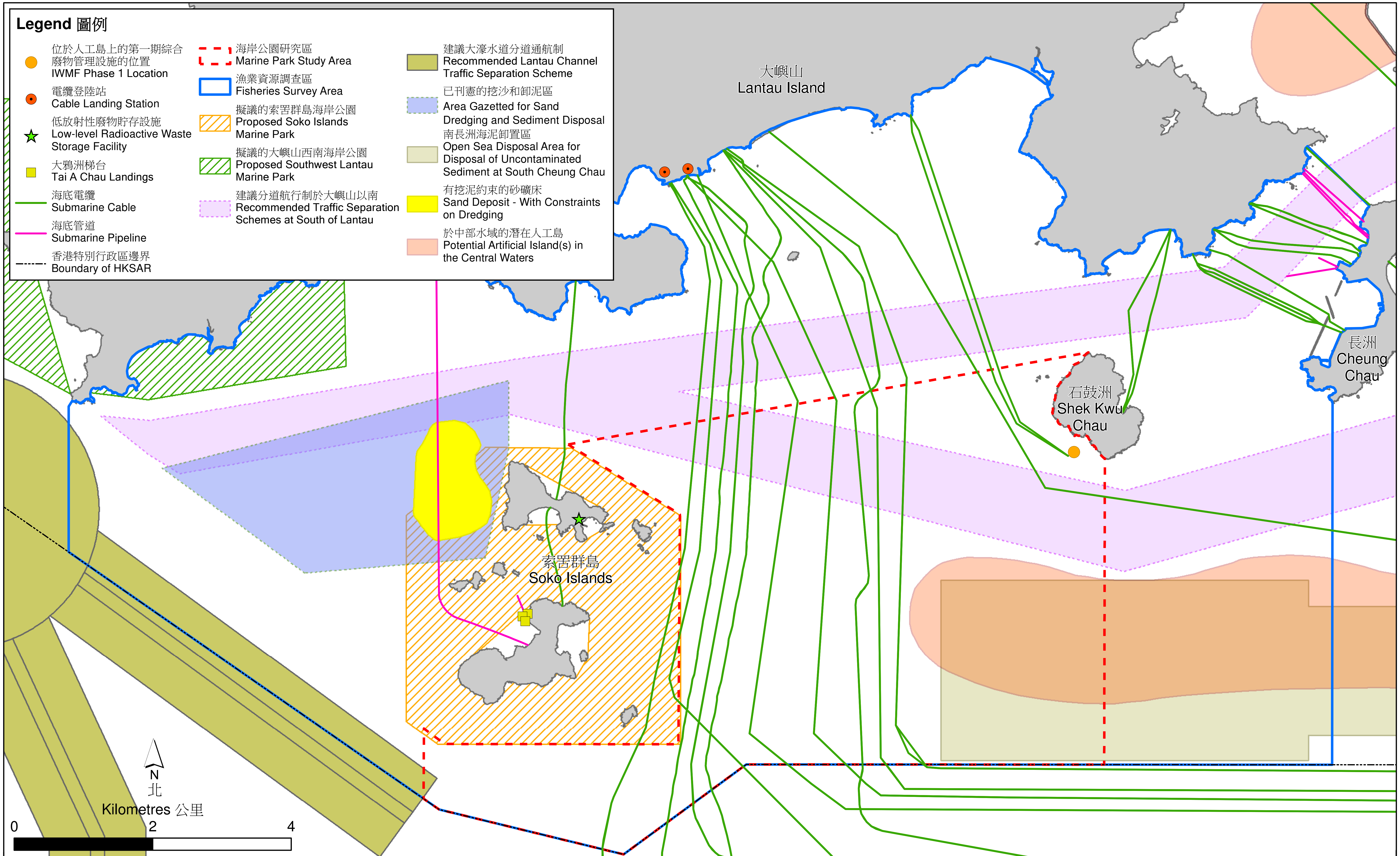

圖 2.10
Figure 2.10

Existing and Planned/ Potential Marine Facilities and Development Projects

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Table 2.3 *List of Existing and Planned/ Potential Marine Facilities/ Developments within the Marine Park Study Area and its Vicinity*

List of Marine Facilities/ Developments
TSS/ fairways
• Lantau Channel TSS,
• Adamasta Channel Recommended TSS
• South of Cheung Chau Recommended TSS
Piers/ berth
• Three landings (IP021, IP022 and IP033) on Tai A Chau
Assorted Marine Facilities/ Developments
• Shek Kwu Chau pier on the east side of the island but outside of the MPSA
• Open Sea Disposal Area for Disposal of Uncontaminated Sediment
• Potential Artificial Island(s) in the Central Waters to be studied by CEDD [(a)]
• Vessels operated by Low-level Radioactive Waste Storage Facility on Siu A Chau
• Submarine Cables and Pipelines
• Shek Kwu Chau Integrated Waste Treatment Facility (IWMF) Phase 1 and associated vessels

*Note:
Planned/ potential marine facilities/ developments are shaded in grey color.
(a) The central waters of Hong Kong (waters between Lantau and Hong Kong Island) has been identified as having good opportunity for artificial islands by Enhancing Land Supply Strategy. The number and the location of artificial islands are subject to further studies.

2.5.2 *Marine Traffic Visual Survey & Analyses of Automatic Identification System (AIS) & Radar Data*

To characterize the marine traffic activities in the MPSA, a one-month visual survey campaign has been conducted along with the analyses of Automatic Identification System (AIS) and Radar data as part of the MTIA.

The Visual Survey was carried out at the Treatment and Rehabilitation Centre on Shek Kwu Chau where there is a suitable location for the installation of the survey cameras and provides the necessary views of the MPSA. The Visual Survey for vessel activities during daylight hours (7a.m to 7p.m.) was conducted at two viewpoints: (1) North Viewpoint to marine traffic within the Adamasta Channel Recommended TSS along the northern edge of the MPSA; and, (2) Southwest Viewpoint to capture marine traffic within the MPSA between Shek Kwu Chau and the Soko Islands.

Visual Survey Results

From the North Viewpoint, an average of 23 transits per hour was identified, with an average total of 271 transits during daylight hours. This is considered to be a moderate level of activity for Hong Kong waters, tightly constrained within the Adamasta Channel Recommended TSS. Vessel movements are dominated by Fast Ferries (78%), followed by Fishing Vessels (14%). Leisure Vessels (3%), Fast Launches (2%), Rivertrade Vessels (2%) and Tugs (1%) were also identified.

From Southwest Viewpoint, an average of two (2) transits per hour was identified, with an average total of 28 transits during daylight hours. This is considered to be a very low level of activity for Hong Kong waters. Vessel movements are dominated by Fishing Vessels/ Small Crafts (80%), followed by Rivertrade Vessels (11%). Leisure Vessels (5%), Fast Launches (3%) and Dangerous Goods Vessels (1%) were also identified.

AIS & Radar Data Analyses

A significant resource was made available with Marine Department's provision of one month of 24-hour AIS and Radar data, at 30 second intervals in October 2015. Vessel characteristics such as timing, position, speed, heading, approximate length and beam of all vessels within the MPSA can be extracted from these data.

Based on the AIS and Radar data, vessel traffic density distributions were calculated and illustrated in *Figure 2.11*, which shows the average number of vessel transits that passed through each grid square per day. Outside of the MPSA to the north, the high traffic density along the Adamasta Channel Recommended TSS can clearly be identified, with some grid squares having up to 150 transits per day.

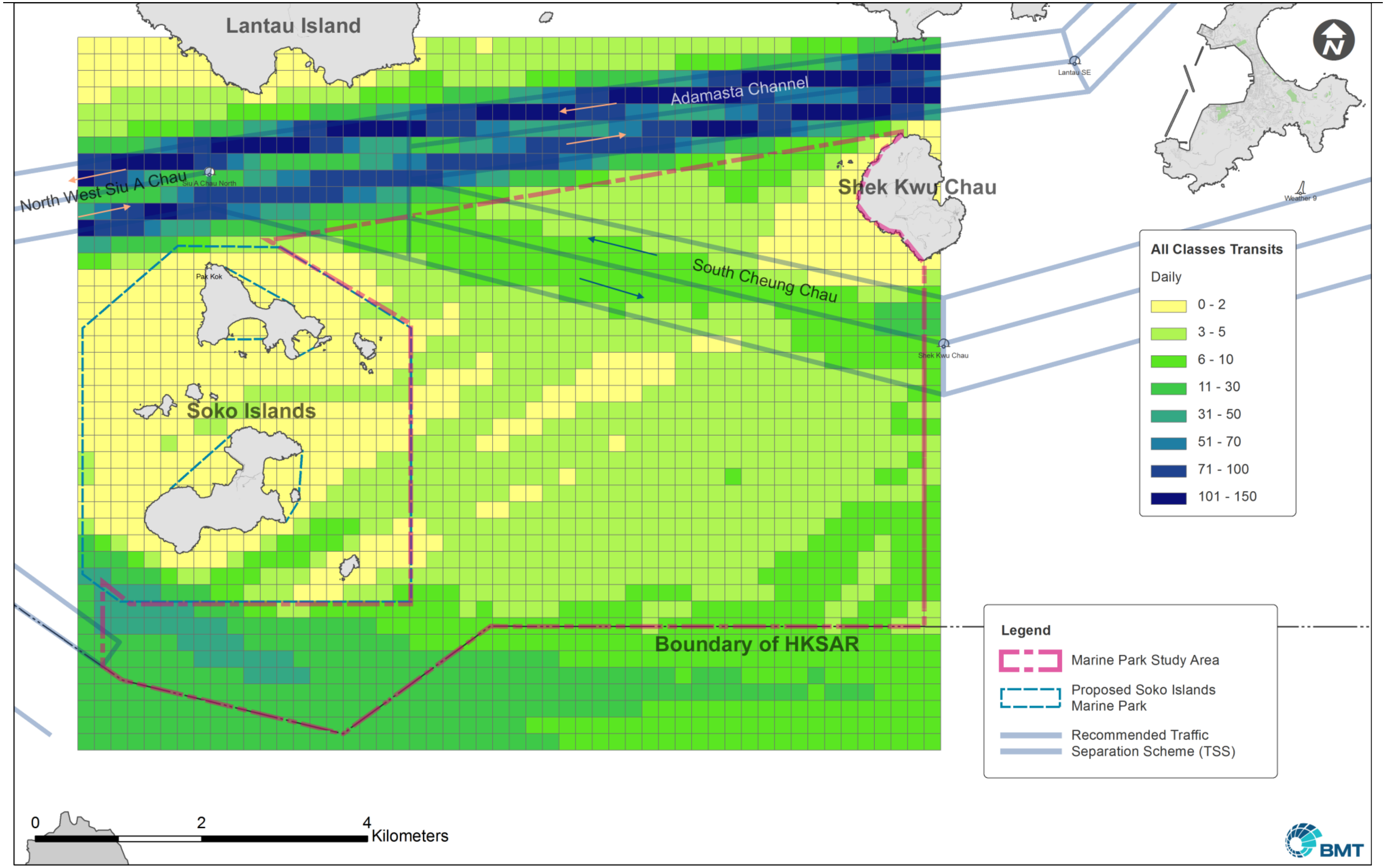
The South of Cheung Chau Recommended TSS had a slightly higher density of marine traffic with many grid squares experiencing 6-10 transits per day when compared to area outside the TSS. However, this density itself is not considered to be of high marine traffic activity.

Within the MPSA itself, *Figure 2.11* shows that the majority of the MPSA experiences a very low level of marine traffic with most grid squares having an average of 5 or less transits per day which may suggest that the establishment of compensatory MP within MPSA would have limited impact to the existing vessel operators. The area with the highest traffic density within the MPSA is in the southwestern corner with many grid squares experiencing from 11-30 and up to 50 transits per day. This is a relatively moderate level of marine traffic density in Hong Kong waters. This finding further supports the recommendation in *Section 2.3* that area to the south of Soko Islands should be avoided in delineating the boundary of the compensatory MP to ensure navigational safety and facilitate marine park enforcement.

2.5.3 Corridor for Unrestricted Passage

Even though marine traffic density in the central part of the MPSA, including the South of Cheung Chau TSS, and therefore the number of potential marine users, is relatively low, not leaving buffers between the marine park and the TSS will mean that the operation of a small percentage of marine users may be impacted. Thus, to further minimize the potential operational impacts to marine users, it is recommended that consideration should be given to an option where the marine park does not take up all of the potential area and buffer zones are maintained around the marine park open for the unrestricted passage of vessels. The rationale for deriving the proposed buffer distance is elaborated below.

Figure 2.11 Vessel Traffic Density for All Classes (Average Transits per Day)



Ship Domain Theory was applied for estimation of buffer distance in this Study. Based on the findings from Visual Survey and analyses of AIS and Radar data, rivertrade vessels are expected to be the largest vessels regularly transiting at low density within the MPSA, and thus the principal characteristics of the Rivertrade vessel with Length Overall (LOA) 90 m is adopted as design ship for the assessment. By adopting the guideline of a two-way channel for an open waterway, a buffer distance of at least **603m** is recommended for unrestricted passage of local vessels around the compensatory MP.

2.5.4 *Constraints and Opportunities from the Marine Traffic Perspective*

The MTIA suggested that the area within the MPSA, in particular waters to the east of Soko Islands, is a relatively quiet water space with a low level of traffic activity dominated by small crafts (e.g. fishing vessel). The findings supported that the waters adjacent to the east of Soko Islands is subject to relatively less marine traffic activities in comparison with the remaining waters of the MPSA. Areas with significant traffic streams are located to the north of the MPSA, with cross-boundary Fast Ferries in the Adamasta Channel, and to the southwestern corner of the MPSA, with Oceangoing, Rivertrade and Tug and Tow transits.

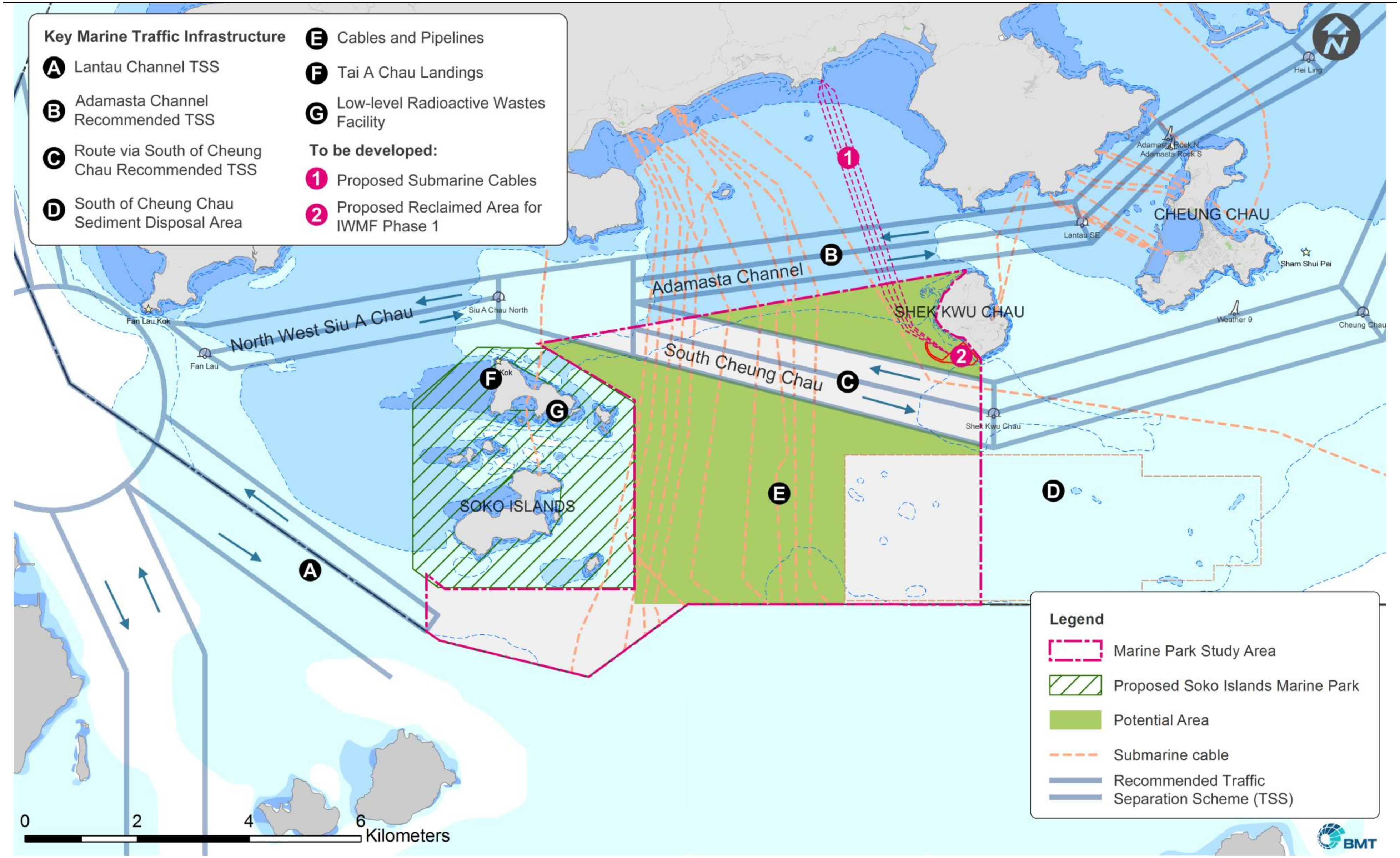
With due considerations of the marine facilities and marine traffic activities presented above, two potential areas are identified where the compensatory MP could be in place, these include waters to the west of Shek Kwu Chau and waters to the east of Soko Islands (*Figure 2.12*). As discussed in *Section 2.4*, waters to the west of Shek Kwu Chau, which encompass an area of 403 ha (*Figure 2.9*), cannot fulfill the size requirement stipulated in *EP Condition 2.8(i)* (i.e. at least 700 ha). By avoiding the area of the existing South of Cheung Chau Sediment Disposal Area, the remaining area of the MPSA adjacent to the east of Soko Islands could provide adequate coverage of the compensatory MP. Consideration should also be given to the proposed buffer distance in order to provide an unrestricted vessel passage around the compensatory MP.

The aforementioned considerations from the marine traffic perspective, in particular the provision of a buffer distance between the compensatory MP and the TSS for unrestricted passage, could help alleviate the potential concern from marine users in terms of conflicting use among marine operators in this waters of Hong Kong.

2.6 VIEWS OF STAKEHOLDERS

The first and second rounds of stakeholder consultation were carried out between May and November 2016 as well as April and November 2017, respectively, to gauge stakeholders' view, including fishery sector, on the design of the compensatory MP and fisheries enhancement measures. The first round stakeholder consultation mainly focused on collecting stakeholders' view on the extent and boundary of the compensatory MP, while the focus of the second round stakeholder consultation was on the

Figure 2.12 Potential Areas for the Establishment of MP within MPSA



management plan and fisheries enhancement measures of the compensatory MP. During the two rounds of stakeholder consultation, a total of 31 briefing sessions and consultation meetings were arranged with stakeholders from the fishery sector, relevant rural committees, district council and advisory committees, green groups etc.. Majority of the briefing sessions and consultation meetings were conducted with relevant fishermen from the fishery sector, including fishermen from Cheung Chau, Aberdeen, Castle Peak Bay, Mui Wo, Peng Chau, Ma Wan, Tai O and Tung Chung homeports. Stakeholders expressed no objections on the proposed boundary of the compensatory MP. However, Marine Parks Committee (MPC) suggested exploring the potentials to extend the northern, eastern and southern boundary towards the Traffic Separation Schemes / South Cheung Chau Sediment Disposal Area to increase the coverage of important FP habitats. On the other hand, marine operators have expressed concerns of the possible risk imposed by the compensatory MP as the proposed MP boundary is close to the recommended Traffic Separation Scheme at South of Lantau, and reduction of area available for fisheries operation may impose risk on marine traffic. Marine operators also expressed their views on possible hazards caused by the boundary buoys of the MP, which were however considered essential for effective management of the MP as raised by other stakeholders (e.g. green groups, fishermen).

Stakeholders also expressed concerns on the effectiveness of management and enforcement in the compensatory MP. Green groups requested a clear demarcation of the MP boundary to allow conducive management and enforcement of the MP. Most stakeholders were concerned about illegal fishing activities and effectiveness of MP patrol and enforcement. In addition, the fisheries sector, Rural Committees and Islands District Council requested the improvement of the current MP fishing permit system, for example, to allow permits to be granted to all fishermen who own a local fishing vessel registered under the Cap 171. However, green groups were worried about conflict of fishing operation in MP and conservation. In addition, they suggested to consider the provision of core area within the compensatory MP to increase the effectiveness of the marine park. Other major comments include the effectiveness of artificial reef deployment and restocking of fish fry as enhancement measures. Green groups and Marine Park Committee concerned about possible ecological imbalance caused by the release of proposed fish species of restocking.

The cable operators concerned about the application procedures and requirements as well as the time required to obtain all the necessary approvals / permits from the relevant government departments / authorities for carrying out repair / maintenance works for the existing submarine cable systems and installation works for new submarine cable systems within or in the vicinity of the proposed compensatory MP. The above comments were taken in account for in the final design.

2.7 *CONSTRAINTS & OPPORTUNITIES WITHIN THE MARINE PARK STUDY AREA*

Further to the review of the best available information and the discussion in *Section 2.1 – 2.6*, a list of constraints and opportunities are summarized in *Table 2.4* and depicted on *Figure 2.1*.

Table 2.4 List of Constraints and Opportunities within the Marine Park Study Area and its Vicinity

Aspect	**Description**
Marine Ecological Resources	The primary objective of the compensatory MP is to conserve the habitat of FPs. Based on the habitat rating, important habitat for FPs is identified in the waters to the east and south of the Soko Islands. The boundary of compensatory MP would aim at covering as many grids with PHI ≥ 11 as possible.
Fisheries Resources	The MPSA is identified as an important spawning and nursery grounds with moderate to high level of fisheries production, particularly to the east and south of Soko Islands, and to the south of Shek Kwu Chau to a lesser extent. The Fisheries Resources Survey indicated the west of Shek Kwu Chau as an area of potentially relatively higher importance as fisheries spawning and nursery ground, but these waters cannot be included in the marine park due the limitation of the TSS. Therefore, the MP boundary would aim to encompass area with high fisheries production, namely area to the east and to the south of Soko Islands.
Management & Enforcement	Considering the challenges in law enforcement, area of south Soko Islands was not recommended in the compensatory MP. By positioning the compensatory MP adjacent to the east of the proposed SIMP, the integrated marine park management would optimize future management and enforcement of the MPs.
Size and Extent	In accordance with *EP Condition 2.8*, at least 700 ha in the waters between Shek Kwu Chau and Soko Islands shall be designated as a compensatory MP. Within the MPSA, waters to the west of Shek Kwu Island could not fulfill this requirement due to the presence of TSS, thus the MP boundary will be delineated in the remaining waters of the MPSA.
Marine Traffic Activity, Existing and Planned/ Potential Marine Facilities/ Developments	Three major TSSs identified in the MPSA and its vicinity, namely Lantau Channel TSS, Adamasta Channel Recommended TSS and South of Cheung Chau Recommended TSS. Marine facilities/ developments overlapping with the MPSA are Open Sea Disposal Area at South Cheung Chau, potential artificial island(s) in the central waters to be studied by CEDD, submarine cables and IWMF Phase 1 at Shek Kwu Chau. To maintain a balance between conservation and use of marine environment, the boundary of compensatory MP has avoided direct encroachment to the identified TSS, fairways and most existing marine facilities. Areas with significant vessel traffic streams located at the northern part and southwestern corner of the MPSA have been avoided. A buffer distance of at least 603 m should be maintained to provide an unrestricted vessel passage around the compensatory MP.
Stakeholder Consultation	No objection on the proposed MP boundary was obtained during the two rounds of stakeholder consultation. Feedback related to the zoning, management and enforcement of the compensatory MP to improve the effectiveness of the MP in conserving marine resources were received and this is addressed in *Section 3.*

2.8 *THE PROPOSED COMPENSATORY MARINE PARK BOUNDARY*

The proposed compensatory marine park boundary is derived by considering all constraints and opportunities summarized in *Table 2.4*. The proposed boundary for the compensatory MP, as illustrated in *Figure 2.13*, encompasses an area of 797 ha adjacent to the east of Soko Islands, which adequately covers important habitats for FPs and area with moderate fisheries production. The proposed boundary has also avoided the identified TSS and area with high density of marine traffic activities and without encroaching into the existing South of Cheung Chau Sediment Disposal Area.

The boundary of the compensatory MP was adjusted subject to the most up-to-date boundary of the adjacent proposed Soko Islands Marine Park. Under this Agreement, consultation with the stakeholders was conducted and their views were solicited before finalizing the boundary of compensatory MP. Relevant stakeholders were consulted on this boundary during the two rounds of stakeholder consultations in 2016 and 2017. There was no objection on the proposed boundary. The boundary of the compensatory MP have also taken account of the most up-to-date information on distribution of FP, marine traffic, fisheries resources, existing and potential developments in the MPSA and its vicinity available at that time and views of relevant stakeholders. In addition, the compensatory marine park boundary has been developed based on a conservative approach that the marine park will not encroach into any TSSs irrespective of its usage.

2.9 *THE PROPOSED MARINE PARK DESIGN - SOUTH LANTAU MARINE PARK*

As mentioned in *Section 2.4*, the proposed compensatory MP would allow for better integrated management and provide potential beneficial effects on ecological connectivity and linkage in marine resources together with the proposed SIMP. Considering this, it is proposed to combine the two proposed MPs (i.e. the proposed compensatory MP and the proposed SIMP) into an integrated MP, namely the proposed South Lantau Marine Park (SLMP), to realise these benefits. The proposed SLMP will cover an area of ~1,270 ha for the conservation of Chinese White Dolphins and an area of 797 ha to compensate for the 31 ha of FP habitat loss due to the reclamation and construction of the IWMF.

Layout of the proposed SLMP is shown in *Figure 2.14*.

Management and enhancement measures to be implemented in the proposed SLMP, including AR deployment and fish restocking, are presented in the following *Section 3*.

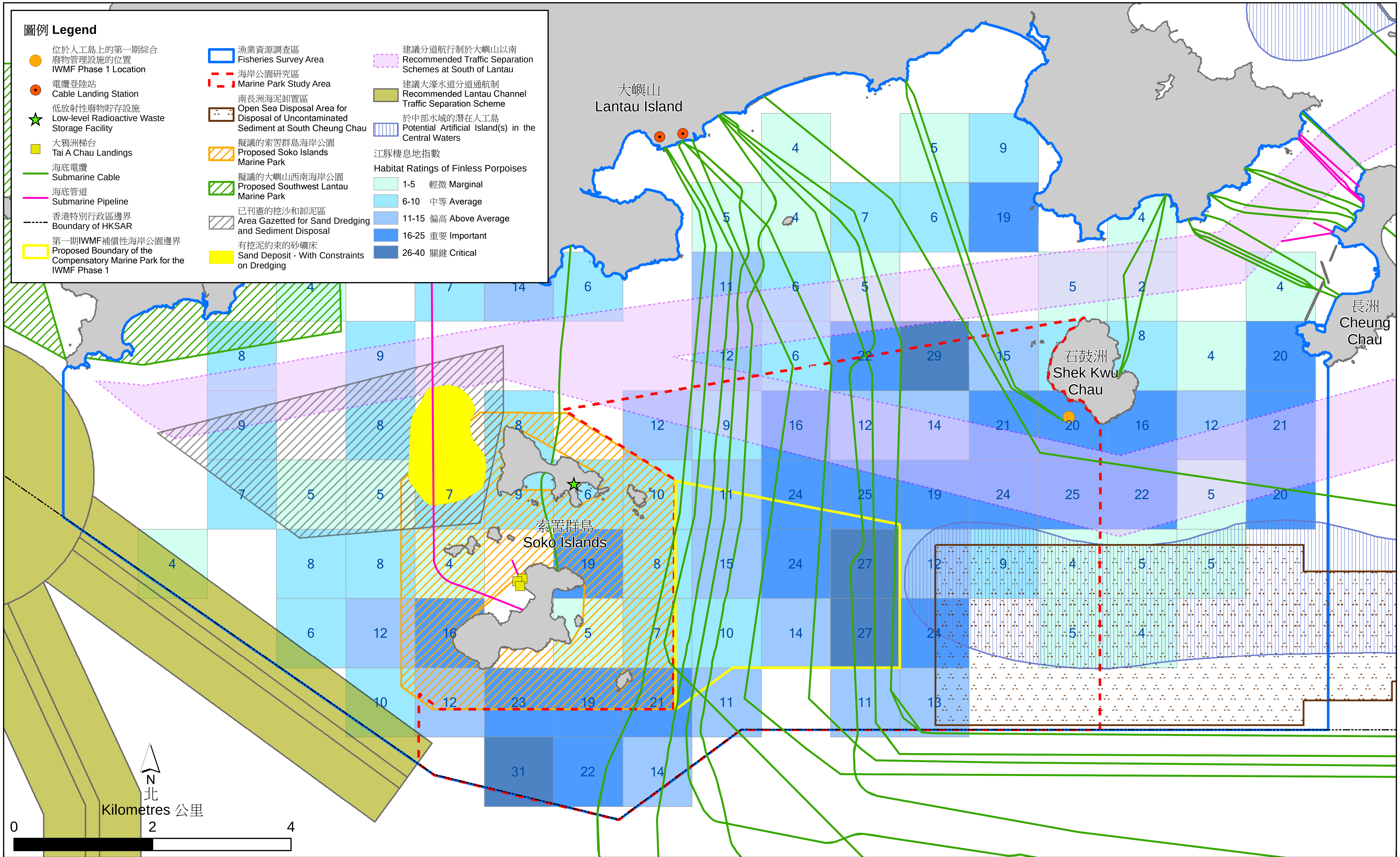


圖 2.13
Figure 2.13

Proposed Boundary of the Compensatory Marine Park for the IWMF Phase 1

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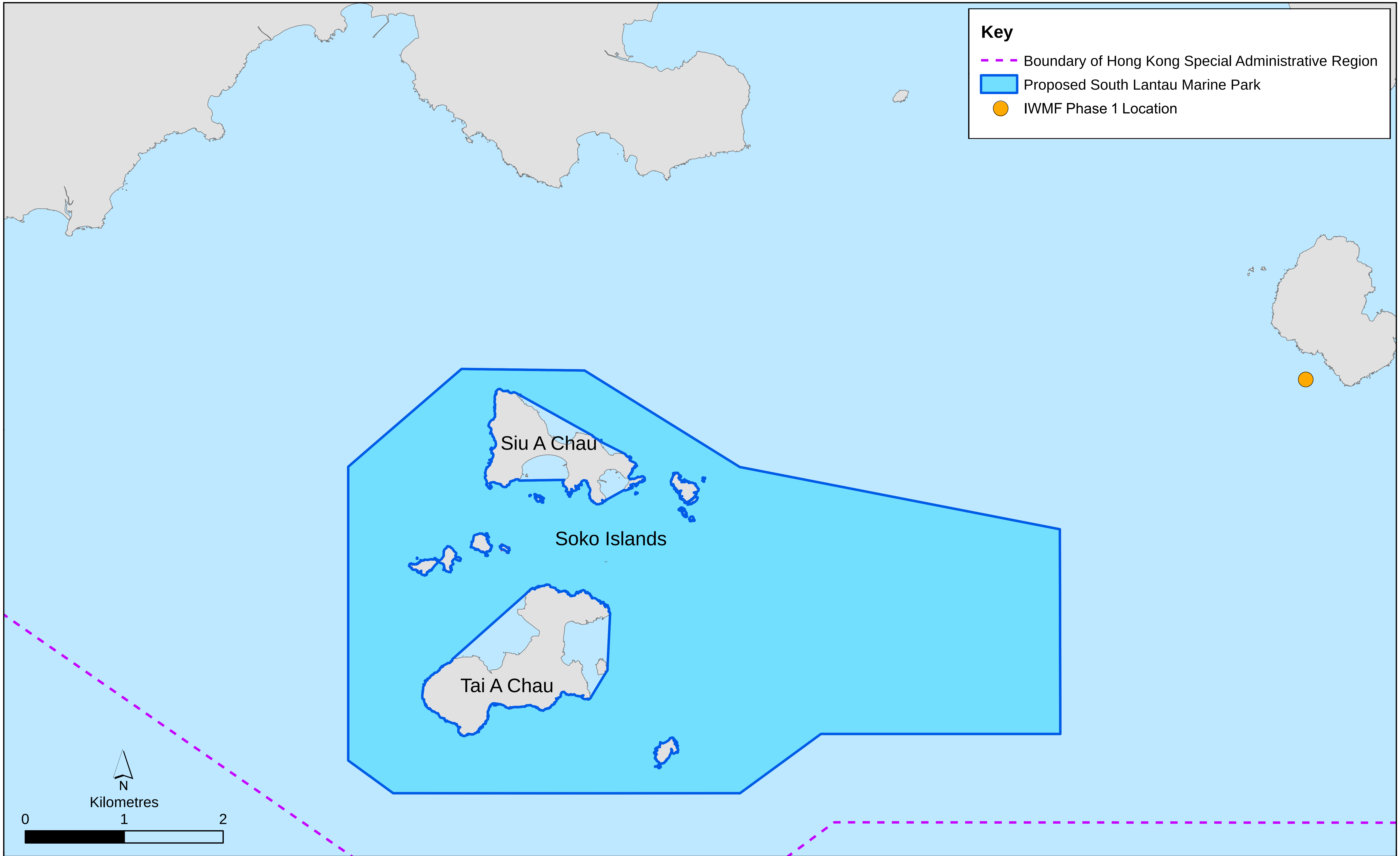

Figure 2.14

Proposed Boundary of South Lantau Marine Park

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Date: 9/11/2017

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3 MARINE PARK MANAGEMENT PLAN & ENHANCEMENT MEASURES

Considering the integration of the proposed compensatory MP and the proposed SIMP into the SLMP as discussed in *Section 2.9*, a management plan is developed for the SLMP and presented in this section. The objective of the management plan is to allow for better achievement of the objective of conservation and protection of FPs and Chinese White Dolphin (CWD) as well as their habitats, marine ecological and fisheries resources in the proposed SLMP. In general, the proposed SLMP will follow the regulations stipulated in the *Marine Parks Ordinance (Cap 476)* and the *Marine Parks and Marine Reserves Regulation (Cap 476A)*. The key management and enhancement measures to be implemented in the SLMP will include:

1. Management by zoning to conserve ecological important habitats;
2. Deployments of ARs and release of fish fry to enhance marine habitats and associated fish stocks in the southern Lantau waters;
3. Fishing control on commercial and recreational fishing within the SLMP to improve ecosystems in marine park and offer better protection for marine ecological resources;
4. Marine park enforcement in accordance with *Marine Parks Ordinance (Cap 476)* and *Marine Parks and Marine Reserves Regulation (Cap 476A)* with specific concern on controlled activities (e.g. fishing or collecting activities) and compliance with vessel speed restrictions;
5. Monitoring programme to collate data of marine mammals, fisheries resources and water quality within the SLMP; and
6. Public use, including educational and public awareness activities, to foster better public support and public awareness of marine conservation.

3.1 SOUTH LANTAU MARINE PARK MANAGEMENT PLAN

The key elements proposed for the operation and management of the SLMP include those necessary for achieving its desired functional, operational, environmental and ecological functions. In line with the existing arrangements for the management of marine parks in Hong Kong, the management options related to planning for proper utilisation of different areas/ zones, monitoring the ecology, environment and activities within the marine parks, enforcing the *Marine Parks Ordinance (Cap 476)* and the *Marine Parks and Marine Reserves Regulation (Cap 476A)* to achieve resource sustainability, and organising marine conservation-related education and public awareness activities are proposed to allow consistency in implementation and enforcement.

For the effective management, MPAs worldwide including those in Hong Kong are commonly segregated into different zones, and then subsequently assigned different management objectives. Zoning is widely viewed as an optimal way of designing protected areas for multiple uses. The zoning scheme can assist in separating conflicting use, while seeking to provide for complementary uses such as habitat/ species protection, scientific study, education and nature appreciation, etc.. The proposed zoning for the SLMP will be the primary approach to draw up the management plan for the SLMP.

3.1.1 Zoning Plan

With a view to meeting the conservation objective of the SLMP, all activities inside the MP must be monitored and regulated. The use of zoning is a way to effectively manage the operation of and the activities within a marine park to achieve its multiple-function purpose. The zoning plan defines the "limits of acceptable use" and the types of developments and activities that can and/or cannot occur in each zone. At present, all marine parks in Hong Kong are managed, in some format, by a zoning plan, which may include anchoring area, core area, mechanized vessels prohibited zone and inboard vessels prohibited zone as appropriate.

Considering the overall purpose of the proposed SLMP, which is to protect, conserve and enhance FP and CWDs habitats as an effective on-site ecological compensatory measure of the IWMF Phase 1, the following zoning types have been considered and evaluated for the SLMP:

- Core Area;
- Anchoring Area; and,
- Special Zone for public uses.

3.1.2 Core Area

Core areas are designated to protect spawning and nursery grounds as well as valuable marine resources, and should be designated depending on the biodiversity and ecological importance of the habitat and species residing in the vicinity. These zones provide the highest level of protection to biodiversity, and thus all forms of fishing and collecting activities are usually prohibited in core areas. Maintaining a core area that prohibits fishing activities is expected to enhance fisheries resources, rehabilitate fish stocks and lead to potential overall beneficial effects to the ecosystem. This is considered as an ecosystem-based approach since the FPs and CWDs are dependent on the food webs, it is essential to not only protect the areas that hold significance for feeding and reproducing, but also the habitats which support the populations of their prey. In Hong Kong, the establishment of a Core Area (i.e. no fishing area) has been successfully implemented at Tung Ping Chau Marine Park and the recently designated BMP.

In terms of sites of fisheries importance, the results of the Port Survey 2006 indicated that the waters of Soko Islands support high level (200-600kg/ha) of fisheries production (*Figure 2.6*). Consequently, the area between Siu A Chau, Tai A Chau and Ma Chau is proposed as the core area of SLMP recognizing the fisheries importance of these waters. The proposed core area is shown in *Figure 3.1*.

In the context of the proposed SLMP which cover key habitats of FPs to the east of the Soko Islands, core area has also been considered to be designated to protect FPs. It is proposed to be established in locations where 'hotspots' of FPs are recorded. Within the marine park boundary, area identified as 'hotspots' of FPs (PHI = 27) is located in the open waters to the west of the South Cheung Chau Sediment Disposal Area (*Figure 2.13*). Since the core area is closed to all kinds of fishing activities, by designating this part of the SLMP as an extra core area in addition to the proposed one between Siu A Chau, Tai A Chau and Ma Chau (as presented in the above paragraph) would likely draw strong opposition from fishermen. In addition, zoning markings with the use of buoys must be easily identifiable to users and a public awareness campaign should be instigated to inform the public and marine users about the codes of practice, such that core area could be enforced through appropriate legislation and policies. However, installing the buoys in the open waters to the east of Soko Islands would hinder the vessel operators who might opt to oppose the core area as well as the MP establishment. In view of the potential conflicting use with the fishermen and vessel operators, setting up another core area in the open waters to the east of Soko Islands is not recommended.

3.1.3 Anchoring Area

Anchoring in ecologically sensitive areas may cause irreversible damage to marine habitats, therefore areas designated for anchoring or mooring is designated in some MPs, such as BMP, Hoi Ha Wan Marine Park, Yan Chau Tong Marine Park and Tung Ping Chau Marine Park, to avoid damage to the marine environment and improper anchoring activities.

With reference to the findings from visual survey in MTIA as summarized in *Section 2.5* above, there is currently not much vessel usage within the area of proposed MP boundary except for small fishing vessels and sampans. These small crafts are considered less likely to anchor in the relatively offshore location of the SLMP. Therefore, an anchoring or mooring area is not considered necessary. The Sha Chau and Lung Kwu Chau Marine Park which serves similar purpose does not have an anchoring/ mooring area.

3.1.4 Special Zone

This zone includes all areas for specified public uses, which may include recreational, educational, public awareness and eco-tourism activities. The objectives of the Special Zone are to allow for safe and sustainable use, provide opportunities for public appreciation and enjoyment of the marine park and the resources therein, and to provide access to sites for the purpose of specified public uses. Currently in other marine parks of Hong Kong, Special Zones with related objectives have been designated as Recreational

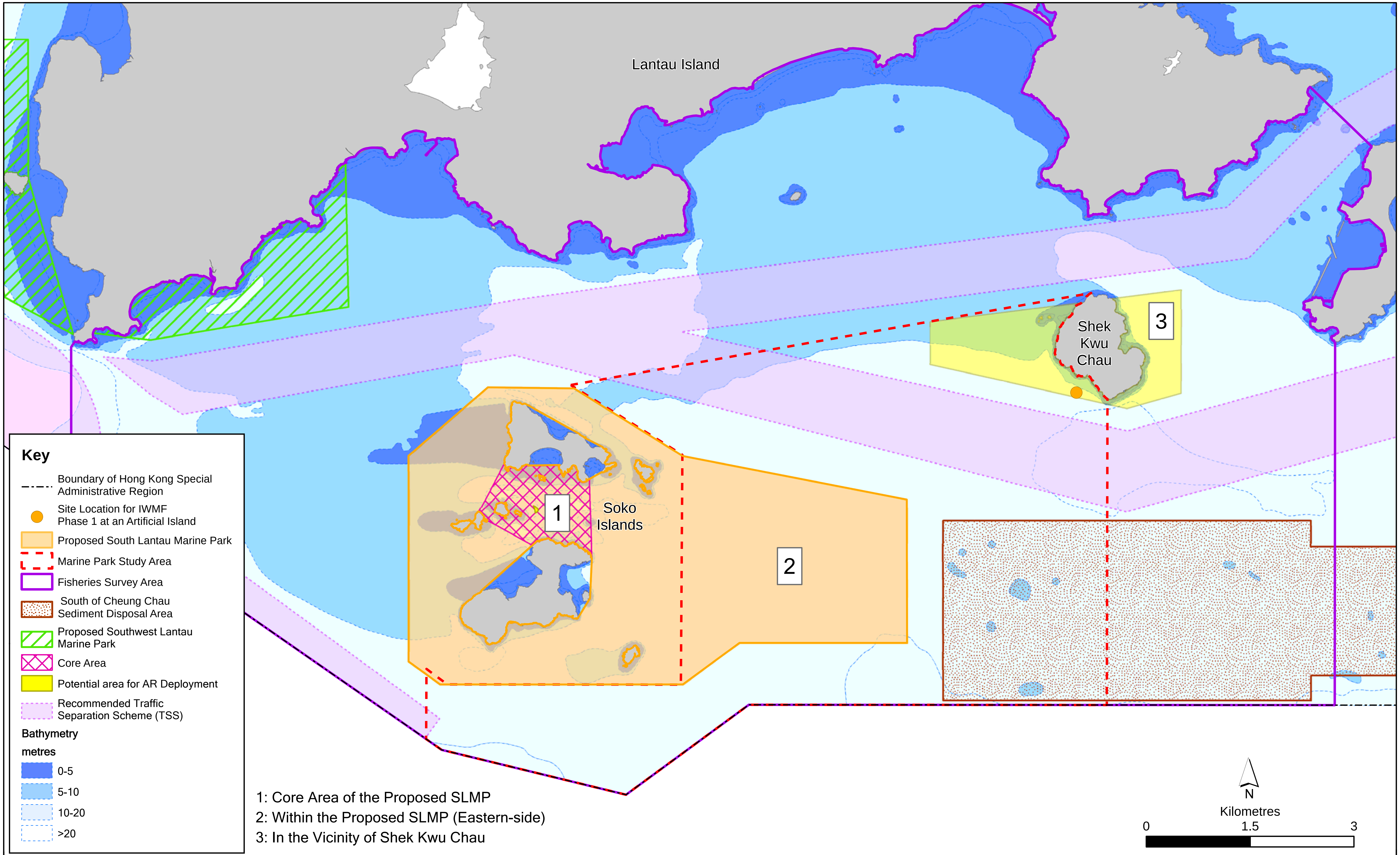

Figure 3.1

Potential Areas for AR Deployment

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Fishing Zones (in Tung Ping Chau Marine Park) or Mechanized Vessels Prohibited Zone and Inboard Vessels Prohibited Zone (in Hoi Ha Wan Marine Park).

The waters of the proposed SLMP has not been identified as a key area for recreational activities, except for some level of recreational fishing. In addition, the SLMP is close to the southwest border of the Hong Kong SAR and the lack of public transportation to the SLMP could make them not easily accessible to the public. Situated nearby the Pearl River, this area is also relatively turbid making it less appealing for other recreational activities such as swimming or diving. Therefore, there does not seem be locations within the boundary of SLMP which should be designated as a special zone

3.2 *POTENTIAL FISHERIES ENHANCEMENT MEASURES*

3.2.1 *Deployment of Artificial Reefs (ARs)*

In accordance with the findings in the EIA report for IWMF Phase 1 and *EP Condition 2.8*, deployment of ARs is recommended as an enhancement measure for the marine habitat within the proposed SLMP.

ARs in general provide food and shelter for adult and juvenile fishes and add habitat complexity for homogeneous marine habitats, thus enhancing the marine biodiversity of a site. ARs function as fisheries enhancement devices because they resemble natural reefs and habitats. In general, they show a similar species composition and community structure to natural reefs in the same area, assuming they are subject to the same environmental conditions (1) (2) and have similar structure to adjacent natural reefs and habitats. Algae and invertebrates usually colonise new reef materials fairly rapidly. The final composition and abundance of the AR community may vary considerably, depending on the composition of the substrata, season, material deposited and numerous environmental variables, including water movement, water temperature and water chemistry. The structures with the greatest complexity and other abiotic and biotic features similar to those of natural reefs have been found to best mitigate in-kind losses of reef fish population and assemblages from natural reefs (3).

The deployment of ARs may enhance fisheries resources but ARs may also aggregate stocks making them potentially easier to catch. ARs will not be fishable by trawlers which have been banned in Hong Kong since 2012. The remainder of the fleet (P4 and mixed vessel operators) will potentially be able to fish the reefs. As such, it is more preferable to deploy AR within area where fishing efforts are controlled.

(1) Ambrose R F and Swarbrick S L (1989) Comparison of fish assemblages on artificial and natural reefs off the coast of southern California. Bull Mar Sci 44(1): 718-733.

(2) Bohnsack J A and Southerland D L (1985) Artificial reef research: a review with recommendations for future priorities. Bull Mar Sci, 37(1): 11-39.

(3) Carr M. H and Hixon M. A, (1997) Artificial reefs: The importance of comparisons with natural reefs. Artificial Reef Management. Vol 22. No. 4.

It is proposed to deploy tailored-made ARs with a goal to enhance primarily fisheries resources and secondarily the recruitment, growth and abundance of FP and CWD prey sources. These ARs can be deployed at locations both inside and outside of the proposed SLMP to provide enhancement across the South Lantau waters. Three potential areas for deployment of ARs have been identified for consideration (*Figure 3.1*), they are:

- Site 1 – Core Area of the Proposed SLMP;
- Site 2 - Within the Proposed SLMP (Eastern-side); and
- Site 3 - In the vicinity of Shek Kwu Chau.

The prime consideration for AR deployment is to avoid areas of conflicting use with existing and planned/ potential marine facilities/ developments. As illustrated in *Figure 2.13*, several submarine cables and pipelines are present in Site 2 which are significant physical constraint for AR deployment (e.g. damage to third party properties). Site 2 is therefore not suitable for AR deployment. Similarly, as illustrated in *Figure 2.10,* several submarine cables present in Site 3 which are significant physical constraint for AR deployment (e.g. damage to third party properties). Site 3 is therefore also not suitable for AR deployment. Site 1 appears to be suitable for AR deployment, as only one submarine cable is present within the site and it is the only absolute constraint is present. The potential for AR deployment at Site 1 within the core area of the proposed SLMP is further evaluated below.

Key Considerations for AR Design & Deployment

The key considerations on AR design and deployment presented below have been based on the review of AR programme within Hong Kong as well as overseas (1). The suitability of areas within Site 1 for AR deployment varies owing to a number of siting constraints. An evaluation has therefore been conducted to identify locations where AR deployment could be accommodated. The selection of deployment location is based on available information of the physical environment, ecological resources and existing uses in waters within Site 1. The preliminary identification of suitable areas for AR deployment has taken into account the following key considerations:

- ***Core area***: AR deployment within the 'Core Area' of a MP, where management control such as control of fishing effort will be implemented, is considered of priority, given a critical factor in the success of ARs is exclusion of fishing on the reefs.
- ***Size of suitable seabed***: The deployment site will need to span an area of suitable seabed large enough to accommodate the AR complex. In an artificial reef deployment study of AFCD, the sphere of influence of ARs of

(1) ERM (2016) Agreement No. CE 14/2012 (EP) Provision of Compensatory Marine Park for Integrated Waste Management Facilities at an Artificial Island near Shek Kwu Chau - Investigation. Review Report.

200 – 300 m was identified based on literature review [(1)]. The study recommended that ARs should not be deployed within 200 m of existing coral reef or high conservation value hard bottom assemblages. This was adopted in ARs deployed in Outer Long Harbour and East Tap Mun in which the ARs maintained a minimum distance of 200 m from the coast [(2)]. Other studies recorded a smaller sphere of influence [(3)(4)], however, it was found that 87% of tagged red snappers stayed within a 200 m radius of their original release site at artificial reefs [(5)]. Thus, on the basis that AR groups exert a sphere of influence of about 200 m, separation between AR groups may serve to reduce overlap of influence between two neighbouring AR complexes, thereby increasing the area of influence. It is thus necessary to consider separation distance between AR groups as well as sizes of the ARs when determine the size requirement of suitable seabed.

- ***Distance from natural reefs***: To mitigate reduction of fish abundance at natural reefs by attraction ("siphoning off") of fish to ARs, a separation distance of more than 200 m between natural reef and ARs has previously been used in Hong Kong [(6)]. This distance is based on research on the sphere of influence of AR groups [(7)].

- ***Seabed composition***: Areas of relatively high existing habitat complexity (e.g. rocky outcrop or coral habitats) may potentially function as areas of benthic primary productivity and shelter or nursery for fisheries resources. These areas need to be avoided. ARs need to be placed in areas of sand or soft sediment that do not, for instance support seagrass, macroalgal beds or complex hard substrate seabed with established epifaunal communities.

- ***Seabed stability***: To function over the long-term, AR sites need to have stable, relatively flat seabed conditions that are not prone to scour or burial.

- ***Water depth***: To prevent ARs from being a navigation hazard, the top of AR structures should have sufficiently deep draft clearance if vessels transit above them. According The Brothers Marine Park study, a minimum depth of 4.5 m below Chart Datum is required to be maintained

(1) ERM (1999) Artificial Reef Deployment Study. Final Report to the Agriculture and Fisheries Department, Hong Kong Special Administrative Region Government.

(2) AFCD (2000) Project Profile – Artificial Reefs Deployment in Outer Long Harbour and East Tap Mun.

(3) Stanley, DR and Wilson, CA (1997) Seasonal and spatial variation in abundance and size distribution of fishes associated with a petroleum platform. International Council on the Exploration of the Sea. Journal of Marine Science 202: 473-475.

(4) Stanley, DR (1994) Seasonal and spatial abundance and size distribution of fishes associated with Petroleum platforms in the Northern Gulf of Mexico. Graduate Dissertation, Louisiana State University, Baton Rouge, Louisiana.

(5) Schroepfer, RL and Szedlmayer, ST (2006) Estimates of residence and site fidelity for red snapper *Lutjanus campecahnus* on artificial reefs in the northeastern Gulf of Mexico. Bulletin of Marine Science 78 (1): 93-101.

(6) AFCD (2000) *Op. cit.*

(7) ERM (1999) *Op. cit.*

above ARs [1]. On the basis that AR structures are up to 2 m tall, areas for AR deployment need to exceed at least 6.5 m below Lowest Astronomical Tide (LAT). This will be confirmed during the design of AR for the current Study. From an ecological perspective, water depth may also be related to water quality with deeper waters tending to have lower dissolved oxygen content. Benthic reefs built in areas with low dissolved oxygen concentration (generally below 3 mg/L) are unlikely to achieve desired productivity levels and will probably not achieve enhancement objectives. Taking into account of ambient water quality in South Lantau waters, deployment in shallower waters (<15 m) may be advantageous in terms of better suitable water quality (generally >= 3mg/L of bottom DO at shallower depths [2]). Similarly, attenuation of photosynthetically active radiation will increase with depth. Given the turbid nature of South Lantau waters from the influence of Pearl River Discharge, the AR is more likely to benefit from production by benthic primary producers (i.e. benthic algae) if deployed at shallower depths.

- ***Avoid navigation areas/ shipping lanes***: The AR deployment location should have sufficient separation distance from vessel traffic routes. Even when operating at reduced speeds (<10 knots), vessel engines emit underwater noise that would be of highest intensity at close range. Transit of vessels over ARs may lead to behavioural effects and avoidance in fish communities, and potentially masking of environmental cues, which would likely diminish the suitability of ARs as fish habitat if the ARs are located in a navigation area. It is thus suggested that the ARs should avoid and set back from areas with marine traffic routes as far as practicable.

- ***Avoid submarine utilities***: The AR deployment location should be set back from submarine utilities, including cables and pipelines. This is to avoid damage to the cable including from anchoring during installation, avoid water quality impacts to AR assemblages if repair/ maintenance works are conducted and minimize exposure to electromagnetic fields which are potentially detectable by fish and can cause behavioural effects in sensitive species.

- ***Avoid anchorage areas***: The AR deployment location should have sufficient separation distance from the anchorage area to avoid conflicting use with the vessel operators.

- ***Avoid existing and future possible maritime uses***: AR deployment location will need to be sited away from existing maritime uses, in particular area which could be considered for reclamation or is currently an active sediment disposal site.

- ***Ease of management:*** Natural geographic boundaries (e.g. shelter bay would be easier to manage than offshore open waters) and proximities to

(1) Highways Department (2015) Working Paper: WP/CMPB/6/2015. The Proposal to designate the Brothers Marine Park. Available at: https://www.afcd.gov.hk/english/aboutus/abt_adv/files/WP_CMPB_6_2015.pdf

(2) ERM (2016) *Op. cit.*

existing/ planned managed areas (e.g. marine parks and marine reserves) would favour AR deployment. Area near HKSAR boundary would be given a lower priority as illegal fishing activities were reported to take place mainly near the HKSAR boundary (1) which would compromise the long-term viability of the ARs.

Based on the above key considerations, deployment of ARs within Site 1 appears feasible and practical as it is located within a managed core area of the proposed SLMP where resources are already devoted to management, and relevant stakeholders are aware of management practices. Consequently, ARs deployed at Site 1 would be easier to manage and it could offer long-term protection to AR which is a key successful factor of AR's function and long-term viability. From the environmental aspect, Site 1 is sheltered by Soko Islands and at water depth ranged between 5 – 25 m. This would provide stable environmental conditions to benefit long-term viability of ARs. As mentioned before, there is only one existing submarine cable with no planned maritime uses, which would minimize direct conflict with other marine users in the subject waters. The subtidal rocky reefs around Soko Islands can be used as reference site for assessing the performance of ARs. Site 1 is thus proposed for AR deployment.

Site-specific seabed features are crucial to ARs deployment and design, management and maintenance, thus findings of geophysical survey conducted under this Agreement in April 2017 were adopted to strengthen the scientific rationale for site selection as well as the suitability of proposed location and design for AR deployment.

According to results of the geophysical survey conducted within Site 1 (core area of the proposed SLMP), the proposed AR deployment location with an area of ~0.35 ha was identified as shown in *Figure 3.2*. The water depth of this location is about 13 - 15 m below Principal Datum (PD) (in which PD = CD + 0.146 m). It appears to be a suitable location given the advantage of AR deployment in shallower waters (<15 m) and the location is more than 200 m away from the coastline to avoid the potential of attracting fishes from natural subtidal hard bottom habitats nearby. The proposed location is also reasonably sited away from the submarine cable within Site 1. The seabed of the proposed AR deployment location is composed of fine sediment (possibly silt/clay) which is believed to support low level productivity that generally do not established epifaunal communities. The slope of the proposed AR deployment location is also small (approximately less than 2 °) to reduce potential of instability of the deployed ARs. Results of the geophysical survey are presented in *Annex A*.

Review of Local AR Designs

A wide range of AR types was previously deployed in Hong Kong by the AFCD, and the enhancement of habitat quality and marine resources have

(1) LC Paper No. CB(2)1621/14-15(05) Implementation of the Trawl Ban. Available at: http://www.legco.gov.hk/yr14-15/english/panels/fseh/papers/fseh20150609cb2-1621-5-e.pdf

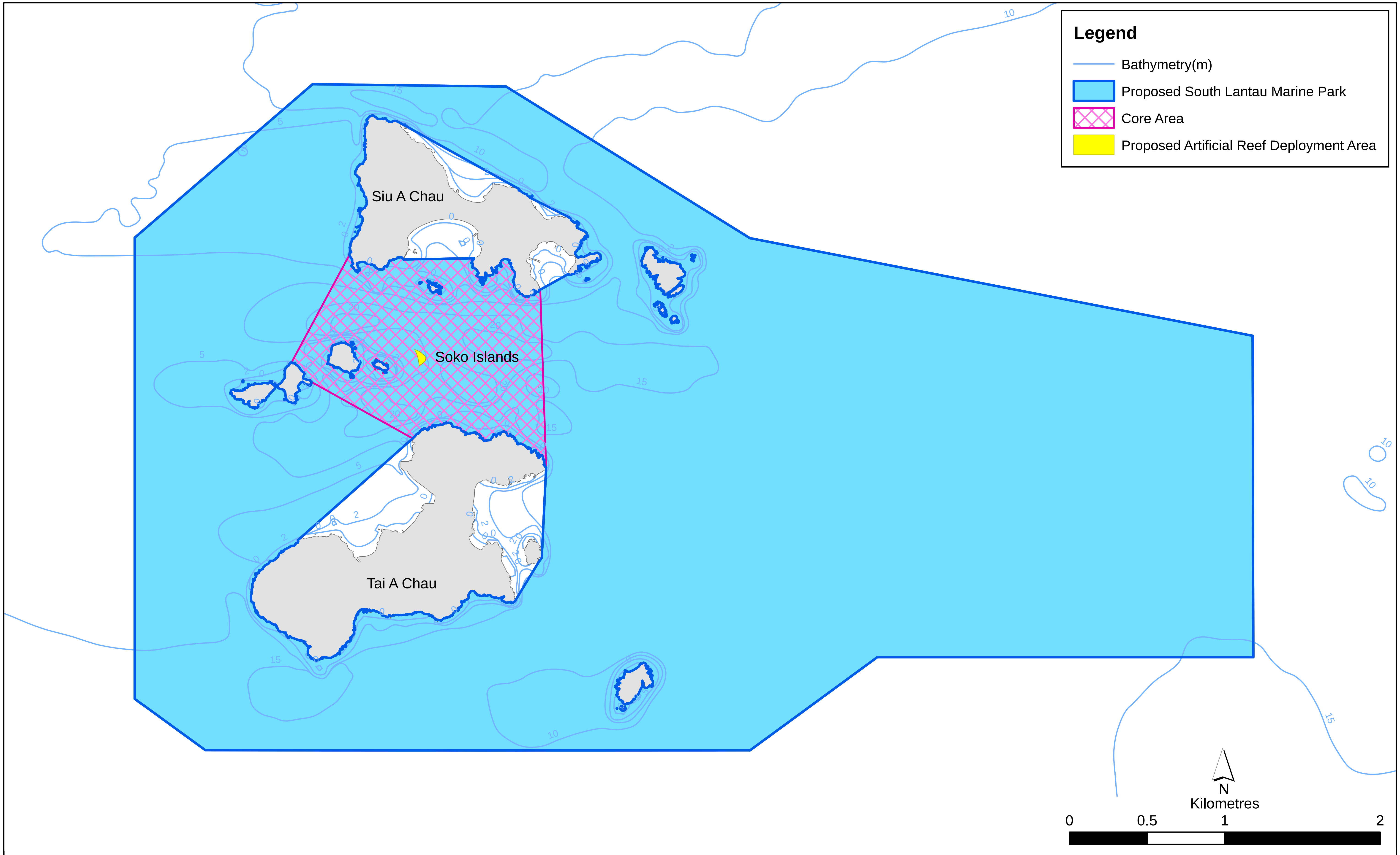

Figure 3.2

Proposed Artificial Reef Deployment Area

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featured as one of the two or three key objectives of deployment at a particular site. Other objectives include to assist in the prevention of trawling near Marine Parks, or to act as biofilters in close proximity to Fish Culture Zones. Two ARs near Hong Kong International Airport have also been deployed with the objective to act as feeding stations for the CWDs. Examples of ARs deployed in Hong Kong are summarised in *Table 3.1.*

Table 3.1 Summary of ARs Materials (1)

Type of ARs	Examples/ Materials	Advantages	Limitations
Concrete reefs	• Reef Balls • Hollow structures	• High degree of flexibility in design to meet a range of ecological, marine wave and fishing resistance requirements	• Least cost-effective due to high purchase and preparation cost • Require a bed foundation materials to be placed on top of soft strata for bed stability and reduction of settlement (i.e. mixed design)
Old ships	• Steel vessels • Wooden fishing vessels	• Easily be relocated for inspection and has considerable resistance to impacts from fishing activities and strong waves; • Physical design complexity providing a range of habitats throughout the water column harboring discrete species	• Vessel will rust in the oceanic conditions and eventually break up
Quarry rock/ marine concrete structures	• Quarry Rocks • Redundant piers	• Long life span with large amount of microhabitats for fauna and flora to shelter in and settle	• Very heavy and compact thus not suitable for soft substratum as it may subsides quickly • Materials from land formation contract may contain contaminated materials
Tyre reefs	• Used tyres	• Construction materials are relatively inexpensive	• Essentially light materials not resist wave action or intensive fishing activities, thus not suitable for exposed areas

Appropriate AR types should be selected to suit the site location to enhance fisheries resources.

(1) Wilson KDP (2003) Artificial Reefs and Reef Fish in Hong Kong.

Ecological Considerations of ARs

In some theories, ARs serve to attract fishes from one area to another (1) (2). Fish are thought to congregate at ARs because of lower risk of predation, higher prey densities and shelter from currents (3). Another theory is that ARs can facilitate fish production through provision of increased habitat, thus relieving the existing restrictions on population abundance. This is particularly evident in fish species where juveniles have higher site fidelity than older fish (4). Provision of habitat for juveniles and the subsequent increase in adult individuals may result in a localised positive benefit to local fish populations. Once deployed, AR structures become inhabited by fish, in some cases within hours of deployment.

Fishes that are attracted to or colonise ARs can be classified into four categories with different affinities related to various characteristics associated with fishes' feeding behaviour, reproduction and activity patterns (5) (6):

- Type A fish species are benthic dwellers that often have physical contact with the reef, occupying holes, crevices and narrow spaces. Examples include rockfish (Scorpaenidae), various species of grouper (Serranidae), blennies (Blennidae) and gobys (Gobidae).

- Type B fish species are found directly around the reef but make no contact with it. They are believed to be linked to the reef through vision and sound. Examples include snappers (Lutjanidae), sweetlips (Haemulidae) and seabreams (Sparidae).

- Type C fish species are found in the upper water column some distance above the reef and are loosely associated with it. Examples include large carangids and schools of clupeids.

- Type D fish are found on or over the substrate next to the reef. Examples include flounders (Bothidae) and lizardfishes (Synodontidae).

The benefits ARs to promote fish production (ie increase overall abundance through reproduction and increase survivorship of recruits) is greater than simply acting as a fish aggregating device. Species most likely to benefit from provision of increased and enhanced habitat by ARs structures in terms of productivity are Type A and Type B species such as groupers, snappers,

(1) Bortone SA (2007) Coupling Fisheries with Ecology through Marine Artificial Reef Deployments. American Fisheries Society Symposium 49: 587-594.

(2) Feary DA, Burt JA, Bartholomew A (2011) Artificial marine habitats in the Arabian Gulf: Review of current use, benefits and management implications. Ocean and Coastal Management 54: 742-749.

(3) Bohnsack JA, Johnson DL and Ambrose RF (1991) Ecology of artificial reef habitats and fishes, in Seaman WJ and Sprague LM (eds) Artificial Habitats for Marine and Freshwater Fisheries. Academic Press, San Diego USA, pp. 61-107.

(4) Shipp RL and Bortone SA (2009) A perspective of the importance of artificial habitat on the management of red snapper in the Gulf of Mexico. Review in Fisheries Science 17: 41-47.

(5) Nakamura M (1985) Evaluation of artificial reef concepts in Japan. Bulletin of Marine Science 37:271-278.

(6) Bortone SA (2007) *Op. cit.*

seabreams and sweetlips. Conversely, Type C and Type D species may only be attracted to ARs and are reported to add little to overall productivity [(1)]. From an ecological perspective, the aim of the ARs design is to create habitat for both adult and juvenile fish that both attracts and maintains a fish community, with a particular focus on Type A and Type B species such as grouper (Serranidae), snapper (Lutjanidae) and seabream (Sparidae), for which grouper and seabream are recorded during the fisheries resources surveys undertaken from September 2015 to August 2016 under the current Assignment within the proposed SLMP. The proposed AR design should provide hard substrate with holes and crevices for these species which often have direct physical contact with reef or are linked to the reef through vision and sound.

In Hong Kong, ARs have provided habitat for a diversity of species including high-value commercial species such as giant grouper (*Epinephelus lanceolatus*), orange-spotted grouper (*E. coioides*), Russell's snapper (*Lutjanus russellii*), mangrove snapper (*L. argentimaculatus*), gold-lined sea bream (*Rhabdosargus sarba*), red drum (*Sciaenops ocellatus*), and cobia (*Rachycentron canadum*) [(2)]. These species may feed, grow and reproduce in the ARs.

Habitat Preference

Adult groupers, snappers, and seabreams are typically reef-associated species that prefer habitat complexity from coral and rocky reef habitats and are therefore among those species most likely to benefit in terms of production from provision of increased and enhanced habitat. Their juveniles are also found at low-relief hard bottom habitat, but also use a broader range of habitats including over mud, rubble or seagrass beds [(3)], indicating ARs have potential to serve as habitat for juveniles and may attract juveniles from their surrounds. It is therefore considered beneficial if the ARs can provide similar enhanced habitat that is favourable to both adults and juveniles of these or similar Type A and Type B species.

Ecological Design of AR

The construction design and configuration of materials are important to the functioning of an AR. Ecological considerations that are important to the AR design are discussed below.

<u>AR Size, Configurations and Density</u>

The ARs design must spread over an area to increase habitat heterogeneity over a wider area, with deployment of ARs onto the seabed organised in a hierarchical arrangement. The smallest element considered in the ARs design is called a reef unit. Reef units can be paired into a reef set which in

(1) Bortone SA (2007) *Op. cit.*

(2) Hong Kong Artificial Reef Project Artificial Reef Fish January 1998 - September 2003 (http://www.artificial-reef.net/English/5_1.htm)

(3) www.fishbase.org. Last visited December, 2016.

turn are organised into a reef group. Several reef groups are then organised into a reef complex. To be effective in enhancing fish resources, reef groups are thought to require a minimum of 400 m^3 volume and higher volumes up to 3000 m^3 of reef for every km^2 of seabed have been linked to higher fisheries catches [(1)]. In terms of overall density, 1,500 m^3/km^2 of ARs volume was previously deemed suitable for ARs projects in Hong Kong [(2)]. These metrics are considered a potential guide to the ARs design for this project.

ARs configuration and density are also taken into consideration as it relates to their ecological function and influence. Each reef group is considered to have a sphere of influence in terms of fish attraction of at least 200 m and therefore the spread of reef groups within reef complexes serves to spread the effect of the ARs over a wider area by extending the area that juveniles and pelagic fish can be attracted [(3)]. Spreading the ARs is a means to maximise the sphere of attraction. Having a spread of ARs can enhance connectivity and reduce mortality when fish move across areas where refuge from predation is lacking. The need for spacing of ARs is also required since a portion of food consumed by ARs-associated fishes comes not from the structure itself, but their foraging activity that takes place away from the structure on surrounding seabed.

Given the sphere of influence of ARs, it is also considered important that the siting ARs is set back at least 200 m from existing natural rocky reefs. This is to avoid attraction ("siphoning off") of their reef-associated fish leading to an undesirable reduction in abundance at natural rocky reefs [(4)]. The minimum distance of 200 m from natural rocky reefs was also adopted another local AR deployment Project in Outer Long Harbour and East Tap Mun as presented in its Project Profile [(5)].

<u>Reef Profile</u>

The vertical profile (i.e. height and shape) of a reef structure is likely an important factor affecting the overall fish species composition and biomass of a given reef. Low profile reefs provide a suitable habitat for more demersal species including Type A and Type B species. High profile reefs (i.e. > 3m above seabed) are more likely to aggregate pelagic species (i.e. Type C species) [(6)]. As such, a combination of high and low profile construction materials may be expected to bring some benefits of aggregating a potentially more diverse fish assemblage, if site conditions allow. It was also shown that ARs with high reef profiles with elevations close to the water surface would be

(1) ERM (1999) *Op. cit.*

(2) ERM (1999) *Op. cit.*

(3) ERM (1999) *Op. cit.*

(4) ERM (1999) *Op. cit.*

(5) AFCD (2000) Project Profile – Artificial Reef Deployment in Outer Harbour and East Tap Mun.

(6) Bortone SA, Martin T, and Bundrick CM (1994) Factors affecting fish assemblage development on a modular artificial reef in northern Gulf of Mexico Estuary. Bulletin of Marine Science 55: 319-332.

better to enhance the benthic primary production [(1)]. Given the maximum depth of the proposed AR deployment location is 15 m and ARs should be deployed at depths exceeding 6.5 m (for ARs 2 m in height), the ARs design may be a combination of high and low profile structures.

Interstitial Space

The interstitial spaces in reef structures are important in determining the degree and complexity of the biological community developing on and around the reef. Numerous holes, crevices, walls and overhangs in a reef structure allow for a diverse community in general than that which would develop on a reef material with less structural complexity. Adequate interstitial spaces are necessary to establish a diversity of mobile invertebrates as well as numerous cryptic fish species. Interstitial spaces may also be a factor in enhancing desired behaviour such as increased reproduction, molting, or predator avoidance [(2)(3)].

The design of AR structures should aim to provide refuge for adults and juveniles through suitable size and shape shelter spaces as this for instance is important for reducing predation risk [(4)(5)]. To enhance habitat for adult individuals, void space of up to 3 m is considered a suitable design parameter. To provide enhanced habitat for juveniles, the design should also provide a variety of voids of different sizes (<0.5 m). It is also considered that spacing between ARs should be around 30 cm or less for type A fish species that live on reefs while the spacing should be around 2-4 m between reef units for type B fish species that are found directly around the reef [(6)].

Material Composition

Colonisation of AR structures over time can lead to the development of a 'fouling' community such as bivalves, sponges, tunicates and bryozoans and benthic algae and a myriad of other associated organisms. The presence of fouling communities can add to habitat complexity on structures and provides additional refuges for predator or prey as well as foraging resources. For selection of ARs materials, there are benefits for using materials that have

(1) Mazzei, V. and Biber, P. (2015) Autotrophic net productivity patterns at four artificial reef sites in the Mississippi Sound. Hydrobiologia 749: 135-154.

(2) Ecklund, A. M. 1996. The importance of post-settlement predation and reef resource limitation on reef fish assemblages. Doctoral dissertation. University of Miami, Coral Gables, Florida.

(3) Sherman, R. L., D. S. Gilliam, and R. E. Spieler. 2001. Effects of refuge size and complexity on recruitment and fish assemblage formation on small ARs. Proceedings of the 52nd Annual Gulf and Caribbean Fisheries Institute Meeting, Key West, Florida: 455-467.

(4) Verweij MC, Nagelkerken I, de Graaff D, Peeters M, Bakker EJ, van der Velde G (2006). Structure, food, and shade attract juvenile coral reef fish to mangrove and seagrass habitats: A field experiment. Marine Ecology Progress Series 306 pp 257-68.

(5) The Joint Artificial Reef Technical Committee of the Atlantic and Gulf States Marine Fisheries Commissions (1998) Coastal Artificial Reef Planning Guide. Available at: http://www.gsmfc.org/publications/Miscellaneous/Coastal_Artificial_Reef_Planning_Guide_1998.pdf [accessed on 15-8-2016]

(6) Lennon, D (2011) Green Zones in Constructed Reefs. Available at: http://www.reefballaustralia.com.au/soi_tech_note-green_zones_in_constructed_reefs.pdf [accessed on 20-2-2017]

surfaces that are irregular and with a rough texture. Such surfaces can provide more microhabitat for different organisms to settle and recruit and are more likely result in a greater diversity and abundance of fouling organisms. The ARs design should take into account of benefits of encouraging development of fouling communities through material selection. The composition and abundance of AR assemblages vary depending on the composition of the substrata, season of deployment and environmental factors, including depth, current, water temperature and water chemistry (1). Tubeworms were more abundant in spring and summer while barnacles and tunicates dominated in autumn and winter as recorded in a biofouling study in Hong Kong (2). Climax communities were observed during the second year of deployment with green mussels and tunicates settled. Seasonal difference of AR assemblage and increase in species diversity in the second year of deployment was also suggested in another local study (3).

Total Surface Area

The total biomass of fish that can be supported on an AR is likely to be influenced by the quantity and quality of effective surface area available. For lower profile reefs, provision of a large surface area to allow higher abundance of fouling organisms will be an essential feature of a reef design as availability of foraging resources is a requirement for maintaining reef-associated demersal fish. Many sessile and mobile invertebrates that occur in fouling communities on the ARs can be expected to serve as food items for fish inhabiting the reefs. Provision of greater surface area, is therefore likely to lead to greater availability of food resource for fish that inhabit and forage on the AR.

Circulation Patterns surrounding Reef Materials

From an ecological perspective, it is important that there is porosity in the ARs to allow water movements to pass through the AR structures. This is needed to avoid stagnation of water, particularly in the interior parts of the reef, which could diminish the productivity of the overall reef. Sufficient water circulation surrounding the reef also allows for better utilisation of all surfaces of structures for the establishment of sessile invertebrates, as well as the potential for improved access to fish and motile invertebrates that may be more cryptic in nature. It was found that area of high velocity flow and low sedimentation around the wreck corresponded to regions of high cover and species diversity, while areas of decelerated flow and increased sedimentation corresponded to regions of less cover and lower species diversity (4). To maximize the growth of sessile benthic growth on AR, it is important to

(1) ERM (1999) *Op. cit.*

(2) Qiu JW, Thiyagarjan V, Leung AW, Qian PY (2003) Development of a marine subtidal epibiotic community in Hong Kong: implications for deployment of artificial reefs. Biofouling 19 (1): 37-46.

(3) Lam KKY (2001) Epibenthic community development on an experimental pulverized fuel ash (PFA) artificial reef. Asian Marine Biology 18: 71-90.

(4) Baynes, T.W. and Szmant, A.M. (1989) Effect of Current on the Sessile Benthic Community Structure of an Artificial Reef. Bulletin of Marine Science 44 (2): 545-566.

maximize the surface area exposed to laminar current flow (eg orient the long axis of a ship to the predominant flow direction for deployment) (1).

Water Quality

General water quality in important consideration for the location of AR deployment, including water turbidity and dissolved oxygen, affect the biological productivity and use value of ARs (2). ARs deployment in waters of low DO (generally below 3 mg/L) or where anoxic conditions periodically occur will not achieve desired biological productivity (3). Marine water quality in proposed SLMP has characteristics of relatively higher depth-averaged level in DO in the dry season than in the wet season. Long term depth-average DO was observed to comply with the Water Quality Objectives within the proposed SLMP and with a value of at least 3 mg/L. There is also great fluctuation in suspended solids levels as the proposed SLMP is subject to some degree of influence from the Pearl River discharge. Water transparency and other associated features, such as suspended sediment concentrations and siltation rate; appear to be the main factors influencing settlement and succession of the benthic community on ARs (4). However, studies have shown that there are no notable differences in the abundance of large fish at ARs in clear and turbid waters, but differences in benthic communities composition were found (5)(6). The ARs in clear waters tend to have an autotrophic algae community, while ARs in turbid waters tend to have a heterotrophic invertebrate community. In addition, turbid waters tend to have shallow photic zone and primary production potential is often limited by the light available (7) (8). It was believed that the deployment of ARs may help to increase autotrophic diversity and primary production by providing substrates for seaweeds to grow where more light is available.

(1) Baynes and Szmant (1989) *Op. cit.*

(2) Jackson, S. and Golden, A. (n.d.) Site Selection for Bay County Artificial Reefs. Available: http://bay.ifas.ufl.edu/seagrant/artificial-reefs/site-selection-for-bay-county-artificial-reefs/ [accessed on 1-8-16]

(3) Lenihan, H.S. and Peterson, C.H. (1998) How habitat degradation through fishery disturbance enhances impacts of hypoxia on oyster reefs. Ecological Applications 8: 128-140.

(4) D'Anna, G., Badalamenti, F. and Riggio, S. (2000) Artificial reefs in north-west Sicily. In: Artificial Reefs in the European Seas, pp. 97-112. Ed. By A. C. Jensen, K. J. Collins and Lockwood, A. M. P. Kluwer, London. 508 pp.

(5) Chang, K.H. (1985) Review of artificial reefs in Taiwan: emphasizing site selection and effectiveness. Bull Mar Sci 37: 143-150.

(6) Ponti, M., Fava, F., Fabi, G. and Giovanardi, O. (2010) Benthic Assemblages on Artificial Ryramids along the Central and Northern Adriatic Italian Coasts. Biol. Mar. Mediterr. 17(1): 177-178.

(7) Alpine, A.E. and Cloern, J.E. (1988) Phytoplankton growth rates in a light-limited environment, San Francisco Bay. Marine Ecology Progress Series 44: 167-173.

(8) Cloern, J,E,, Foster, S.Q. and Kleckner, A. E. (2014) Phytoplankton primary production in the world's estuarine-coastal ecosystems. Biogeosciences 11: 2477-2501.

Effect on Surrounding Environment

Considerations should be taken in the design of AR as the deployment of AR may affect the composition soft benthic infaunal assemblages by producing alternation in the surrounding substratum by (1) (2):

- Burial a portion of soft benthos assemblages under the base of the AR;
- Modification of the bottom current and cause variation on the sediment size distribution and siltation rate;
- Change of sediment organic content through metabolic activity of both benthic and nektonic reef assemblages; and
- Increase in feeding pressure on infauna due to aggregation of fish.

The infauna benthic assemblages in the vicinity of the Soko Islands, which is partly within the SLMP, were dominated by polychaete worms with no rare species recorded (3). Although the deployment of ARs may cause some changes to surrounding benthos, the overall ecological value of the area will be enhanced, through the protection of sensitive habitat from illegal trawling and nutrient input by the fauna and flora on the AR.

Environmental Engineering Criteria

Bathymetry

Detailed geophysical survey using echo sounding and seismic reflection were undertaken to determine suitability of proposed location and design for AR deployment. Seismic sub-bottom profiling can provide information on the material type and thickness of the strata. As mentioned in *Section 3.2.1*, deployment in shallower waters (<15 m) may be advantageous in terms of better suitable water quality (generally >= 3mg/L of bottom DO at shallower depths (4)). A geophysical survey was undertaken within the core area of the proposed SLMP in April 2017 and the results are presented in *Annex A*. These results were considered in selection of AR location.

Ground Conditions

The ground conditions should be evaluated at the proposed AR deployment location. Sufficient area of flat seabed bottom is preferred to provide stability and area for AR deployment. Further ground investigation study, which may include ground investigation field work, will be conducted during the

(1) Davies N., Van Blaricom G.R. and Dayton, P.K. (1982) Man-made structures on marine sediments: Effects on adjacent benthic communities. Marine Biology 70: 295-303.

(2) Ambrose, R.F and Anderson, T.W. (1990) The influences of an artificial reef on the surrounding infaunal community. Marine Biology 107: 41-52.

(3) ERM (2006) EIA Report for Liquefied Natural Gas (LNG) Receiving Terminal and Associated Facilities.

(4) ERM (2016) *Op. cit.*

design review before construction of the ARs. Appropriate anti-subsidence measures, if necessary, will be incorporated into the AR design considering the stability of ground condition.

Water Depth for Navigation

Water depth is important for the site selection for AR deployment as sufficient water depth shall be maintained for safe navigation of vessels. The height of the AR units shall be designed to provide the minimum clearance to accommodate the vessels that operate in the vicinity of ARs. A minimum clearance of 4.5 m is required for safe navigation for AR deployed in BMP and this minimum clearance was adopted for reference in the design of ARs to be deployed in the proposed SLMP.

Hydrodynamic Conditions

The hydrodynamic conditions will have a strong influence on the effectiveness of the AR units. Hydrodynamic modelling of bottom current was conducted at the proposed AR deployment location of Site 1 and the results predicted average bottom current velocities of 0.201 ms^{-1} and 0.170 ms^{-1} in dry and wet season, respectively. The maximum bottom current velocity is ~ 0.43 ms^{-1} during both seasons. The bottom current velocities were similar with those identified at existing or future AR locations in western waters.

Sedimentation / Scouring

Sedimentation or scouring may result from the seabed nearby. It would be important to analyse the potential sedimentation or scouring to ensure that AR structures will not subside and the volume of ARs will not be significantly compromised or the structure will not be altered due to this natural hydrodynamic process.

Design review will be undertaken before construction of the AR which will include review of the hydrodynamic modelling data and result of the further ground investigation study to confirm any issue of sedimentation / scouring / sinkage / movement of ARs.

AR Engineering Criteria

Feasibility

The material for the ARs should be selected using commonly available material and the AR should be easy to manufacture, transport and deploy. The material should not induce any adverse effect to the existing environmental impact.

Effectiveness

The ARs are designed to function as ecological enhancement measures to improve fisheries resource of the SLMP.

Design Loading

The AR units should be designed to resist the environmental loads and human-induced loads during construction and after deployment.

Design Life

The deployed AR should be durable with a design life of more than 20 years.

Durability and stability

The ARs will require time for the biological entities to mature and colonise the unit. Durability and stability are considered in the design of ARs. The AR is subject to the aggressive marine environment and the proposed material for the ARs should be durable to ensure the structure integrity is achieved during the design operation life of the units. The ARs may also subject to current and wave force under the extreme weather condition and should be designed to withstand the result impact force of the deployment locations.

The geology of the seabed for the proposed deployment location will have an impact to the design of the ARs. The substrate that is suitable for AR deployment should be firm so that it will not subside significantly into the substrate (1). Soft silty seabed is considered to be unsuitable for AR deployments as any modules laid down will subside and will be useless in providing additional habitats and niches for the benthic community. These substrates are also very easily disturbed and will significantly reduce light penetration and visibility. Silt that are easily stirred up by the current have a scouring effect and reduces the settling success of organisms on AR and the survival of organisms already settled (2). Further ground investigation study, which may include ground investigation field work, will be conducted during the design review before construction of the ARs. Appropriate anti-subsidence measures, if necessary, will be incorporated into the AR design considering the stability of ground condition.

Suitability of proposed monitoring programmes

A suitable monitoring programme should be proposed to study effectiveness of deployed ARs. Baseline studies shall be carried out to provide the benchmark data for monitoring the fishery resources. The monitoring programme should be separated in the different phase in order to review the performance of the short term, medium and long term goals. The performance of the ARs can also be affected by other activities in the vicinity and should be taken into consideration during the monitoring period.

(1) Mathews, Jr. H. (1981) Artificial reef site selection and evaluation. In: Aska, D Y (Ed.) Artificial reefs: conference proceedings. Florida Sea Grant College, report no. 41: 50 -54.

(2) McAllister, Raymond F. (1981) Engineering considerations for artificial reefs. In: Aska, D Y (Ed.) Artificial reefs: conference proceedings. Florida Sea Grant College, report no. 41: 17-22.

Recommended AR Type and Size

<u>Materials and Size</u>

The materials for the AR units should be durable and strong enough to withstand wave conditions. The material shall be free of toxic substances and should avoid leaching harmful substances. Common types of materials used for AR units are concrete, steel, quarry rocks, obsolete vessels and redundant marine structures. Steel and dismantled vessels are not as durable as the concrete-made ARs and some components may deteriorate or partly collapse over time. Concrete has been used locally and overseas for the fabrication of AR units and has been shown to be more durable. Marine concrete with rebar can be used to provide structural capacity and provide the durability for the AR units under marine conditions. The AR units are fabricated off-site and transported to the proposed deployment location by barges. Therefore, the weight of the AR unit shall not be too heavy to suit the common lifting equipment for deployment.

<u>Design</u>

The water depth at the proposed AR deployment location is <15 m and a minimum clearance of 4.5m is maintained for safe navigation. Therefore, it is proposed to deploy ARs with mixed design (low and high profile ARs). Many low profile ARs have been deployed around the world, and have proven the ability to obtain recruitment and to attract fish. As mentioned, high profile reefs (i.e. > 3m above seabed) are more likely to aggregate pelagic species. The combination of high and low profile ARs may be expected to bring some benefits of aggregating a potentially more diverse fish assemblage. In addition, high reef profiles with elevations close to the water surface would be better to enhance benthic primary production (1). High profile prefabricated reef units of 5 m in height with similar designs to those presented in *Figure 3.3* can be considered for deployment. A variety of voids can be designed to provide enhanced habitat for adult (>0.5m voids) and juveniles (<0.5m voids). For AR unit with both voids suitable for adult and juveniles (see high profile AR design Type 2 in *Figure 3.5*), separation between compartments with smaller and larger voids are suggested to provide protection for smaller fish. Rough surfaces should be introduced on the AR to encourage the colonisation of marine organisms. The AR is also a suitable artificial habitat potentially to act as a spawning or nursery ground (large amount of shelter and microhabitat). Low profile Reef Balls (see *Figure 3.4*) can be deployed and it can be specifically designed to match goals and expectation. The basic Reef Ball is a hollow semicircle with an opening at the top and is made out of concrete that has been estimated to withstand chemical and physical elements of the ocean, giving it a life expectancy of over 500 years (2). The highest profile Reef Ball available is proposed for AR

(1) Mazzei, V. and Biber, P. (2015) Autotrophic net productivity patterns at four artificial reef sites in the Mississippi Sound. Hydrobiologia 749: 135-154.

(2) Sea and Coastal Protection with Reef Ball (n.d.) Reef Ball Italia. Available at: http://www.reefballitalia.it/wp-content/uploads/2016/03/brochure-english.pdf [accessed on 19-07-2018]

deployment. The Reef Ball is 1.52 m in height and 1.83 m in width with 25 to 40 holes providing surface area and protection.

Figure 3.3 ***Suggested Design of Prefabricated Concrete AR Units for High Profile ARs (Source: Hae Joo, AFCD)***

Figure 3.4 ***Suggested Design of Prefabricated Concrete AR Units (Reef Ball) for Low Profile ARs (Source: The Reef Ball Foundation)***

Potential Layout

The AR design is recommended to use a mixture of high and low profile prefabricated concrete ARs. The design comprises reef unit, reef set and reef group. A reef unit is the fundamental structure made of the prefabricated concrete ARs. A combination of reef units will form a reef set to increase the three-dimensional complexity, so as to enhance its potential in the recruitment of larvae of benthic organisms and juvenile fish. It is considered that spacing between reef units should be around 30 cm or less for fish that live on reefs while the spacing should be around 2-4 m between ARs for fish that are found directly around the reef [(1)].

It is proposed to use low profile ARs to connect between high profile ARs in order to enhance connectivity between the AR units. AR units of ~125 m^3

(1) Lennon, D (2011) Green Zones in Constructed Reefs. Available at: http://www.reefballaustralia.com.au/soi_tech_note-green_zones_in_constructed_reefs.pdf [accessed on 20-2-2017]

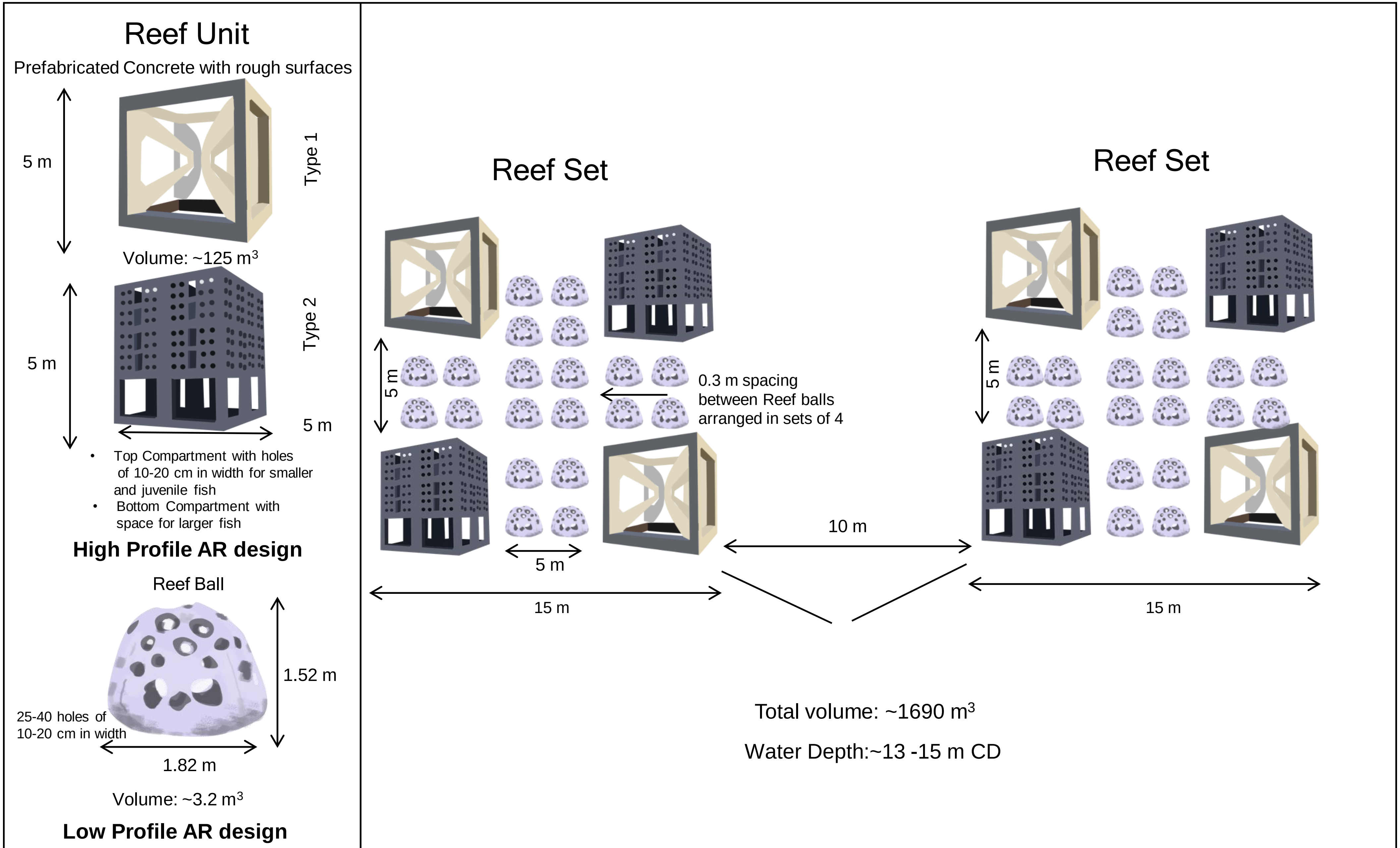

Figure 3.5

Recommended Layout for AR Deployment

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(5m x 5m x 5m) is proposed for the design of high profile reef units with each high profile AR separated by 5 m and connected by Reef Balls (low profile ARs) which will be organised in reef sets in between to increase connectively between the deployed ARs. It is suggested that 0.3 m spacing between each individual Reef Ball is adopted to ensure connectively and influence within the reef set. The potential layout of low and high profile ARs, comprising about 1,700 m^3 is presented in *Figure 3.5.* It should be noted that this layout is determined based on available information and designed based on an ecological approach to serve the purpose of fishery enhancement. As shown in the *Figure 3.5,* mixture of low and high profile ARs will form a reef group and reef groups will be separated by 10 m to form a reef complex. *Figures 3.6* to *3.9* presents the proposed layout of AR design with the geophysical survey results. The EPD approved Western Harbor Model predicted that waters generally move from the southeast towards northwest during the flood tide within the MPSA [(1)] and flows direction reverse during the ebb-tide. The AR is thus orientated with larger surface area exposed to the laminar current flow to enhance growth of sessile benthic fauna.

Engineering and Design

According to the results of the geophysical survey, the proposed deployment location is comprised of 3-5 m thick of marine deposits of fine sediments (possibility silt/clay) (*Figures 3.7* and *3.8*).

To understand whether the AR design is feasible to withstand prevailing and extreme environmental conditions, as well as the ability to anti-subside on the seabed, further ground investigation study, which may include ground investigation field work, will be conducted during the design review before construction of the ARs. Appropriate anti-subsidence measures, if necessary, will be incorporated into the AR design considering the stability of ground condition. In addition, review of hydrodynamic modelling results will also be undertaken during the design review.

Statutory Procedures

According to Environmental Impact Assessment Ordinance (Cap 499) Schedule 2, reclamation of 1 hectare in size may be regarded as a Designated Project and Environmental Permit (EP) is required for the construction, operation and decommissioning of a Designated Project. The area covered by the AR is less than 1 hectare in size within the proposed SLMP. The deployment of AR, however, has to be gazetted according the Foreshore and Sea-bed (Reclamations) Ordinance (Cap 127) (FS(R)O) which may require approximately 12 – 18 months to complete.

3.2.2 *Restocking of Fish*

In accordance with the EIA findings of IWMF Phase 1 and *EP Condition 2.8*, release of fish fry at the proposed ARs is recommended as an enhancement

(1) ERM (2006) *Op. cit.*

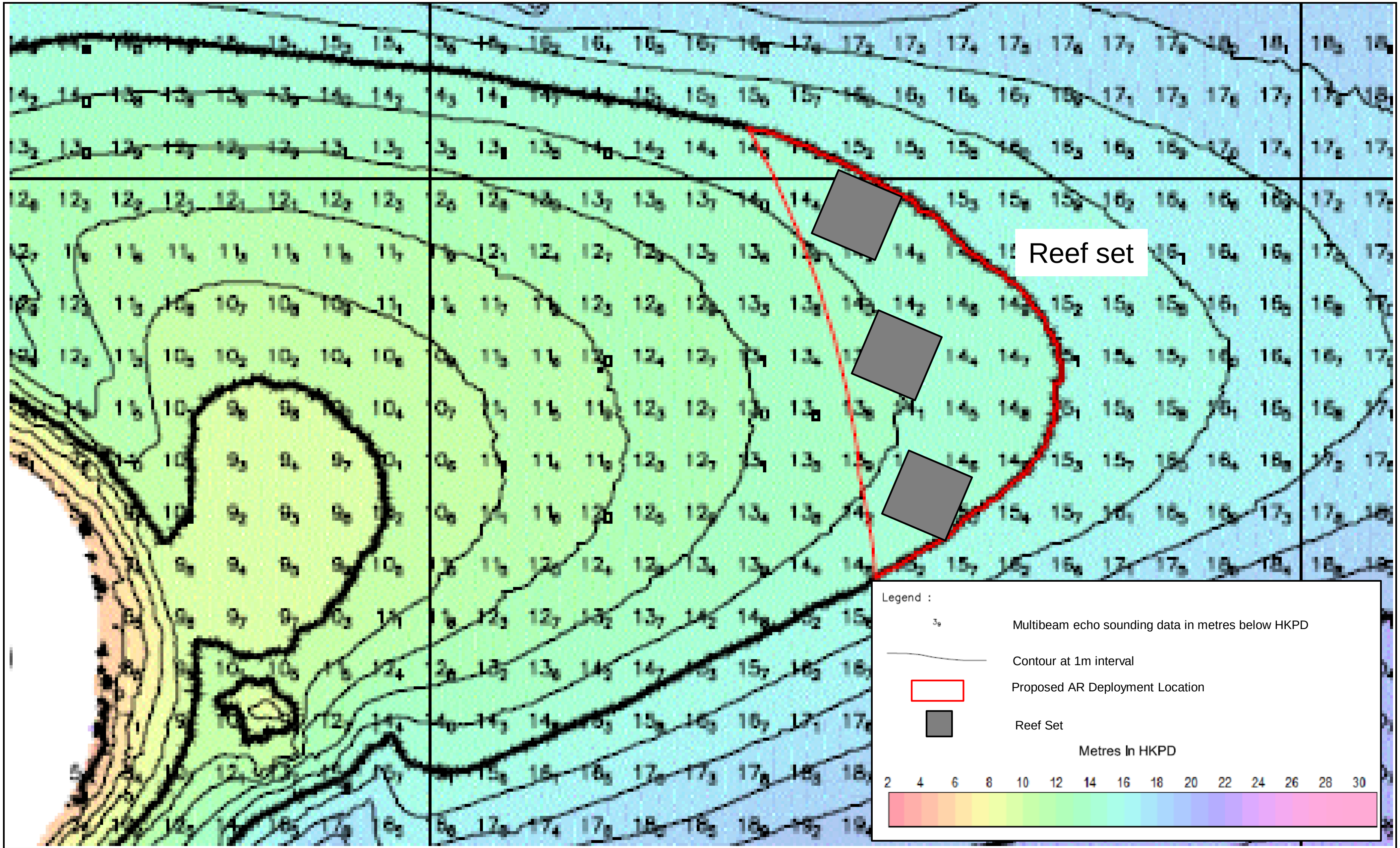

Figure 3.6

AR design with Bathymetry

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ERM

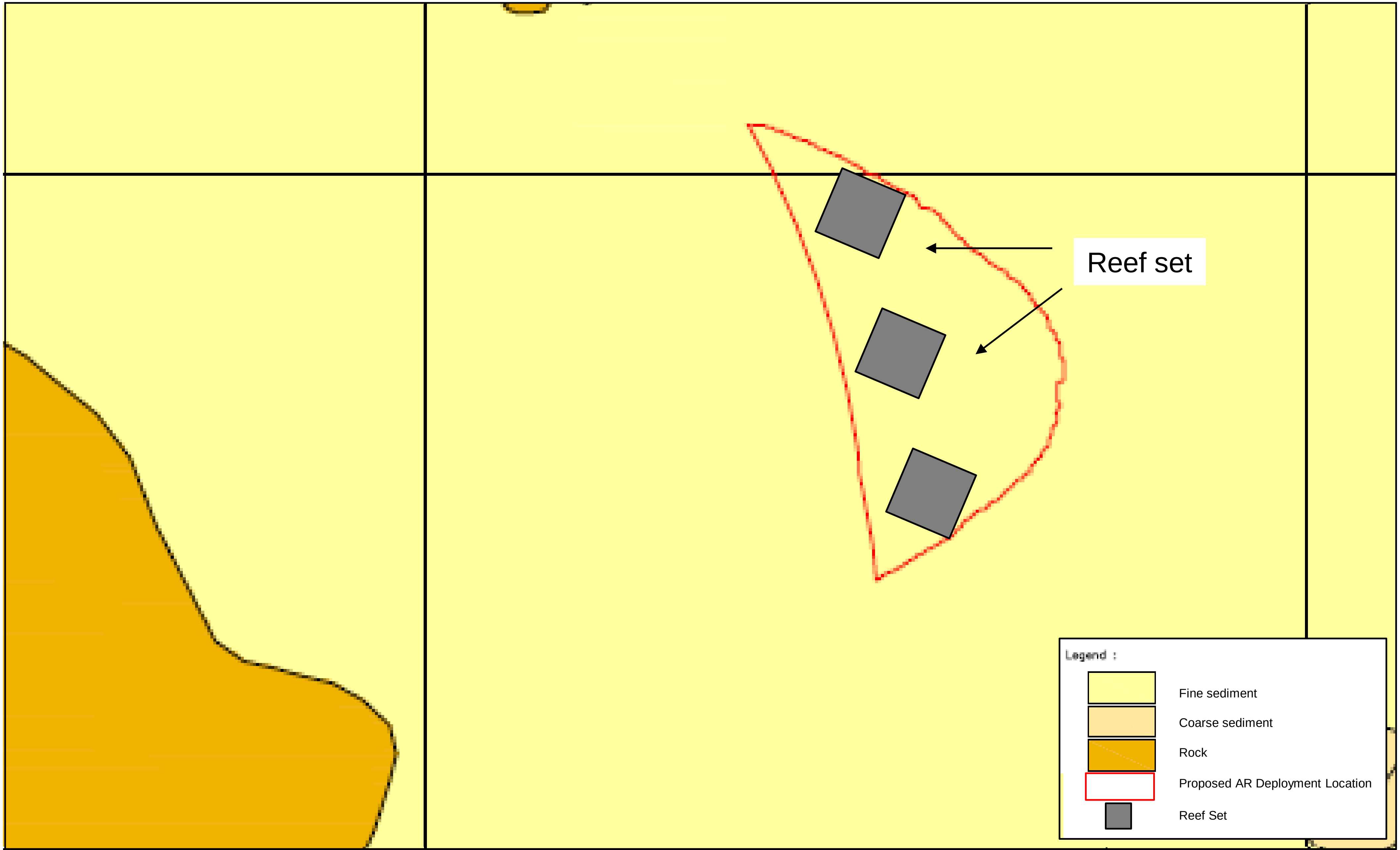

Figure 3.7

AR design with Seabed Features

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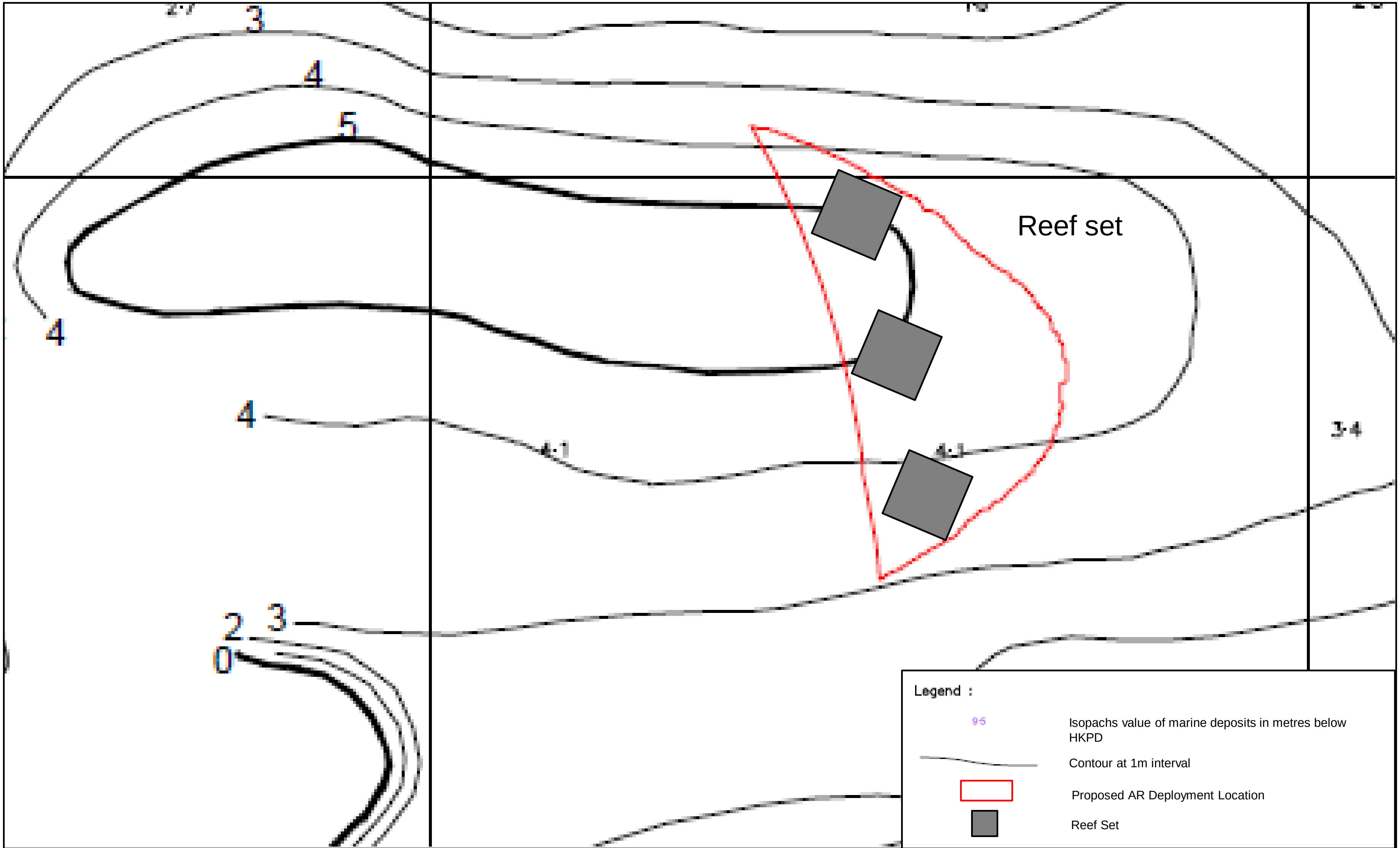

Figure 3.8

AR design with Contoured Isopachs of Marine Deposits

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Environmental Resources Management

ERM

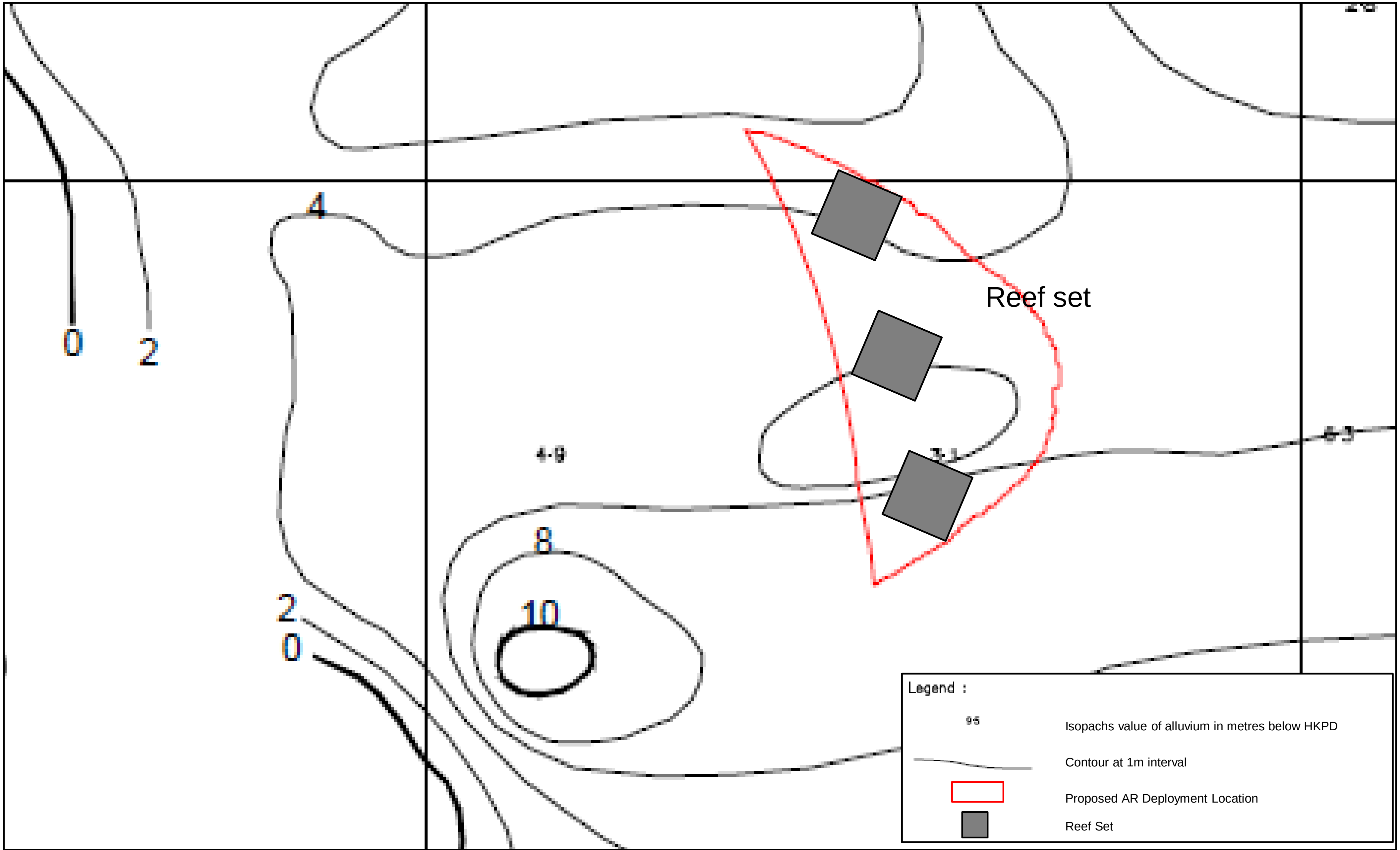

Figure 3.9

AR design with Contoured Isopachs of Alluvium

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measure for the fisheries resources in nearby waters and potentially prey resources for FPs.

The restocking, translocation and introduction of marine organisms and fishes are frequently used in an attempt to improve the quantity or quality of catches and provide long-term beneficial effects on fish stocks (1).

Restocking can be carried out for restoration, enhancement and conservation reasons:

- *Restoration stocking* is carried out after a limiting factor on stock recovery or improvement has been removed or reduced;
- *Enhancement stocking* is carried out to maintain or improve stocks where production is actually, or perceived to be, less than that the water body could potentially sustain; and
- *Conservation stocking* is carried out when native fish species are under considerable threat from extinction and stocking can be used to maintain these species.

Considerations for fish restocking can be complex, as the species, quantities and timing of the restocking exercise may result in different trophic and ecological interactions with the communities of the restocking site. This is no study to-date to confirm that fish restocking, using either adults or juveniles, can enhance fish stocks to directly benefit FPs and CWDs, e.g. notable increase abundance or usage of an area by FPs and CWDs. The potential of fish restocking in benefiting FPs and CWD, therefore, remains to be demonstrated. To maximize the potential to enhance fisheries resources, restocking could be conducted at the proposed ARs within the core area of the proposed SLMP where fishing will be prohibited at all times. As the fish resources study results indicate the areas around South Lantau waters support a moderate diversity of fish species, including those reef-associated species, it is expected that the introduction of fish fry and fingerlings of native species into the ARs could be beneficial to enhance fisheries resources in a long-term.

Guidelines

The objective of the restocking is to release fish fry to replenish populations of fish species that exist historically or currently in the FSA and are likely to associate with AR structures. In addition, the released fish could establish breeding population in a long-term to enhance fisheries resources.

<u>Species</u>

As mentioned above, there is no study that confirms that fish restocking can enhance fish stocks to directly benefit FPs and CWDs. The release of these species may thus not directly enhance the food availability for the FPs and

(1) Cowx (1994) Stocking strategies. Fish. Mange. Ecol. 1:15-31.

CWDs. The following criteria should be considered when determining the fish species to be released:

- Reef-associated species with high site fidelity to its home habitat in order to easily monitor the effectiveness of restocking.
- The availability of fish fry from hatchery; preferably sourced from a captive broodstock (hatchery reared) to reduce pressure in catching wild fry population.
- Native species is preferred to prevent the spread of invasive, exotic species that may threaten the local ecosystems.
- Species with high rarity or facing a high risk of depletion in the wild.
- Species with moderate to high economic value.
- Species that are naturally present in waters of the release area and its vicinity to avoid ecological imbalance.

Based on the above criteria and ease of monitoring, the following native fish species could be considered for the fish restocking at proposed AR deployed within the core area of the proposed SLMP. It is preferably to release only one species of the following species at one time to evaluate the effectiveness of fish restocking of that particular species, in terms of change in fish assemblages and intra-specific competition. In addition, this approach eliminates the potential inter-specific competition between each released species that may add complexity on the ecological interactions with the communities to determine the effectiveness of the fish restocking programme. It should be noted that the fish species proposed below are not meant to be exhaustive but represent the available fish species in market feasible for fish release. Other reef-associated fish species could also be considered in view of the available stock of fish fry in market at the time of fish restocking exercise.

As mentioned in *Section 2.6*, green groups and Marine Park Committee concerned about possible ecological imbalance caused by the release of proposed fish species of restocking. Therefore, considerations were taken to release species that are recorded during the fisheries resources surveys from September 2015 to August 2016 under the current Assignment within the proposed SLMP and with commercial value. The longlist of species that was considered is presented in *Table 3.2* below.

As presented in *Section 3.2.1,* species most likely to benefit from provision of increased and enhanced habitat by ARs structures in terms of productivity are Type A and Type B species such as groupers, snappers, seabreams and sweetlips. As such, the longlist of fish species included groupers, snappers, seabreams and sweetlips species recorded during the fisheries resources surveys from September 2015 to August 2016.

Table 3.2 Longlist of Fish Species considered for Fish Restocking

No.	Family	Species Name	Common Name
1	Haemulidae	*Pomadasys maculatus*	Saddle grunt
2	Serranidae	*Cephalopholis boenak*	Chocolate hind
3		*Epinephelus awoara*	Yellow grouper
4		*Epinephelus fasciatomaculosus*	Rock grouper
5		*Epinephelus coioides*	Orange-spotted grouper*
6	Sparidae	*Acathoopagrus latus*	Yellowfin seabream
7		*Pagrus major*	Red porgy
8		*Evynnis cardinalis*	Threadfin porgy

Note: * Orange-spotted grouper is not recorded during the surveys.

Amongst the longlist presented in *Table 3.2*, two seabream species that were recorded during the fisheries resources surveys were proposed for restocking which are of higher commercial value with available fish fry from hatchery. However, groupers species recorded within SLMP were of lower commercial value and a native grouper that was recorded in western waters in other surveys was proposed. It should be noted that groupers and seabreams are considered as potential prey of FPs and CWDs (1).

1) Orange-spotted grouper (*Epinephelus coioides)* [青斑]

Orange-spotted groupers are reported to be locally abundant and recorded in Indo-Pacific region, including China, Taiwan, Ryukyu Islands, Vietnam, Philippines, Singapore and Indonesia. This species has become uncommon in local waters nowadays, it is still one of the economically important species and moderately priced *Epinehpelus* groupers in Hong Kong.

The habitat preferences for this species include brackish estuarine environments and records indicate they are native to Hong Kong including western waters (2). Recent fisheries survey also reported that an individual of size 42 cm TL and biomass 760 g were recorded by trawling in the North Lantau waters during 2012-2013 and indicated that small number of this species inhabits western Hong Kong waters (3). Although not recorded in the fisheries resources survey in this Study, adult orange-spotted groupers' habitat includes turbid waters and brackish environment along the coast from inshore waters to deep offshore grounds while their juveniles are reported to recruit in brackish environments (4). The optimum salinity and temperature ranges are 20 to 35 ppt and 25°C to 32°C, respectively. Studies indicated that females mature at 25-30 cm TL (2-3 years old) and transition from female to

(1) Parsons, E.M (1997) Hong Kong's Cetaceans: the biology, socioecology and behaviour of *Sousa chinensis* and *Neophocaena phocaenoidaes*. University of Hong Kong. Unpublished Thesis.

(2) Sadovy Y, Cornish AS (2000) Reef Fishes of Hong Kong. Hong Kong University Press.

(3) Mott Macdonald (2014) Expansion of Hong Kong International Airport into a Three-Runway System. Environmental Impact Assessment Report.

(4) Sadovy Y, Cornish AS (2000) *Op. cit.*

male occurs between 55-75 cm TL [(1)]. It also showed to be long lived with 22 years as maximum record [(2)]. It is a tertiary consumer of trophic level 4 [(3)].

2) Yellowfin seabream (*Acanthopagrus latus*) [黃腳鱲]

Yellowfin seabream was reported as one of the moderately abundant to common species in Hong Kong water [(4)]. It was a common catch during January to March in 1970s. It is one of the economically important species and moderately priced fish in Hong Kong. It was formerly considered widespread in the Indo-West Pacific, but it is currently known to occur from the Pacific coasts of Honshu, Shikoku and Kyushu Islands, Japan, South Korea, Taiwan, China and northern Vietnam. This species occurs in shallow waters of river mouths and estuaries with a depth range to about 50 m [(5)]. It feeds on tidal flats mainly on echinoderms, worms, crustaceans and molluscs [(6)]. The maximum length of this species is 50 cm TL and is common to 30 cm TL [(7)]. This species reaches sexual maturity at ~24 cm TL [(8)(9)]. Low number of adult and larvae of yellowfin seabream were recorded during the Fisheries Resources Surveys under this Study which suggested that this species occur in the natural environment of the waters within the FSA in southern waters. The optimum and tolerance salinity is 30 to 33 ppt and 9 to 44 ppt, respectively. Studies indicated that sexual maturation occur at ~24 cm TL [(10)]. It is a tertiary consumer of trophic level of 3.8 [(11)]. The spawning period is during December to February [(12)].

(1) Sadovy Y, Cornish AS (2000) *Op. cit.*

(2) Mathews CP, Samuel M (1991) Growth, mortality and length weight parameters for some Kuwaiti fish and shrimp. Fishbyte 9: 30-33.

(3) Fishbase (n.d.) *Epinephelus coioides* (Hamilton, 1822). Available at: http://www.fishbase.org/Summary/SpeciesSummary.php?ID=6465&AT=Orange-spotted+grouper [accessed on 29-09-17]

(4) Sadovy Y, Cornish AS (2000) *Op. cit.*

(5) Randall, J.E. 1995. Coastal fishes of Oman. University of Hawaii Press, Honolulu, Hawaii.

(6) Mathews, C.P. and M. Samuel. 1991. Growth, mortality and length-weight parameters for some Kuwaiti fish and shrimp. Fishbyte 9(2): 30-33.

(7) Buxton, C.D. and Garratt, P.A. 1990. Alternative reproductive styles in seabreams (Pisces: Sparidae). Environmental Biology of Fishes 28(1-4): 113-124.

(8) Fishbase. Available at: http://www.fishbase.se/summary/6356

(9) Vahabnezhad A., Kaymaram F., Taghavi Motlagh, SA, Valinassab T. and Fatemi, S. M.R. (2016) The reproductive biology and feeding habitats of yellow fin seabream, *Acanthopagrus latus* (Houttuyn, 1782), in the Northern Persian Gulf.

(10) Vahabnezhad et al. (2016) *Op. cit.*

(11) Fishbase (n.d.) *Acanthopagrus latus* (Houttuyn, 1782). Available at: http://www.fishbase.org/Summary/SpeciesSummary.php?ID=6356&AT=yellowfin+seabream [accessed on 29-09-17]

(12) AFCD (n.d.) *Pagrus major* (Temminck & Schlegel, 1843) Available at: http://www.hk-fish.net/english/marine_fauna_database/fish_search_result_new_window.php?id=345 [accessed on 26-9-2017]

3) Red porgy / Red seabream (*Pagrus major*) [紅魟]

This species is a common species in Hong Kong. Seabreams are one of the economically important fish family in Hong Kong. Juveniles of this species are more likely to be observed underwater since adults inhabit areas of soft substrata in deeper waters (1). It can be found on open and soft substrates between 10 and 50 m and around reefs. This species is reported to be both protgynous and gonochoristics and its sexual patterns may vary in different areas. It is known to aestivate at 12°C or below and can live for more than 20 years. Red porgy were recorded during the Fisheries Resources Surveys under this Study which suggested that this species occur in the natural environment of the waters within the FSA in southern waters. Sexual maturity occurs at 2 year old (2). This species is a tertiary consumer of trophic level of 3.7 (3).

Size, Quantity and Frequency

It is considered preferable to release fingerlings (~10-15 cm) under the restocking programme due to the following reasons:

- Fingerlings are less susceptible to environmental changes than fries which are of smaller size (e.g. change in temperature, salinity) and usually with better developed immunity system.
- The effectiveness of the restocking programme can be monitored through hand-lining or other fish capture monitoring if fingerlings of large size are used.
- Larger fish size of fingerlings could lower the risk of predation with a higher possibility of successfully settlement and recruitment onto the enhanced features.
- According to local restocking experience, it is manageable to transport fingerlings from hatcheries to the release sites by simple means of using plastic bags and foam boxes.

Carrying capacities of the release sites are considered as useful data to determine the quantity of fish to be released. However, there is currently no publicly available information on carrying capacity of the core area of the proposed SLMP or its vicinity. As such, it is difficult to determine the optimum quantity of fish to be released at ARs before further monitoring and review. As a conservative approach to reduce the potential impacts of the released fish to the wild fisheries population, for example, through inter-specific competition, it is recommended to release a smaller quantity of fish to

(1) Sadovy Y, Cornish AS (2000) *Op. cit.*

(2) Lara, RT., Matsuyama, M and Matsuura, S (1987) Sexual Maturity of the Red Sea Bream *Pagrus major* from the Chikuzenkai, Northern Kyushu, in 1985. J. Fac. Agr., Kyushu Univ 31 (4): 383-389.

(3) Fishbase (n.d.) *Pagrus major* (Temminck & Schlegel, 1843). Available at: http://www.fishbase.org/summary/445 [accessed on 29-09-17]

the site. The release of smaller amount of fish will also reduce fish packing time which will in-turn reduce the stresses experienced by the fish during the restocking process. Under the current design, each low profile AR will provide 25 to 40 holes of 10-20 cm in width while each high profile AR with large and small voids will provide around 400 holes of 10-20 cm in width (*Figure 3.5*). As such, a total of 4,800 holes of 10-20 cm in width will be provided by the ARs for shelter of released fingerlings. Based on the above, it is considered that ~5,000 fingerlings per species should be released. The quantity of fish to be released will be further reviewed through the monitoring programme which will be undertaken for at least one year as discussed in the following sections.

The frequency of stocking will depend on the effectiveness of the initial release through extensive monitoring. The effectiveness of the restocking programme should be assessed before the subsequent release in order to confirm if the released fish is a suitable species to inhabit the AR and the surrounding area. The following key performance indicators should be used to determine the effectiveness of the restocking programme:

- Re-capture rate of the fish species at the AR deployment location and nearby subtidal hard bottom habitat. Given the low abundance of red porgy and yellowfin seabream recorded as well as the absence of orange-spotted grouper during the fisheries resources surveys from September 2015 to August 2016, it can be assumed that the re-captured fishes are those released by the restocking programme;
- Growth rate of released fish species; and
- Change in the fish community in terms of species richness.

The effectiveness of the restocking programme should be evaluated through monitoring which should be conducted for at least one year after fish fry release to cater for seasonal difference before further decision on the restocking frequency. If no released fish are encountered after a year, further investigation should be carried out to review the species chosen, time of release and the amount of fish to be released in future restocking event. Further restocking event should only be carried out when it has been proven to be beneficial to the ecosystems (e.g. increased biomass of the released species). The way forward of the restocking programme will be further reviewed with AFCD based on the monitoring results.

Fish Restocking Implementation

To allow time for establishment of fouling organisms and assemblages on the deployed ARs to provide potential food source for released fish, it is proposed that fish release to be conducted one year after AR deployment. Considering the cost effectiveness of the restocking programme, efforts should be made to source the fish fingerlings locally. This will lower the cost and also mortality associated with transporting juvenile fish. A hatchery or farm that can supply healthy fish fingerlings of the target species should be identified in advance. If local hatchery is not available, priority will then be made to identify the hatcheries in Guangdong Province in order to shorten the transportation time and maintain the health of the fish. In case of fish fry being imported outside Hong Kong, it is recommended to obtain health certificates issued by health authorities of the exporting countries to certify that the fish fry/fingerlings are free from harmful substances, parasites and diseases.

To prevent the released fish from passing potential disease agents infecting or associated with them into the natural environment, the sourced fish should be quarantined before releasing at the deployed ARs. The health conditions of fish should be closely monitored during the transport of fish to the site for fish release exercise. *Annex B* provided further details and guidelines for fish restocking.

3.3 CONTROL ON FISHING ACTIVITIES & ENFORCEMENT

Under the current arrangement, fishing activities in marine parks are controlled by a permit system. With reference to the existing marine parks, it is considered to allow eligible bona fide fishermen to continue fishing within the proposed SLMP subject to a permit system. On the other hand, AFCD is now reviewing the fisheries management measures in marine parks and exploring appropriate enhancement measures. In accordance with the recommendations of the review, AFCD will consider incorporating these enhancement measures into the management plan of the proposed SLMP.

3.4 PARK ADMINISTRATION

The government department responsible for the operation and management of the SLMP is AFCD.

3.4.1 Ecological and Environmental Monitoring

AFCD carries out long-term biological and water quality monitoring in the MPs and marine reserve of Hong Kong. The information obtained from monitoring is used to assess the conditions of ecologically important species, habitats and the marine physical environment. The information will provide the basis to guide the direction of future management strategies.

Long term biological and water quality monitoring similar to those conducted in others MPs in Hong Kong is recommended to be undertaken for the proposed SLMP. The detailed monitoring programme will be subjected to the resources and funding available and shall be further confirmed with AFCD. This is described in further detail in *Section 3.5.*

3.4.2 Marine Park Facilities

The facilities proposed for the SLMP are summarised in *Table 3.3*. These are consistent with those installed by the AFCD for visitors and marine users in other MPs of Hong Kong. These facilities are expected to be regularly maintained and updated to ensure optimum condition.

Table 3.3 ***Proposed Facilities of the Marine Parks***

Facilities	Purpose
Boundary buoys and poles	A boundary buoy has a yellow flash light attached which is activated at night. The boundary buoys marks the seaward boundary of the MP. These devices are designed to remind visitors and park users of the Ordinance and regulations when they enter the MP. A boundary pole is a metallic pole of alternative red and white colour that is erected on the coast.
Core Area Pole	Core area pole is a metallic pole with red colour, erected on the coast.
Marine Park Sign	A wooden sign established on an elevated level to show the name of the marine park (the marine park sign will be located on Soko Islands).
Marine Park Information Board	A wooden roof-top information board shows a map of the SLMP, as well as other information (the information board will be located on Soko Islands).
Marine Park Sign Board	A PVC information board with a symbol and descriptions are used to inform visitors of the regulations of MPs (the marine park sign board will be located on Soko Islands).

3.4.3 Enforcement

Whilst the plan presented in this report represents the recommendations with respect to managing the SLMP, it is evident that the success of any zoning or management initiative for the SLMP will be hinged upon the approval of the AFCD, the provision of supporting legislation and an effective enforcement framework, the engagement of all stakeholders and a sound public education strategy.

Effective enforcement should strive to monitor and minimize the degree of anthropogenic disturbance arising from visitors so that the integrity of the marine habitats can be maintained. Legislation relevant to the management of marine parks in Hong Kong will be implemented and enforced for the SLMP. In order for the SLMP to be successful, enforcement of the regulations specified in the *Marine Parks Ordinance (Cap 476)* is essential, particularly with regard to controlled activities (e.g. fishing or collecting activities) and compliance with vessel speed restrictions (a key issue with marine mammals). It is recommended that routine sea patrols and law enforcement operations within the SLMP are carried out by AFCD staff in joint enforcement action with other relevant authorities in order to suppress prohibited activities. As with the current practice, AFCD will work closely with relevant departments to enforce *Marine Parks Ordinance (Cap 476)*, including conducting joint enforcement operations from time to time to deter irregularities.

Marine park wardens regularly patrol all marine parks and marine reserve in Hong Kong, both by sea and/or on land and over daytime and night-time. One of the tasks of the marine park wardens is to pay attention to all activities inside marine parks and marine reserve, and make sure all users comply with the *Marine Parks Ordinance (Cap 476)* and the *Marine Parks and Marine Reserves Regulation (Cap 476A)*. A marine park warden can also provide advisory services to visitors upon request, and where necessary, warnings to visitors and prosecute those people who committed offences such as littering, collection of marine life, non-compliance with vessel speed restrictions etc.

3.4.4 Public use

Potential public uses of the SLMP include educational and public awareness activities. To promote education and public awareness of the marine environment and to foster better public support for marine conservation, AFCD annually:

- Produces and distributes educational and publicity materials, organizes talks, outreach programmes and exhibitions such as in the Hong Kong Wetland Park, public venues and schools; and
- Disseminates nature conservation messages and information about MP resources and facilities through AFCD's websites; organizes educational activities and guided tours for the general public and students.

Ongoing effort in key marine education programmes and publicity activities organised by the AFCD is recommended to be extended to the SLMP.

3.5 ECOLOGICAL & ENVIRONMENTAL MONITORING

Effective monitoring programmes will help determine whether a marine park is successful in achieving its goals. Monitoring of ecological/ fisheries resources will also help provide for the sustainable use and public appreciation, and understanding and enjoyment of marine parks.

Developing a suite of suitable performance indicators and tracking them using a specific monitoring and audit programme are considered to be essential for the management of the SLMP. When the monitoring programme detects that the key performance indicators are not met, management, enhancement or remedial measures may need to be undertaken to allow for the recovery of the affected aspect or value. The following monitoring components are suggested:

- Marine mammals;
- Water quality;

- Fish resources; and
- Evaluation of enhancement measure.

The diversity of monitoring theme reflects the broad range of ecological and fisheries information required for effective marine park management. The monitoring and audit programme for the SLMP are proposed for AFCD's consideration which will be subjected to the resources and funding available.

3.5.1 Marine Mammal Monitoring

The purpose of the marine mammal monitoring programme for the SLMP is to provide long-term data and scientific knowledge to determine if the marine park serves as a sanctuary for FP and CWD as intended. The characteristics of FP and CWD (e.g. abundance, density, behaviour and habitat use, etc.) and their natural variability in the SLMP and its vicinity will be established. Findings would also be used to facilitate the allocation of conservation effort in order to focus on areas of high ecological /conservation interest. This would allow cost-efficient and ecologically-relevant conservation programmes to be implemented in the future.

It should be noted that the detailed study methodology should be consistent with the AFCD long-term marine mammal monitoring. Consistency in survey methodology will ensure that the results obtained in the marine monitoring can be compared and used in conjunction with previous AFCD's marine mammal data and that the monitoring programme in the SLMP is defensible as the methodology has been accepted and approved previously.

Abundance Monitoring

Potential change in the abundance, density and spatial distribution of marine mammals (especially FP and CWD) in the SLMP should be monitored regularly. The findings of these long-term monitoring programmes would contribute to the identification of spatial and temporal changes in FP and CWD population structure in response to the designation of the SLMP and ongoing activities and marine uses in the vicinity.

Spatial and temporal patterns of distribution and abundance of marine mammals in the vicinity of the SLMP would be investigated by systematic boat-based line transect surveys. The feasibility (resource availability) of extending surveys into nearby waters to collect additional population data for the evaluation of larger-scale distribution patterns will be explored. The survey effort will be evenly distributed throughout the year, e.g. at least six surveys to be conducted per solar season in order to generate a representative dataset.

Behavioural Studies

Behaviour studies are important as the behaviour of an animal can reflect its health status and the level of disturbance it is experiencing. Marine mammal behavioural research is common in other parts of the world (e.g. the US), but are not common in Hong Kong due to shortage of funds.

Behavioural observations and acoustic monitoring could be considered to be implemented in the studies. However, FPs are shy and behavioural observations (both vessel and land-based) for the species may be hard and ineffective. Theodolite tracking and analysis capabilities could be used during behavioural observations to locate the animals. Acoustic monitoring (e.g. PAM, C-PODs or EARs) could be used to help determine the activities of the FP and CWD at key locations within and in the vicinity of the SLMP.

Recommendation

The AFCD long-term marine mammal monitoring programme covers waters of the SLMP and its vicinity. Therefore, to reduce the capital and operating cost and to avoid redundancy in monitoring effort, no specific marine mammal monitoring programme is proposed for the SLMP.

3.5.2 Water Quality Monitoring

Similar to the existing MPs and MR, it is recommended to monitor the conditions on marine physical environment and to guide future management strategies. It is proposed for AFCD consideration to conduct water quality monitoring quarterly every year following the existing monitoring methodology for MPs and MR where possible. Monitoring will be conducted at four (4) stations within the SLMP (see *Figure 3.10*). Water parameters will be compared with the Water Quality Objectives (WQOs) of Environmental Protection Department (EPD) in the relevant Water Control Zones (WCZs). The water quality parameters to be monitored will be same as those monitored by AFCD in other MPs and MR:

- Temperature (˚C);
- Salinity (‰);
- Dissolved Oxygen (mg/L);
- pH;
- Secchi Disc Depth (m);
- Turbidity (NTU);
- Suspended Solids (mg/L);
- 5-day Biochemical Oxygen Demand (mg/L);
- Ammoniacal Nitrogen (mg/L);
- Unionised Ammonia (mg/L);
- Nitrite Nitrogen (mg/L);
- Nitrate Nitrogen (mg/L);
- Total Inorganic Nitrogen (mg/L);

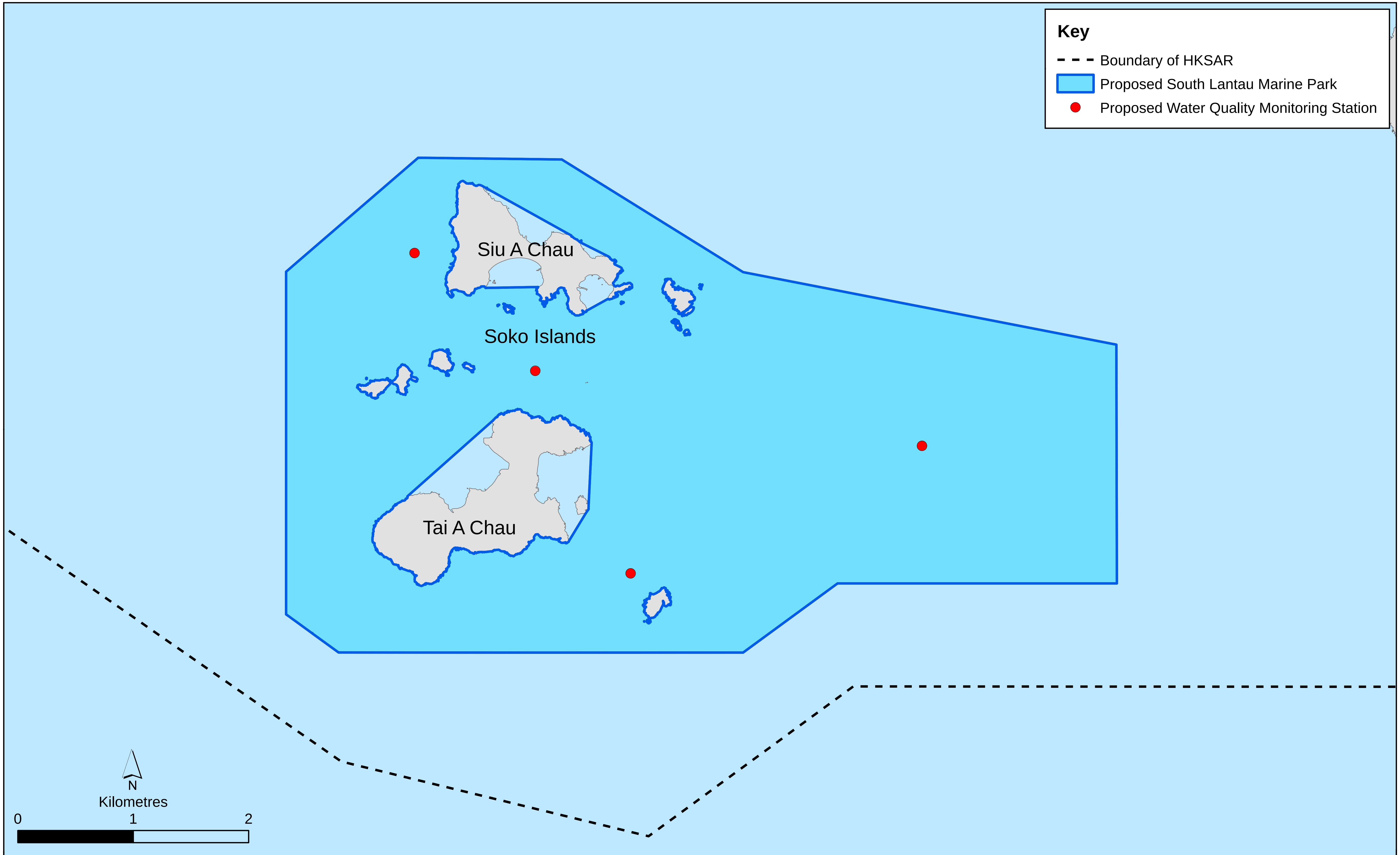

Figure 3.10

Proposed Water Quality Monitoring Stations

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- Total Kyeldahl Nitrogen (mg/L);
- Total Nitrogen (mg/L);
- Orthophospate Phosphorus (mg/L);
- Total Phosphorus (mg/L);
- Chlorophyll-*a* (µg/L);
- *E. coli* (cfu/100 mL); and
- Faecal Coliforms (cfu/100 mL)

3.5.3 *Fish Resources Monitoring*

The purpose of the fish resources monitoring programme for the SLMP is to provide long-term data on fish resources for the evaluation of the effectiveness of the designation of the MP. The biodiversity of fish resources (e.g. abundance, distribution and assemblage structure, etc.) and their natural variability in the proposed MP and their vicinity will be studied.

Spatial and temporal pattern of distribution, abundance and diversity of fisheries resources in the SLMP and their vicinity will be monitored by field surveys using fishing methods such as gill-netting and hand-lining (subject to issuance of relevant fishing permit). Typical methodology of these fishing methods is summarised below:

Gill netting: Gill nets (30 m x 1 m three –layered gill net, of mesh sizes (6 cm) will be deployed at each location for 2 hours before harvesting. Upon retrieval, all fish caught will be collected with length and weight measured. The number of fish caught per net per hour will be calculated.

Hand Lining: Hand lines will be deployed by fishermen at each site for 30 minutes. Same group of fishermen and similar fishing bait (preferably life shrimp) will be used in each sampling site to standardize the fishing techniques.

The monitoring programme can focus on the study the changes in biodiversity and abundance of prey species of FP and CWD. The fisheries resources monitoring programme will provide both qualitative and quantitative data in order to generate a comprehensive dataset of fish biodiversity of the areas. Qualitative data gathered from the surveys (e.g. a list of species recorded, photos), can be used to produce a short book/ brochure/ website to describe the marine biodiversity around the SLMP to support potential recreational, educational, public awareness and eco-tourism activities. Quantitative data (i.e. distribution and abundance data) will be used as the database for tracking and comparing the monitoring results easily and systematically over time. When a relatively large database has been gathered, a review and evaluation can be conducted to decide whether the monitoring would be continued. Monitoring will be conducted at six (6) sampling stations within the SLMP and two (2) control stations outside the SLMP (see *Figure 3.11*). The

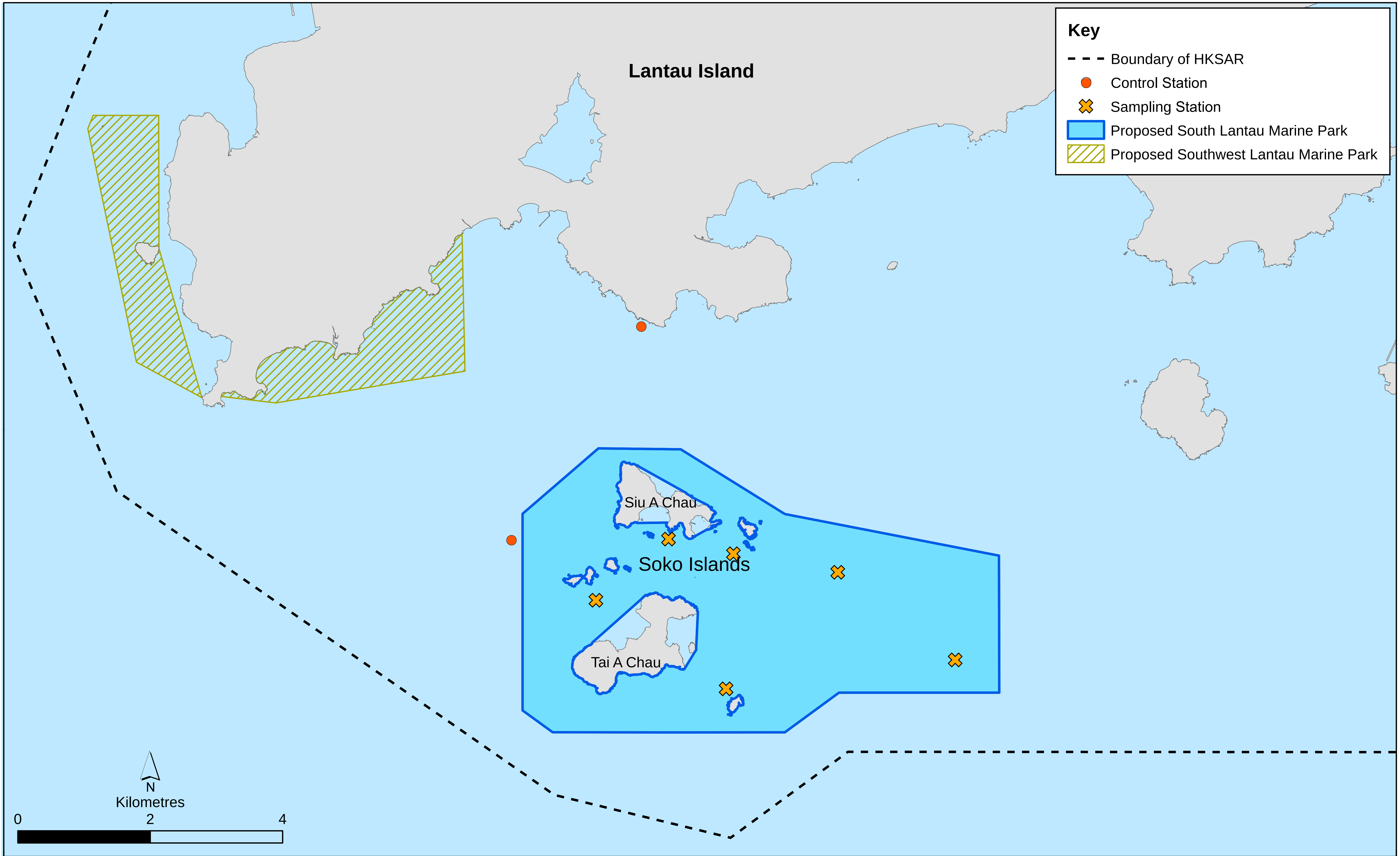

Figure 3.11

Proposed Fish Resources Monitoring Stations

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frequency and duration of fisheries resources monitoring will be further discussed with AFCD.

3.5.4 *Evaluation of Enhancement Measure*

Performance of AR Deployment

To evaluate the performance of the deployed ARs, the following monitoring programme is proposed to be conducted:

Structural Monitoring

Annual side-scan sonar surveys are proposed to be conducted yearly for at least two years at the AR areas to determine if any lateral movement of the ARs has occurred and to determine the sinking rate of the ARs structures. The first monitoring will be conducted at least one year after the AR deployment during the non-typhoon season while the second monitoring will be undertaken one year after the first monitoring.

Fish Resources Monitoring

Fish resources monitoring surveys are recommended to investigate the performance of ARs after deployment. Adult fish surveys for the ARs monitoring will be conducted at AR deployment area (one sampling station) and two (2) control stations at nearby subtidal hard bottom habitats within the core area to record fish diversity, abundance and catch per unit effort (CPUE) (*Figure 3.12*). Monitoring is suggested to be performed quarterly for at least two years after the AR deployment to cater for seasonal difference. Baseline data will be adopted from the results of the fisheries resources survey under this Study. The survey methods are described below:

Gill netting: Gill nets (30 m x 1 m three –layered gill net, of mesh sizes (6 cm) will be deployed at each location for 2 hours before harvesting. Upon retrieval, all fish caught will be collected with length and weight measured. The number of fish caught per net per hour will be calculated. The gill nets should be deployed according to the water current to minimise the disturbance and entanglement to ARs during monitoring.

Hand Lining: Hand lines will be deployed by fishermen at each site for 30 mins. Same group of fishermen and similar fishing bait (preferably life shrimp) will be used in each sampling site to standardize the fishing techniques.

The catches from the gill netting and hand lining surveys will be identified to species level as far as practicable. The catches will be analyzed for species composition, diversity and abundance. All fish captured during the hand lining survey will be released after record of species and number.

Although *in situ* observations and fish counts are widely used to estimate fish abundance on ARs, the underwater visual census method is not feasible for this study area due to the water clarity which precludes 1) required duration

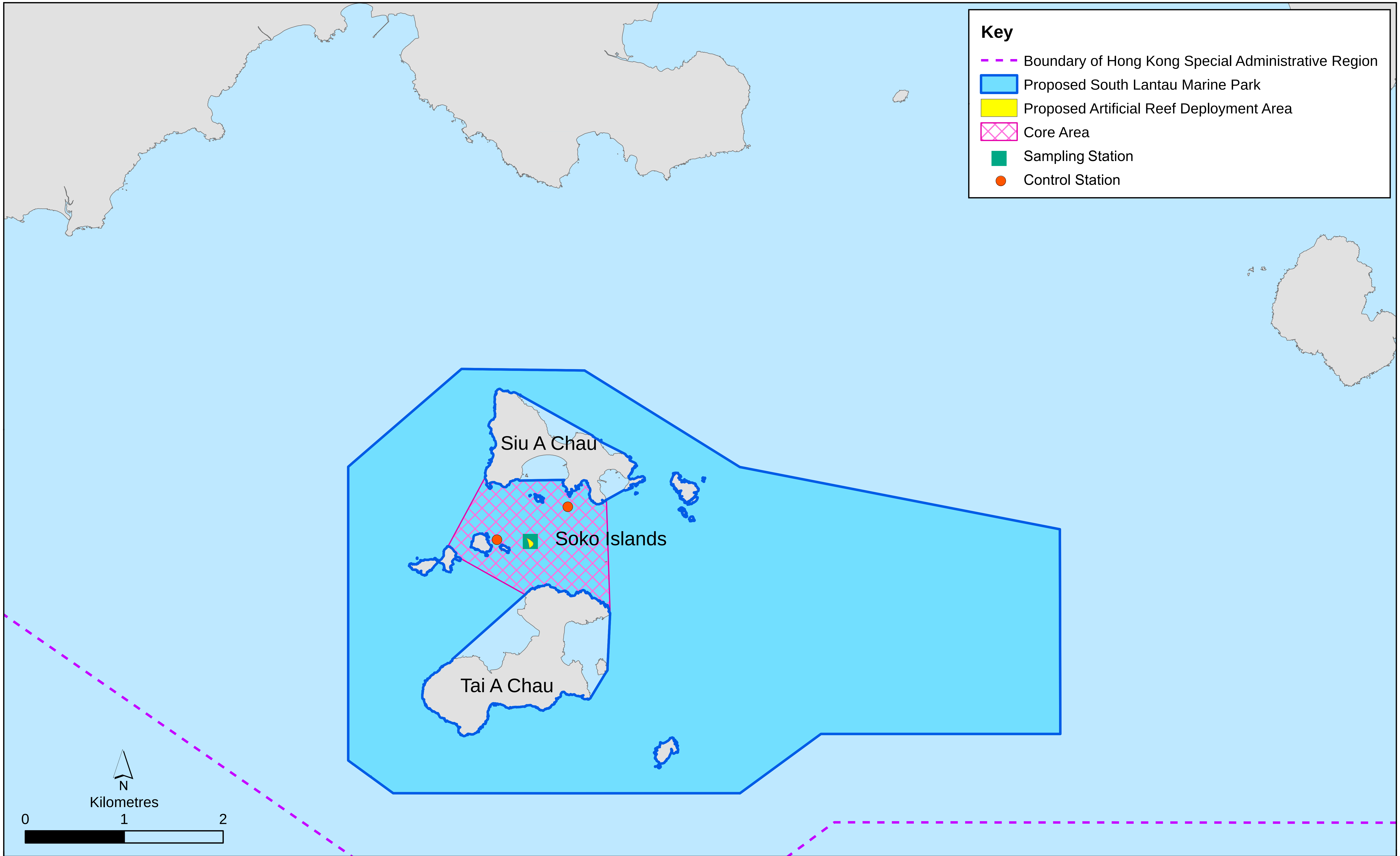

Figure 3.12

Proposed Enhancement Measures Monitoring Stations

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of dives for proper fish census, and 2) visibility necessary for counts. Thus, this method of fish census is not proposed for monitoring.

Performance of Fish Restocking

To evaluate the effectiveness of the fish restocking programme, it is suggested that monitoring are conducted for at least one year after fish fry release to cater for seasonal difference before further decision on the restocking frequency. If the released fish are no longer encountered after a year, further investigation is proposed to be carried out to review the species chosen, time of release and the amount of fish to be released in the future. Further restocking should only be carried out when it has been proven to be beneficial to the ecosystems (e.g. increased biomass of that particular species). The way forward of the restocking programme will be further reviewed with AFCD based on the monitoring results.

As mention in the discussion of AR monitoring, usually, non-destructive visual methods such as underwater visual census (UVC) surveys are preferred for recording observed fish assemblages around and within the AR. However, in view of low underwater visibility due to high sediment loading from Pearl River discharge, it will preclude the use of UVC techniques.

Tagging methods can also potentially be used to monitor the released fish species. Different types of physical, chemical and biological tagging may be used to mark the cultured fish so as to distinguish them from the naturally-occurring stock. However, most tagging can only employed for fingerlings (>10cm) or adult fish. The tagging methods are discussed below.

Physical tags have been developed and first used in the 1990s for fingerlings or adult fish. External tags, such as clip tagging and strap tagging, are widely used to allow visual and individual recognition, but these kind of tags are almost certainly associated with high mortality of the stocked fish due to predators attraction, interference with locomotion and increase susceptibility to disease and infection [(1)]. More advanced internal tags have also been used, such as coded wire tags, passive integrated transponder (PIT) tags, radio tags, sonar tags and data storage tags with global positioning system (DST GPS tag). These tags may prevent alternation of the fish behaviour due to the absence of protruding tags. They also allow long-term automatic monitoring to be performed. However, some of these tagging methods can be expensive and require additional detection equipment.

Chemical tagging involves staining and tattooing through immersion and feeding with dyes and injection with chemical markers, such as alizarin, oxytetracycline and calcein. These methods are relatively low cost, fast and can mark large number and different size of fish within a short period of time. The chemical exposure may pose toxicity to fish and cause a higher mortality rate. The toxicity may accumulate along the food chain and affect human

(1) Wydoski R, Emery L (1983) Tagging and marking. 215-237

who consume the fish. The duration of the tagging depends on retention time of the marker. For example, marking the otoliths (ear bones) of juvenile fish by submerging them in alizarin with 10-300mg/L can retained for at least 160 days with 0–3% mortalities [(1)] [(2)] while marking of the otolith of adult snappers by oxytetracycline injection are still visible after 3 years [(3)] .

Biological features of the released fish, such as morphology and genetic markers, have been used as the tagging, but this technique cannot be performed in fish fry. Thermal tags is one of the technique to effectively marking culture fish in the hatchery, but the otoliths of the captured fish need to be retrieved and this destructive method prevent long-term monitoring. Another method is identifying released fish stock using genetic analysis, such as microsatellite-based genetic parentage assignment [(4)]. This method can also identify the genetic diversity of the fish population after stocking practice and investigate the reproductive success of the hatchery rearing fish. However, to perform the genetic analysis, it can be costly and time consuming to collect and preserve blood samples.

According to the fisheries resources surveys from September 2015 to August 2016, no orange-spotted grouper was recorded and there was low abundance of red porgy and yellowfin seabream. As such, it can be assumed that individuals of orange-spotted grouper, red porgy and yellowfin seabream recorded are those released by the restocking programme. No tagging is thus recommended to be undertaken to identify released individuals.

Considering the above, fish capture is the only option to monitor the performance of the fish restocking programme. It is proposed that monitoring will be conducted at two ARs with fish released within the AR deployment location as well as two nearby natural reefs. Monitoring of fish restocking will share the same monitoring location (see *Figure 3.12*) as monitoring of the ARs deployed. To minimise fishing pressure on the restocked fish, it is proposed to conduct hand lining only during fish capture survey. All fish captured during the hand lining survey will be released after size measurement and species determination.

Baseline monitoring will be conducted quarterly for one year before fish release to provide data of pre-release conditions. The surveys shall be conducted for a period of one year after fish release to observe the status of the released fish against different seasons, so as to monitor the fish size over time and the movement of the fish. It is initially proposed to conduct biweekly surveys during the first 3 months after fish release, followed by monthly

(1) Beckman DW, Schulz RG (1996) A Simple Method for Marking Fish Otoliths with Alizarin Compounds. Transactions of the American Fisheries Society. 125:146-149.

(2) van der Walt B, Faragher RA (2003) Otolith Marking of Rainbow Trout Fry by Immersion in Low Concentrations of Alizarin Complexone. North American Journal of Fisheries Management. 23:141-148.

(3) Francis R, Paul LJ, Mulligan KP (1992) Ageing of Adult Snapper (*Pagrus auratus*) from Otolith annual ring counts: Validation by tagging and Oxytetracycline Injection. Australian Journal of Marine and Freshwater Research. 43:1069-1089.

(4) Araki H, Schmid C (2010) Is hatchery stocking a help or harm? Evidence, limitation and future directions in ecological and genetic surveys. Aquaculture 308:S2-S11.

surveys. The monitoring frequency and survey location will be reviewed based on data collected during the yearly period. Environmental data (such as water temperature, salinity, DO, SS, turbidity etc) should be collected to provide supplement information for result analysis.

The following key performance indicators should be considered to determine the effectiveness of the restocking programme:

1. Re-capture rate of the fish species at the ARs and nearby reefs;

2. Growth of released fish species; and

3. Change in the fish community in terms of species richness.

The cost-effectiveness of the monitoring programme will be determined based on the re-capture rate of the released fish. The re-capture rate of the released fish will be determined based on the number of release fish caught per unit survey effort. The results of the re-capture rate will determine the suitability of the size and fish species released. If the re-capture rate is found relatively stable, the monitoring frequency can be relaxed to quarterly monitoring.

The change in size of released fish species can determine the growth of the fish so as to evaluate whether there are sufficient amounts of released fish that are grown to mature size for breeding in the future. This is critical to demonstrate the sustainability of the fish restocking programme.

The change in fish community is also important for the restocking program. The release is thought to be beneficial if the species richness (in terms of abundance and diversity) within and around the ARs sites are found to be higher. In contrast, the release may be adverse when the species richness decreased. In such case, the species, size, quantity as well as the frequency of the fish release exercise should be immediately reviewed to prevent further deterioration of the sites.

3.5.5 *Summary of Monitoring Programme in the SLMP*

A summary of the monitoring programme of the SLMP is presented in *Table 3.4*.

Table 3.4 Summary of Monitoring Programme

Monitoring Programme	Description	Frequency
Marine Mammal Monitoring	No specific monitoring programme is proposed as the AFCD long-term marine mammal monitoring programme cover the waters of SLMP.	Nil
Water Quality Monitoring	Water Quality Monitoring according to the current water quality monitoring methodology in MPs and MR.	Quarterly by AFCD.
Fish Resources Monitoring	Fish Resource Monitoring by gill netting and hand lining which is in line with the methodology of fish resources monitoring in other marine parks.	Frequency and duration to be further discussed with AFCD
AR deployment Monitoring (Evaluation of enhancement measure) by EPD	Monitoring the effectiveness of the ARs deployed through fish resources monitoring (by gill netting and hand lining) and Structural Monitoring by side-scan sonar surveys.	Fish resources monitoring at deployed ARs will be conducted quarterly for at least two years. Structural monitoring of ARs will be conducted yearly for at least two years. The first structural monitoring will be conducted at least one year after the AR deployment during the non-typhoon season while the second monitoring will be undertaken one year after the first monitoring.
Fish Restocking Monitoring (Evaluation of enhancement measure) by EPD	Hand lining to monitor the effectiveness of the restocking programme.	Baseline monitoring for quarterly for one year before fish release. Biweekly surveys for the first three months after release, followed by monthly surveys afterwards for at least one year. The Monitoring frequency can be relaxed to quarterly monitoring if re-capture rate is found relatively stable.

3.6 *POTENTIAL MANAGEMENT PLAN*

The potential management plan is summarized in *Table 3.5*.

Table 3.5 Summary of Management Plan

Item	Description
Zoning Management	Core area proposed within the SLMP.
Location of ARs Deployment	ARs can be deployed inside the core area of the proposed SLMP.
Fish Restocking	Restocking could be conducted at the ARs within the core area of the proposed SLMP.
Control of Fishing Activities	With reference to current arrangement in the existing marine parks, fishing activities in the SLMP are proposed to be controlled by a permit system.
Public Uses	Potential public uses of the SLMP include educational and public awareness activities.
Enforcement	Ensure all users comply with the *Cap 476 Marine Parks Ordinance* and the *Cap 476A Marine Parks and Marine Reserves Regulation*
Ecological & Environmental Monitoring	Long-term water quality monitoring, monitoring on marine mammals (by existing AFCD long-term marine mammal monitoring programme), fish resources and evaluation of enhancement measure (AR deployment and fish restocking) are recommended.

The marine park design should also ensure that location of the marine park and its zones are easy and simple for marine user to identify. Tools should be available to educate users about the positioning of marine park boundary and to assist compliance and enforcement within the marine park. Boundary shape, methods for defining boundary (e.g. use of buoys at appropriate location) and management (e.g. zoning) consistent with other marine parks in the system would aid community understanding. The proposed management plan of the SLMP is presented in *Figure 3.13.*

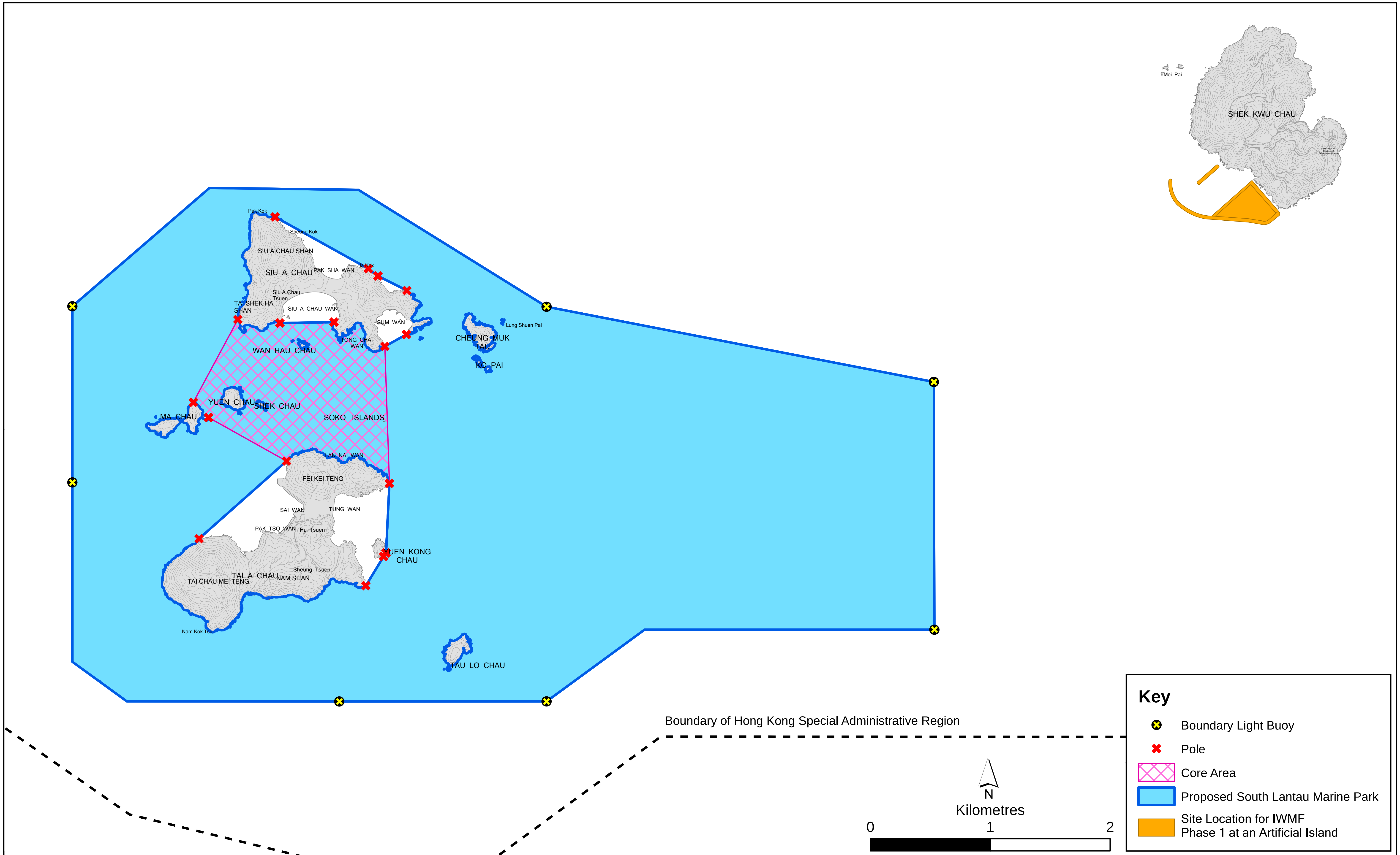

Figure 3.13

Proposed South Lantau Marine Park - Management Plan and Marine Park Facilities

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4 CONSTRUCTION PROGRAMME

4.1 DESIGNATION OF SOUTH LANTAU MARINE PARK

Designation of the SLMP will involve statutory procedures under the Marine Parks Ordinance (Cap 476). Subject to the views of the Country and Marine Parks Board (CMPB) and any other opinions collected, the Country and Marine Parks Authority may proceed with the following statutory procedures:

(a) the Authority, at the direction of the Chief Executive in Council, to prepare draft map in consultation with CMPB;

(b) the Authority to publish in the Gazette a notice about the availability of the draft map for public inspection;

(c) the CMPB to hear any objections to the draft map, if any; and

(d) the Authority to submit the draft map, together with objections and representations, to the Chief Executive in Council for approval.

It is expected that designation of the SLMP will be completed in 2019.

4.2 FISHERIES ENHANCEMENT MEASURES

A design review and construction of the ARs will be conducted after the designation of the proposed SLMP. After the design review of the ARs, the deployment of ARs will be gazetted by notice under Section 5 of the Foreshore and Seabed (Reclamations) Ordinance Cap 127. It is anticipated that Designation of SLMP will be completed by 2019. The tentative implementation schedule for the fisheries enhancement measure is presented in *Annex C.*

5 CONCLUSIONS

The proposed boundary of the compensatory MP of the IWMF Phase 1 project has been delineated based on key considerations including importance of FP habitat, fisheries resources, management and enforcement, size, compatibility with existing and planned/ potential marine facilities/ developments and marine traffic activities, as well as views from stakeholders. The proposed boundary for the compensatory MP, as illustrated in *Figure 2.13*, encompasses an area of 797 ha adjacent to the east of Soko Islands, which adequately covers important habitats for FPs and area with moderate fisheries production. The proposed boundary of the compensatory marine park also avoided the identified TSS and area with high density of marine traffic activities, and without encroachment into the existing South of Cheung Chau Sediment Disposal Area.

The proposed compensatory MP will be integrated with the proposed SIMP into a larger SLMP, as shown in *Figure 2.14*, to allow for better integrated management as well as ecological connectivity and linkage in marine resources.

The management plan and enhancement measures have been proposed for the SLMP, and the key measures included the following:

1. Management by zoning to further conserve ecological important habitats;

2. Deployments of ARs and release of fish within the core area of the proposed SLMP to enhance marine habitats and associated fish stocks;

3. Fishing control on commercial and recreational fishing within the SLMP to improve ecosystems in MP and offer better protection for marine ecological resources;

4. Enforcement in accordance with *Marine Parks Ordinance (Cap 476)* and *Marine Parks and Marine Reserves Regulation (Cap 476A)* with specific attention on controlled activities (e.g. fishing and collecting activities) and compliance with vessel speed restrictions;

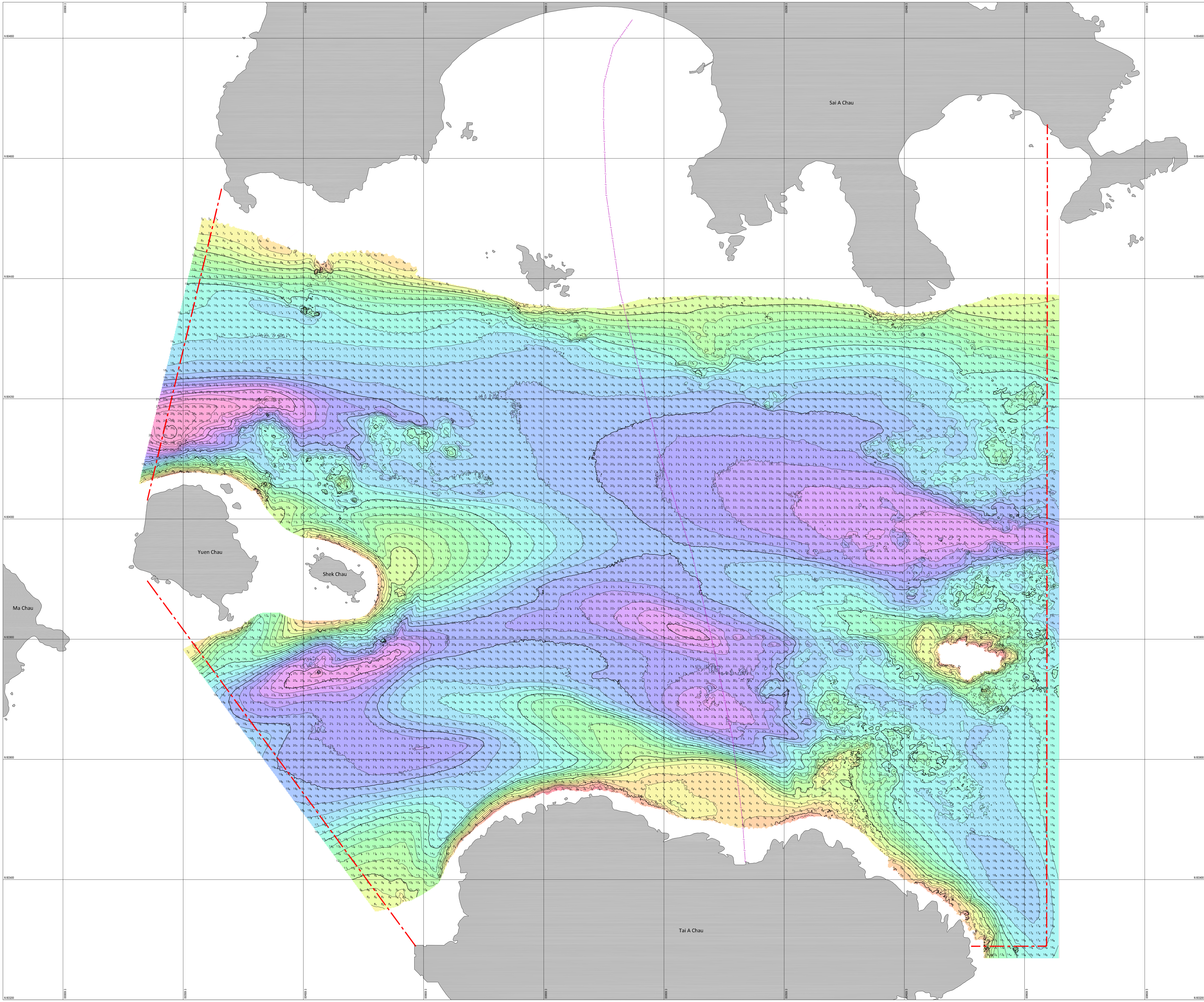
5. Monitoring programmes to collate data of marine mammals, fisheries resources and water quality within the SLMP and adjacent waters to evaluate its effectiveness; and

6. Public use, including educational and public awareness activities, to foster better public support and public awareness of marine conservation.

Designation of the SLMP will involve statutory procedures under the Marine Parks Ordinance (Cap 476). The AFCD and the EPD will work closely together during the process of the marine park designation, with an aim to completing the statutory designation procedures of the SLMP by 2019.

Annex A

Results of Geophysical Survey

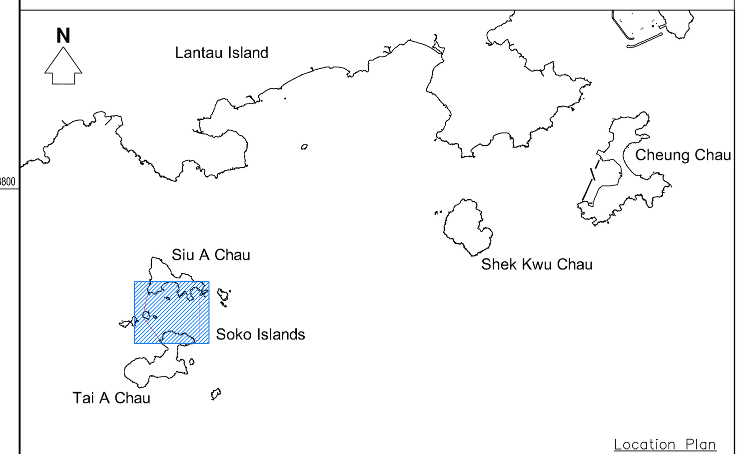


Legend :

- Multibeam echo sounding data in metres below HKPD
- Contour at 1m interval
- Survey boundary
- Existing power cable

Metres in HKPD

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30



Location Plan

Project : AGREEMENT : CE 14/2012 (EP) PROVISION OF COMPENSATORY MARINE PARK FOR INTEGRATED WASTE MANAGEMENT FACILITIES AT AN ARTIFICIAL ISLAND NEAR SHEK KWU CHAU - INVESTIGATION SEABED GEOPHYSICAL SURVEY

FIGURE NUMBER : A -1

Drawing Title :

SWATH BATHYMETRY PLAN

Notes :

1. Survey Date : 05–06/04/2017
2. Survey Grid : Hong Kong 1980 Grid System
3. Vertical Datum : Hong Kong Principal Datum
4. Positioning : C–Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
   Knudsen 320M Echo Sounder
   R2Sonic Sonic 2024 Multibeam Echo Sounder System
   Klein 3000 Side Scan Sonar System
   Geometrics G882 Caesium Vapour Magnetometer
6. Coastline taken from 1:1,000 Survey Sheets, Survey and Mapping Office, Lands Department

Revision No.	Date	Drawn by	Checked by	Approved by	Remarks
0	04/05/2017	Chester Quek	Kenny Zhang	Margie Chen	Preliminary

METRIC SCALE 1:2000

100 80 60 40 20 0 100 200

Client : Environmental Resources Management

Surveyor : EGS (ASIA) LIMITED
5TH FLOOR, ZUNG FU INDUSTRIAL BUILDING,
1067 KING'S ROAD,
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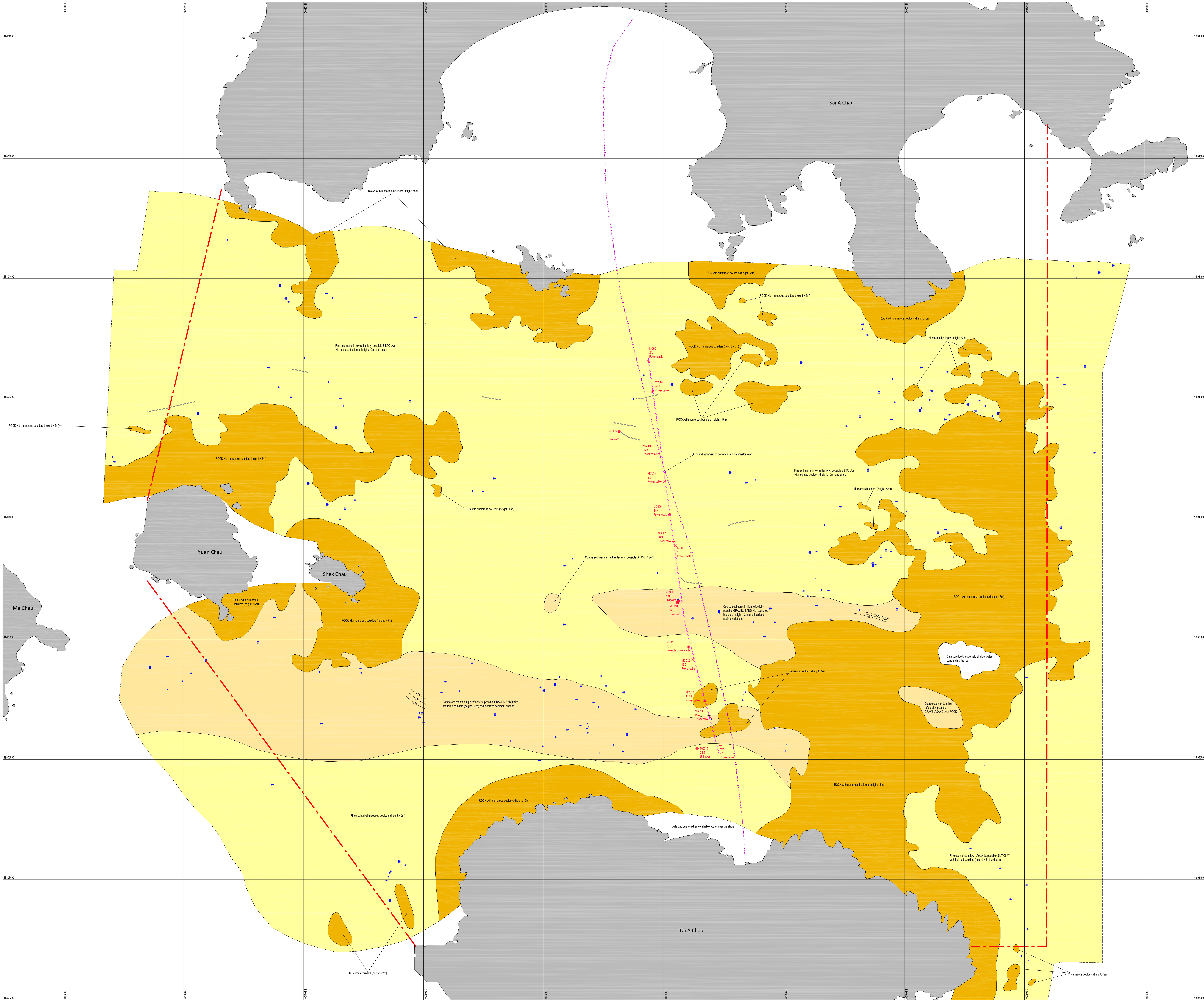
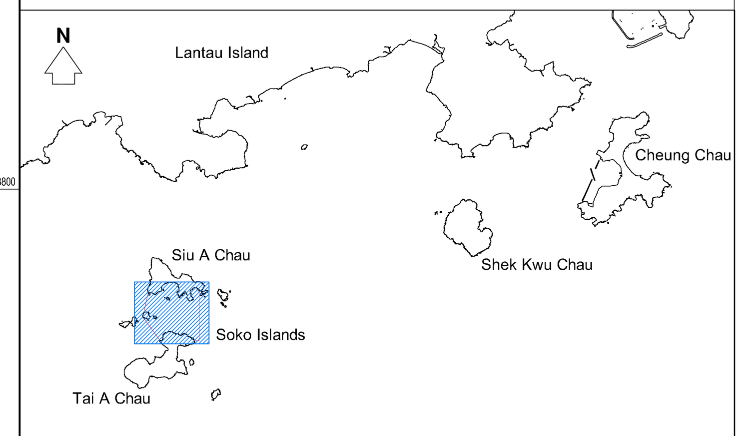


Legend :

- Fine sediment
- Coarse sediment
- Rock
- MC001 24.4 Power cable — Magnetic anomaly with reference number, amplitude (in nano–Tesla)
- MC009 390.1 Unknown — Unidentified magnetic anomaly with reference number, amplitude (in nano–Tesla)
- Scar
- Isolated rock above seabed
- Orientation of sediment ribbon
- As–found IS cable
- Sediment or feature boundary
- Survey boundary
- Existing power cable



Location Plan

Project : AGREEMENT : CE 14/2012 (EP)
PROVISION OF COMPENSATORY MARINE PARK
FOR INTEGRATED WASTE MANAGEMENT
FACILITIES AT AN ARTIFICIAL ISLAND
NEAR SHEK KWU CHAU - INVESTIGATION
SEABED GEOPHYSICAL SURVEY

FIGURE NUMBER : A-2

Drawing Title :

SEABED FEATURES

Notes :
1. Survey Date : 05–06/04/2017
2. Survey Grid : Hong Kong 1980 Grid System
3. Vertical Datum : Hong Kong Principal Datum
4. Positioning : C–Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
   Knudsen 320M Echo Sounder
   R2Sonic Sonic 2024 Multibeam Echo Sounder System
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Revision No.	Date	Drawn by	Checked by	Approved by	Remarks
0	04/05/2017	Chester Quek	Kenny Zhang	Margie Chen	Preliminary

METRIC SCALE 1: 2000
100 80 60 40 20 0 100 200

Client : ERM Environmental Resources Management

Surveyor : EGS EARTH SCIENCES & SURVEYING
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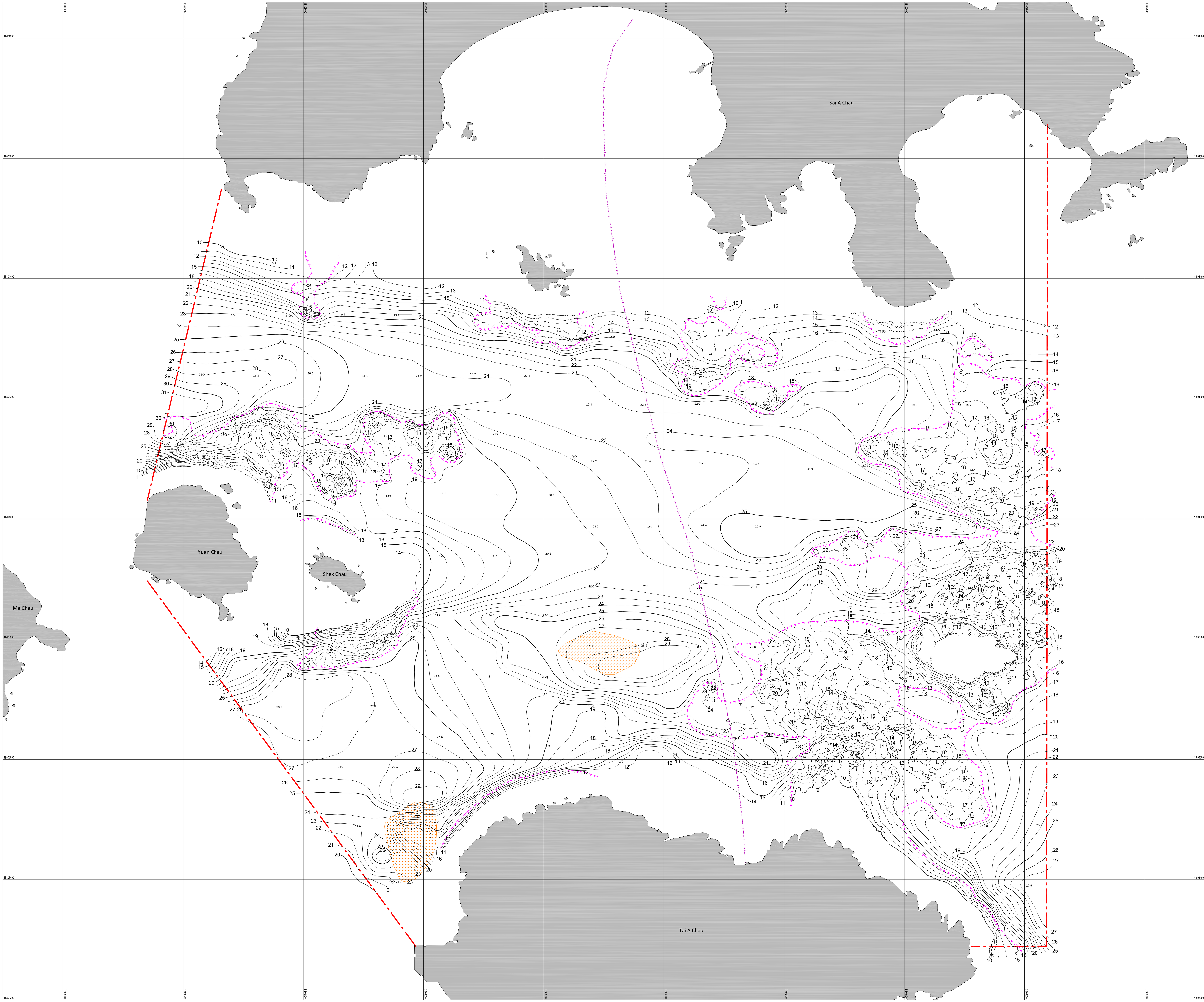
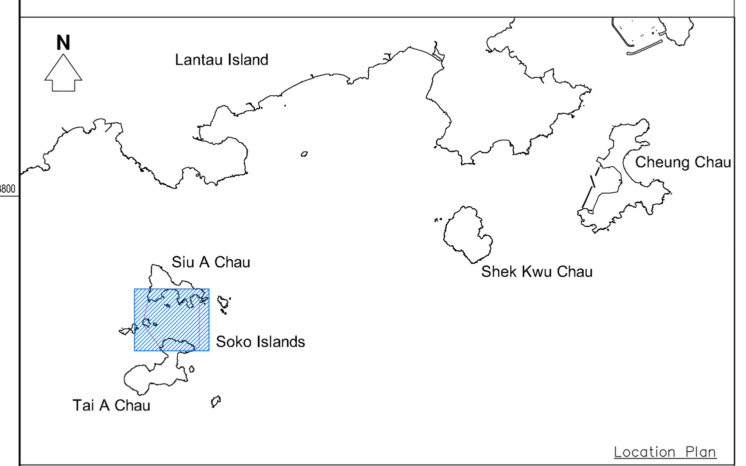
JOB NO. : HK244317



Legend :

9·5	Spot value in metres below HKPD
	Contour at 1 m interval
	Gas masking area
	ROCK outcrop
	Survey boundary
	Existing power cable



Location Plan

Project :

AGREEMENT : CE 14/2012 (EP)
PROVISION OF COMPENSATORY MARINE PARK
FOR INTEGRATED WASTE MANAGEMENT
FACILITIES AT AN ARTIFICIAL ISLAND
NEAR SHEK KWU CHAU - INVESTIGATION
SEABED GEOPHYSICAL SURVEY

FIGURE NUMBER : A-3

Drawing Title :

CONTOURED LEVELS AT BASE OF MARINE DEPOSITS

Notes :
1. Survey Date : 05–06/04/2017
2. Survey Grid : Hong Kong 1980 Grid System
3. Vertical Datum : Hong Kong Principal Datum
4. Positioning : C–Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
   Knudsen 320M Echo Sounder
   R2Sonic Sonic 2024 Multibeam Echo Sounder System
   Klein 3000 Side Scan Sonar System
   Geometrics G882 Caesium Vapour Magnetometer
6. Coastline taken from 1:1,000 Survey Sheets, Survey and Mapping Office, Lands Department

Revision No.	Date	Drawn by	Checked by	Approved by	Remarks
0	04/05/2017	Chester Quek	Kenny Zhang	Margie Chen	Preliminary

METRIC SCALE 1: 2000
100 80 60 40 20 0 100 200

Client : Environmental Resources Management

Surveyor :

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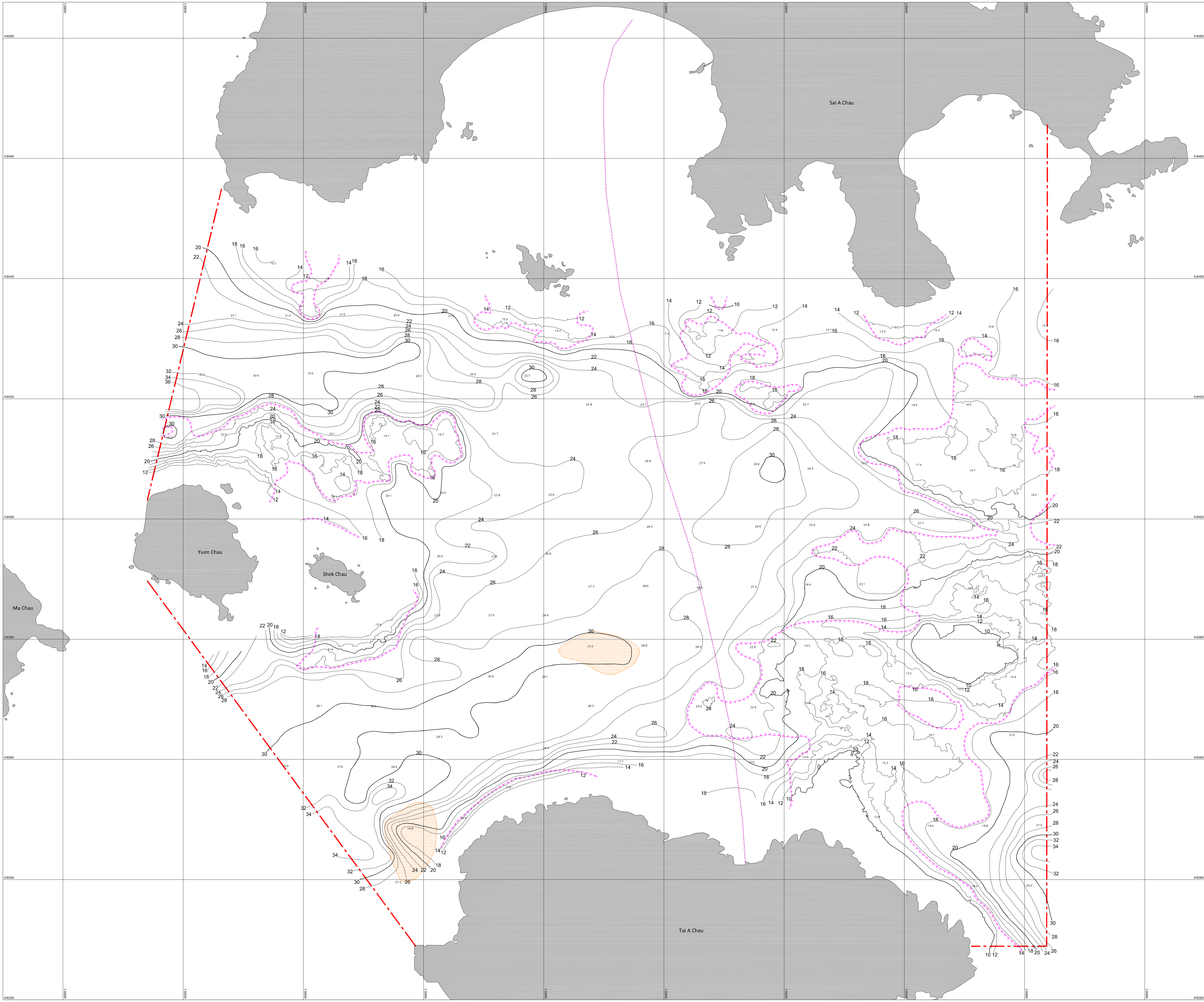
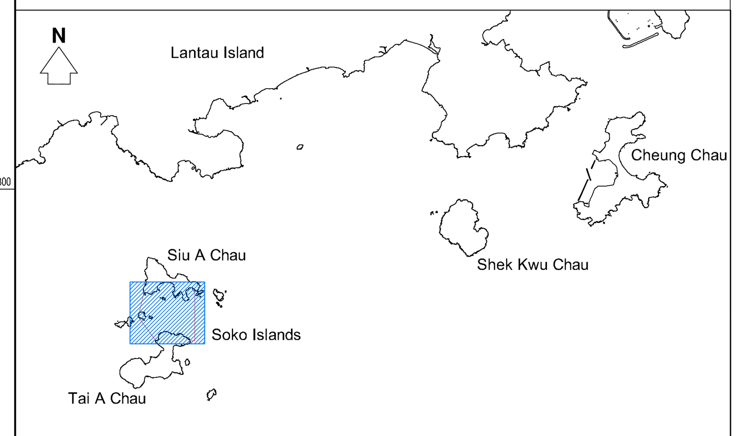
JOB NO. : HK244317



Legend :

9·5	Spot value in metres below HKPD
(line)	Contour at 2 m interval
(hatched area)	Gas masking area
(pink symbols)	ROCK outcrop
(red dash-dot line)	Survey boundary
(pink wavy line)	Existing power cable



Location Plan

Project :

AGREEMENT : CE 14/2012 (EP)
PROVISION OF COMPENSATORY MARINE PARK
FOR INTEGRATED WASTE MANAGEMENT
FACILITIES AT AN ARTIFICIAL ISLAND
NEAR SHEK KWU CHAU - INVESTIGATION
SEABED GEOPHYSICAL SURVEY

FIGURE NUMBER : A-4

Drawing Title :

CONTOURED LEVELS ON TOP OF ROCK IN ANY STATE OF DECOMPOSITION

Notes :

1. Survey Date : 05–06/04/2017
2. Survey Grid : Hong Kong 1980 Grid System
3. Vertical Datum : Hong Kong Principal Datum
4. Positioning : C–Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
   Knudsen 320M Echo Sounder
   R2Sonic Sonic 2024 Multibeam Echo Sounder System
   Klein 3000 Side Scan Sonar System
   Geometrics G882 Caesium Vapour Magnetometer
6. Coastline taken from 1:1,000 Survey Sheets, Survey and Mapping Office, Lands Department

Revision No.	Date	Drawn by	Checked by	Approved by	Remarks
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METRIC SCALE 1:2000

100 80 60 40 20 0 100 200

Client : Environmental Resources Management

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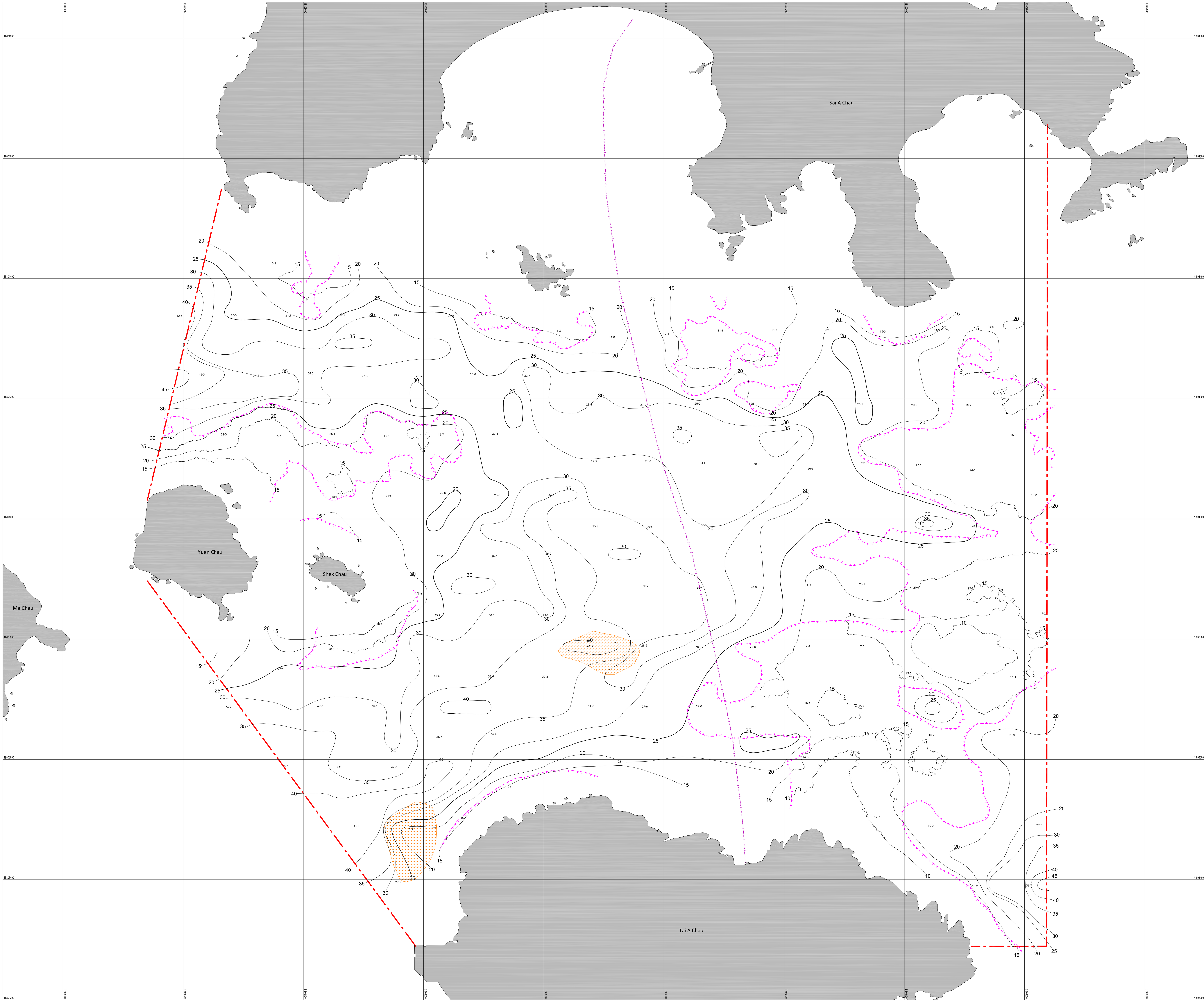
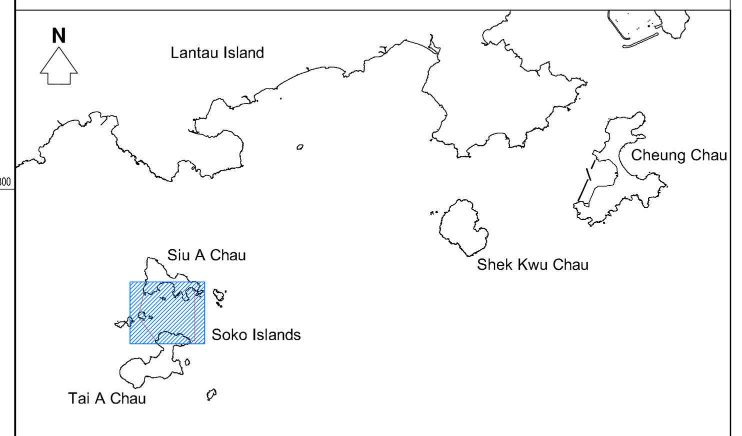
JOB NO. : HK244317



Legend :

9·5	Spot value in metres below HKPD
	Contour at 5 m interval
	Gas masking area
	ROCK outcrop
	Survey boundary
	Existing power cable



Location Plan

Project :

AGREEMENT : CE 14/2012 (EP)
PROVISION OF COMPENSATORY MARINE PARK
FOR INTEGRATED WASTE MANAGEMENT
FACILITIES AT AN ARTIFICIAL ISLAND
NEAR SHEK KWU CHAU - INVESTIGATION
SEABED GEOPHYSICAL SURVEY

FIGURE NUMBER : A-5

Drawing Title :

CONTOURED LEVELS ON TOP OF PRESUMED MODERATELY DECOMPOSED ROCK

Notes :

1. Survey Date : 05–06/04/2017
2. Survey Grid : Hong Kong 1980 Grid System
3. Vertical Datum : Hong Kong Principal Datum
4. Positioning : C–Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
   Knudsen 320M Echo Sounder
   R2Sonic Sonic 2024 Multibeam Echo Sounder System
   Klein 3000 Side Scan Sonar System
   Geometrics G882 Caesium Vapour Magnetometer
6. Coastline taken from 1:1,000 Survey Sheets, Survey and Mapping Office, Lands Department

Revision No.	Date	Drawn by	Checked by	Approved by	Remarks
0	04/05/2017	Chester Quek	Kenny Zhang	Margie Chen	Preliminary

METRIC SCALE 1:2000

100 80 60 40 20 0 100 200

Client : Environmental Resources Management

Surveyor :

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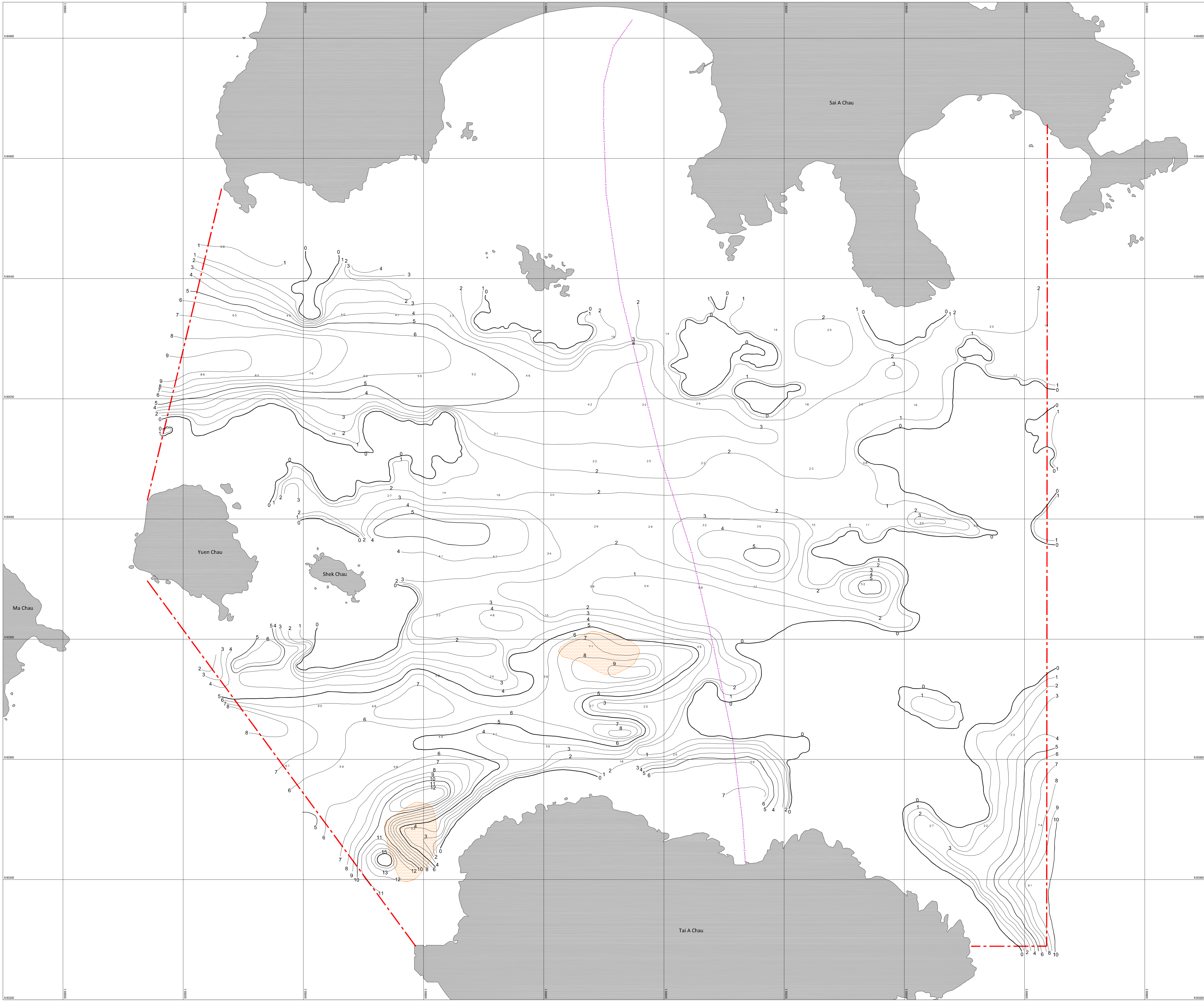


Legend :

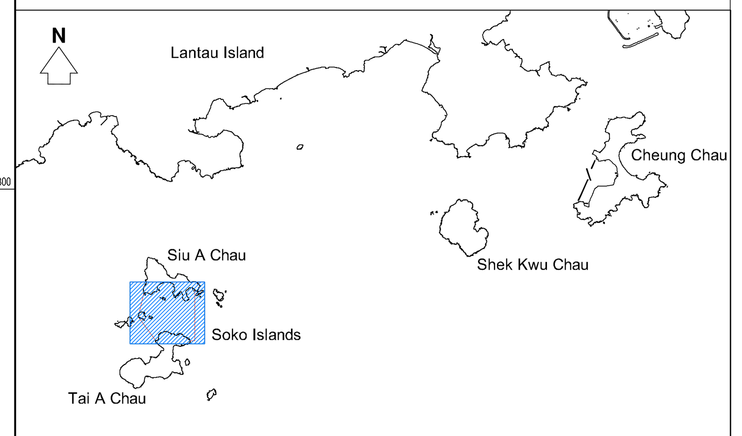
9·5 Isopachs value in metres below HKPD

Contour at 1 m interval

Gas masking area

Survey boundary

Existing power cable



Location Plan

Project :

AGREEMENT : CE 14/2012 (EP)
PROVISION OF COMPENSATORY MARINE PARK
FOR INTEGRATED WASTE MANAGEMENT
FACILITIES AT AN ARTIFICIAL ISLAND
NEAR SHEK KWU CHAU - INVESTIGATION
SEABED GEOPHYSICAL SURVEY

FIGURE NUMBER : A-6

Drawing Title :

CONTOURED ISOPACHS OF MARINE DEPOSITS

Notes :

1. Survey Date : 05–06/04/2017
2. Survey Grid : Hong Kong 1980 Grid System
3. Vertical Datum : Hong Kong Principal Datum
4. Positioning : C–Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
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   Geometrics G882 Caesium Vapour Magnetometer
6. Coastline taken from 1:1,000 Survey Sheets, Survey and Mapping Office, Lands Department

Revision No.	Date	Drawn by	Checked by	Approved by	Remarks
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METRIC SCALE 1: 2000

100 80 60 40 20 0 100 200

Client : Environmental Resources Management

Surveyor :

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Legend :

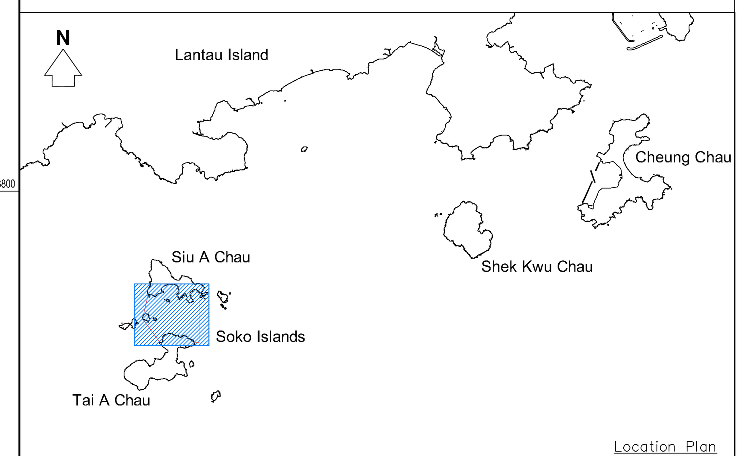
9·5 Isopachs value in metres below HKPD

Contour at 2 m interval

Gas masking area

Survey boundary

Existing power cable



Project :

AGREEMENT : CE 14/2012 (EP)
PROVISION OF COMPENSATORY MARINE PARK
FOR INTEGRATED WASTE MANAGEMENT
FACILITIES AT AN ARTIFICIAL ISLAND
NEAR SHEK KWU CHAU - INVESTIGATION
SEABED GEOPHYSICAL SURVEY

FIGURE NUMBER : A-7

Drawing Title :

CONTOURED ISOPACHS OF ALLUVIUM

Notes :
1. Survey Date : 05–06/04/2017
2. Survey Grid : Hong Kong 1980 Grid System
3. Vertical Datum : Hong Kong Principal Datum
4. Positioning : C–Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
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   Klein 3000 Side Scan Sonar System
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Revision No.	Date	Drawn by	Checked by	Approved by	Remarks
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METRIC SCALE 1: 2000

100 80 60 40 20 0 100 200

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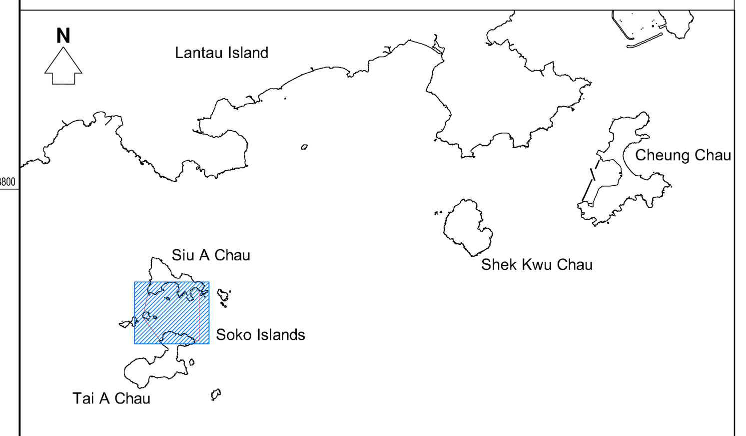
JOB NO. : HK244317

Legend :

- 9·5 — Isopachs value in metres below HKPD
- Contour at 5 m interval
- Gas masking area
- Survey boundary
- Existing power cable



Location Plan

Project : AGREEMENT : CE 14/2012 (EP)
PROVISION OF COMPENSATORY MARINE PARK
FOR INTEGRATED WASTE MANAGEMENT
FACILITIES AT AN ARTIFICIAL ISLAND
NEAR SHEK KWU CHAU - INVESTIGATION
SEABED GEOPHYSICAL SURVEY

FIGURE NUMBER : A-8

Drawing Title :

CONTOURED ISOPACHS OF ROCK IN ANY STATE OF DECOMPOSITOIN

Notes :
1. Survey Date : 05-06/04/2017
2. Survey Grid : Hong Kong 1980 Grid System
3. Vertical Datum : Hong Kong Principal Datum
4. Positioning : C-Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
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Revision No.	Date	Drawn by	Checked by	Approved by	Remarks
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METRIC SCALE 1: 2000

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JOB NO. : HK244317

Annex B

Restocking Procedures

1 FISH RESTOCKING IMPLEMENTATION

1.1 FISH FRY PROCUREMENT

Considering the cost effectiveness of the restocking programme, efforts should be made to source the fish try / fingerlings locally. This will lower the cost and also mortality associated with transporting juvenile fish. A hatchery or farm that can supply healthy fish fry of the target species should be identified in advance. If local hatchery is not available, priority will then be made to identify the hatcheries in Guangdong Province in order to shorten the transportation time and maintain the health of the fish.

The followings are considered as basic requirements of the hatchery from where fish fry should be sourced from:

- Possess valid aquaculture production permit locally in Hong Kong or from the exporting countries;
- Sufficient water supply;
- Broodstock should be sourced from Hong Kong or adjacent waters with relevant certification (e.g. genetic audit);
- High quality broodstock should be maintained with proper management to avoid inbreeding;
- Prevent mixing of hybrid or genetically modified fish;
- Fulfil the water quality requirements of the area (e.g. WQO in Hong Kong; Water Quality Standard for Fisheries in China); and
- Apply general good aquaculture technique for fish production.

In case of fish fry being imported outside Hong Kong, it is recommended to obtain health certificates issued by health authorities of the exporting countries to certify that the fish fry/fingerlings are free from harmful substances, parasites and diseases.

1.2 QUARANTINE

Quarantine is to rear animals under conditions which prevent escape of the animals or the organisms and potential disease agents infecting or associated with them into the natural environment [(1)]. Quarantine process for fish generally involves examination of animals for disease agents and certification to state that a particular batch of animals and/or a production facility has

(1) http://www.fao.org/docrep/003/W3594E/W3594E02.htm

been inspected to be free from infection by a particular pathogen or pathogens.

In Hong Kong, there are no laws on the quarantine of imported fishes but health/ quarantine inspection/ medical testing documentations are required for custom clearance in trans-boundary procedures. It is also difficult to implement an effective quarantine programme in hatcheries of Hong Kong, mainly due to the long period of time and high cost in maintaining a virus-free water condition (1). Some diseases may be difficult to discover and thus it may be too late to apply drugs to cure the diseases when symptoms are discovered (2). Therefore, instead of quarantine in Hong Kong which is not cost-effective with uncertain performance, it is suggested that precautionary measures should be taken to safeguard the quality of fish fry.

1.3 *CULTURING*

To safeguard the health of fish fry, it is recommended to implement the following general precautionary measures developed by the AFCD (3) throughout fish culturing in the hatcheries:

1. Maintain a good culture environment

    - Maintain a suitable stocking density as a crowed culture environment may cause disease infection. Also, the fish may knock against each other and get surface wounds on which infection could be resulted easily.

2. Prevent the deterioration of water environment

    - Fish carcasses should be promptly removed to avoid contamination caused by excessive organic matters depositing on the bottom.
    - Fouling organisms or other physical obstructions should be cleared regularly to maintain water circulation and thus organic matter could be removed or treated.
    - Fish feed should be applied in phases and in appropriate quantities to avoid water pollution by excessive fish feed.
    - Use floating feed to reduce pollution to the bottom of the water column if possible.

---

(1) OECD (2010). Advancing the Aquaculture Agenda: Policies to Ensure a Sustainable Aquaculture Sector.

(2) ftp://ftp.fao.org/fi/cdrom/fao_training/FAO_Training/General/x6709e/x6709e15.htm

(3) AFCD (2009). Good Aquaculture Practices Series 4: Prevention and Treatment of Fish Diseases.

3. Use hygienic and nutritious fish feed to boost resistance of the fish stock

    - Dry pellet feed which is hygienic, nutritious and low in bacteria level is preferable over trash fish.

    - Vitamins and minerals could be added into the fish feed to enhance fish immunity.

    - Sterile live feed could be used in small quantity to allow the fish to experience natural habitats and search for live food.

4. Minimise the chance of introducing pathogens to the water body

    - Disinfect fish culture gear before culturing using appropriate methods such as sun drying or chemicals to remove any residual pathogens remained during previous usage.

    - The fish feed should be stored in a cool, dry and covered place properly to prevent bacterial growth.

    - Use quality fry either from quality broodstock or healthy fry with health certificates from reputable suppliers.

5. Regular monitoring of fish health

    - Observe fish behaviour to monitor if the fish reduce feed intake or show abnormal swimming patterns.

    - Examine the body surface, fins and gills to check if there are any surface parasites.

    - Maintain contact with and approach relevant authorities to seek for assistance if disease symptoms are detected.

1.4 FISH RELEASE

During the fish release exercises, the fish should be packed in plastic bags with oversaturated oxygen and stored in numbers of polystyrene boxes for the transportation to the release site. Ice bags or frozen gel packs should be placed in the polystyrene boxes to slightly lower the water temperature to slow down the metabolic rates of the fish, reduce their activity and stress levels.

Good packing technique is important in order to reduce mortalities in transport and involves the optimum packing density according to the fish size [(1)], as follows:

(1) Sadovy Y. (2000) Regional survey for fry/fingerling supply and current practices for grouper mariculture: evaluating current status and long-term prospects for grouper mariculture in South East Asia, Final report to the Collaborative APEC grouper research and development network (FWG 01/99).

- Fish of 5 cm should be packed at 400 seeds per foam box;
- Fish of 7.3-10 cm should be packed at about 120 seeds per foam box; and
- Fish of 15-20 cm should be packed at about 40 - 70 seeds per foam box.

The fish should be starved for at least 24 hours before packaging to reduce their wastage from polluting the small volume of packing water during transportation. Anaesthetic may be added to the packing water depending on the transportation time. Water temperature should be lowered to 18-20 °C for transport which could be achieved by adding ice into the foam box. There should not be any direct contact of ice with the fish to avoid "cold-burn" (1).

It is suggested that the optimum temperatures of fish culture is 27-31°C for most tropical and 20-28°C for most temperate species (2) . Lower temperature, which occurs in winter of Hong Kong, may inhibit the growth of fish and weaken their immune system. The fish release should thus be carried out in spring to autumn time from April to November when the seawater temperature is greater than 20 °C in Hong Kong. The fish release should be carried out in the morning or in the late afternoon to prevent the packed fish from heating under direct sunlight.

When the fish are transported to the pier near the release site, they should be kept in seawater tanks provided on vessel for at least 30 minutes for temperature acclimatisation together with the plastic bags. Upon arrival at the release site, health conditions of the fish should be checked. Temperature, pH and salinity of selected bag water should be measured and checked for acclimatisation. If there are large difference of temperature, pH and salinity between bag water and seawater, longer acclimatisation period will be required. After acclimatisation on the vessel, the fish will be transferred to cages submerged in the sea surface layer for 10-minute on-site underwater acclimatisation. The cage will then be descended slowly to the bottom of the artificial reef where the habitat enhancement features are installed for another 10-minute underwater acclimatisation and be released.

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(1) Sadovy Y. (2000) Op. *cit.*

(2) FAO (1989) Site selection criteria for marine finfish net cage culture. UNDP/FAO Regional seafarming development and demonstration project in Asia NACA-SF/WP/89/13.

Annex C

Tentative Implementation Schedule of Fisheries Enhancement Measures

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Activity	Duration	Tentative Schedule
Tendering of D & C Contract for AR Deployment and Fish Restocking	2 months	2019 Q4
Deployment of Artificial Reef		
Design of ARs	3 month	2019 Q4 – 2020 Q1
Consultation with Country and Marine Parks Board and to Seek Approval by Director for the development within SLMP	2 months	2020 Q2
Gazettal of draft map to public under Cap 127 Foreshore and Seabed (Reclamations) Ordinance (Section 5) (statutory)	2 months	2020 Q3
Written Statement of objection (if any) (statutory)	2 months	2020 Q3
Hearing of objections by Director of Lands Department	6 months	2020 Q4 – 2021 Q1
Prefabrication of AR	4 months	2021 Q2 – 2021 Q3
Deployment of AR	1 month	2021 Q3
Monitoring of AR	24 months	2021 Q3 – 2023 Q3
Fish Restocking		
Baseline Monitoring	12 months	2021 Q3 – 2022 Q3
Sourcing of Fish	2 months	2022 Q2
Transport and Quarantine of Fish	1 month	2022 Q3
Fish Release at AR	1 day	2022 Q3
Monitoring of fish release	12 months	2022 Q3 – 2023 Q3

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