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致財務委員會主席及委員

各位議員鈞鑒：

回應財務委員會(會議議程)2020 年 7 月 17 日的事項 VI.
「768CL：中部水域人工島相關研究」 (中文翻譯版)

財務委員會將於 2020 年 7 月 17 日討論上述項目。

世界自然基金會（WWF）認為要解決土地供應問題，應採用更平衡的「棕地優先」政策，使人與大自然能同時蓬勃發展。填海不但會對環境造成災難性的破壞，而且亦是昂貴的增加土地供應方法。世界自然基金會促請政府與其於東大嶼填海研究上投入資源，不如於大嶼山及其水域實踐良好的保護和管理，讓市民、野生動物、濕地和近岸水域能從該區的環境中受益，享受高質素的生活，並推動綠色自然經濟。

中部水域人工島相關研究堤出的填海地點包括了具重要海洋生態價值及生物多樣性的水域。研究顯示最少有 14 種八放珊瑚及黑珊瑚，以及 21 種石珊瑚生長於大嶼山東部海域中[1]。本會亦一直密切監測當區的海洋生態狀況，並曾在該海域進行水下生態調查，當中更發現了香港比較罕見的海洋物種，如管海馬(*Hippocampus kuda*)、海龍(*Trachyrhamphus* sp.)及海筆(*Virgularia* sp.)。這些海洋物種的棲息地需被保護及得到的良好管理，牠們才能繼續在香港水域中生存和繁衍。

另外，大嶼山北部和西北部各大型沿岸工程已迫使中華白海豚遷離原有生境，其出沒範圍漸漸南移至大嶼山南部和西部沿海水域，是香港為數不多的白海豚核心棲息地之一。擬議的填海工程將會進一步減低中華白海豚本已所剩無幾的棲息地的完整性。填海工程會改變水流，降低鄰近工程範圍重要海豚棲息地的環境質素。本會正在進行的調查顯示大嶼山東面的水域可能是江豚(*Neophocaena phocaenoides*) 重要的棲息地[2]。大型填海工程將大幅增加水底噪音水平，嚴重干擾鯨豚類回聲定位等行為，損害牠們的聽覺，影響牠們進行導航、溝通和覓食等重要活動。棲息地的喪失和水質惡化與水底噪音同樣對本地鯨豚品種構成重大威脅。

[1] Oceanway Corporation. 2018. unpublished data
[2] Sea Mammal Research Unit (Hong Kong). 2019. unpublished data

together possible™

WWF 建議與其進行中部水域人工島及任何未來填海的影響研究，不如實施由來自 15 個組織的海洋科學家共同製定的《*中華白海豚緊急保育行動*》所提出的建議，馬上將大嶼山南部和西部沿海水域劃為海豚保護管理區。為確保受威脅的白海豚和江豚能夠繼續於香港水域長存，我們強烈敦促政府嚴格規管區內和附近水域工程發展、船舶交通、捕魚活動以及水質和水底噪音污染等人為威脅。

填海會對附近島嶼的陸地生態有嚴重負面影響。特別是周公島，它是政府指定的「具特殊科學價值地點」，以保育被國際自然保護聯盟（IUCN）紅色名錄列為「瀕危」物種的鮑氏雙足蜥（*Dibamus bogadeki*）。香港是現時世上唯一記錄到鮑氏雙足蜥的地方，目前已知只在周公島、喜靈洲和石鼓洲出現。由於相關研究提出的填海項目非常接近周公島，大量的野貓和老鼠等以蜥蜴為食的入侵物種容易被帶到島上，威脅此「瀕危」蜥蜴的生存。

香港有責任根據已制定的《生物多樣性策略及行動計劃》及作為《生物多樣性公約》簽署者的義務，確保這獨特且瀕危的蜥蜴品種能得到適當保護。除了不可勝言的環境成本外，潛在的社會成本亦不容忽視。研究提出的填海範圍內和附近的水域由於在大風天氣期間水面能相對保持平靜，為當地漁民的重要漁場。

政府應聚焦於疫情過後推動綠色經濟復甦，並着重「棕地優先」發展，以配合聯合國的可持續發展目標，並履行《巴黎協議》所規定的義務，以捍衛大嶼山及鄰近水域的自然環境，及實現與自然和諧共融的發展。

鈞安

世界自然基金會香港分會
保育總監 David Olson

世界自然基金會香港分會
海洋保育主管 Laurence McCook

謹啟
二零二零年七月十五日

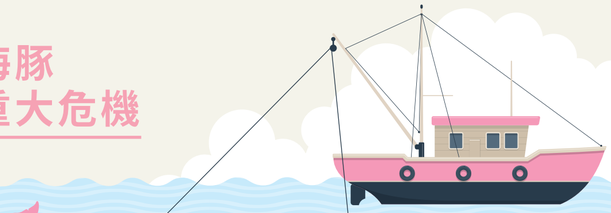
中華白海豚
緊急保育行動

中華白海豚正面臨重大危機

嚴重威脅

中華白海豚正面臨各種生存威脅——當中七種主要威脅需要採取緊急行動：

1. **棲息地喪失及退化**由沿岸發展、建築工程、養蠔活動（中國內地水域內）、流域發展及其他近岸人類活動所引致。這些因素進一步減少白海豚本來已非常有限的覓食範圍。
2. **獵物消耗**是由棲息地破壞，以及不可持續、破壞性、非法的漁業和養殖活動導致。由於食物供應不足，白海豚傾向捕食種類較少和尺寸較小的魚類。
3. **水底噪音干擾**主要來自沿岸發展、海上交通和大橋交通。這些噪音影響白海豚覓食、導航和溝通行為，更會令牠們的聽覺受損甚至死亡。
4. **海上交通**會擾亂白海豚行為，導致覓食和繁殖頻率減少。**船隻撞擊**會嚴重傷害甚至殺死白海豚。
5. **毒素和污染物**來自不同的陸地和海洋源頭，包括未經處理和淨化的工業和農業廢水。這些毒素和化學物會在白海豚體內積聚，降低其存活和生育率。
6. **漁具纏繞**主要由非選擇性的漁業活動，包括拖網和刺網捕魚所引致。被纏繞的白海豚可能會受傷甚至溺水而死。
7. 氣候變化引致的**海平面上升**將會改變白海豚及其獵物常用的淺水棲息地分布，令適合白海豚棲息的水域大大縮小。



白海豚非常倚賴聲音作覓食、社交和導航用途。因此牠們對水底噪音非常敏感，並容易受其干擾。

白海豚捕食的魚種大部分也經常被商業漁民捕捉。牠們有時候會尾隨漁船覓食，因而大大增加被漁具纏繞的風險。

40米

白海豚主要出沒於沿岸河口的淺水水域，水深大多於40米內。這些水域同時也是人類活動最頻繁的地方。

白海豚的繁殖速度非常緩慢——雌性海豚在9歲或以上才開始生育，平均每隔三年甚至更久才產下一胎。因此，海豚種群需要更長的時間才可恢復及穩定。

由於中華白海豚的全球數目大幅減少，白海豚在世界自然保護聯盟（IUCN）《瀕危物種紅色名錄》的保護現狀自2017年由「近危」提升至「**易危**」級別。

簡要

珠江三角洲一帶水域孕育着相信是全球最大的中華白海豚（*Sousa chinensis*）種群，同時是全球其中一個人口密度最高和最工業化的沿岸地區。珠三角的白海豚種群由約二千隻海豚組成，然而嚴重的人為威脅正令該種群以每年約3%的速度減少。由於香港本地白海豚的數目在過去15年間下跌超過80%，因此我們無法判斷更廣泛的珠三角中華白海豚種群是否穩定。科學研究更預計，按照目前的下降趨勢，珠三角白海豚種群可能面臨本地滅絕。

中華白海豚正面對異常嚴峻的生存威脅，我們需要採取緊急保育行動。因此，來自珠三角的鯨豚專家包括政府代表、學者和保育專家共同提出一套緊急保育計劃，希望為恢復白海豚種群奠下良好基礎。粵港兩地的跨境合作對保育白海豚甚為重要，兩地政府應抓緊最後機會保育這珍貴物種。

拯救
中華白海豚

拯救中華白海豚的方案

有見中華白海豚數目急劇下跌，珠三角的鯨豚專家制定了一套緊急保育行動計劃，旨在穩定及恢復白海豚種群。計劃建議對一系列覆蓋白海豚主要棲息地的核心區和緩衝區（參見背面的地圖）進行管理，以把人類對白海豚的干擾和威脅減至最低。

核心區保護重要中華白海豚生境

核心區包括白海豚恆常用作覓食、交配、育幼和社交的主要水域。**歷史核心區**則是白海豚過去頻密使用的生境。當該水域的人為影響和干擾減低，白海豚很大機會重返來使用。所有核心區對珠三角白海豚長遠的存活和種群恢復都非常重要，因此必須優先推行有效和及時的保育與管理。核心區不但為白海豚提供直接的好處，也有助保育其他海洋生物以至整個海洋生態系統。

緩衝區連接各中華白海豚核心生境

緩衝區是白海豚棲息地的生態走廊，可以為白海豚及其獵物提供重要及低人為干擾的通道來往返重要的生境。保護這些生態走廊或緩衝區可使白海豚靈活分布在不同的核心區，從而建立聯繫緊密的重要生境網絡，減低珠三角白海豚種群絕種的風險。

以下六大主要管理措施可有效減低中華白海豚在重要生境受到的人為威脅。這些方案需要兩岸跨境執法和協調、收緊現有規例和公眾教育的配合才可發揮最大成效。

白海豚核心區和緩衝區內應禁止任何建築工程和養蠔活動（中國內地水域內），而相關發展活動也需要在附近水域受到監管。天然海岸線和流域須維持完整並不受發展干擾。鄰近的沿岸建築工程必須採用將生態破壞減至最低的建築方法。

延長季節性休漁期，加強巡邏及執法機制以打擊非法及破壞性漁業活動，並管理不受監管的小型養殖及漁業活動。在禁捕區進行增殖放流以恢復供給白海豚的魚群數目。

嚴格規管在核心區及緩衝區的船舶數目及船速，高速船及大型船舶則應繞道航行，遠離海豚保護區。

評估、監管及減低來自沿岸發展、大橋交通和船舶活動所產生的水底噪音，並將其納入環境影響評估。

支持可持續漁業轉型及其他沿岸活動，例如修復紅樹林及其他濕地生境以增加漁業資源和改善水質。

把來自陸地、海洋的污染及塑膠廢物減至最少，並長期監察白海豚體內的污染物和毒素，以追蹤和解決主要來源。

合作夥伴和支持機構

珠江三角洲水域的主要中華白海豚生境

這些區域乃根據現有最新和最全面的研究成果所擬定，包括已發布的數據和在珠江三角洲(珠三角)水域及陽江的實地觀察。

珠三角東面的緩衝區

香港

江門

大襟島

珠海

三灶島

三灶島緩衝區

小襟島

珠三角西面的緩衝區

陽江

龍鼓洲

大嶼山

放大倍率為 0.5X

N

W

E

S

0 20 40 80 公里

極重要核心區

1. 三峽口區
2. 大小襟島區
3. 南大嶼與西大嶼區

重要核心區

4. 上下川島區
5. 高欄島——荷包島區
6. 三灶島區
7. 青州——三角山區
8. 龍鼓洲區

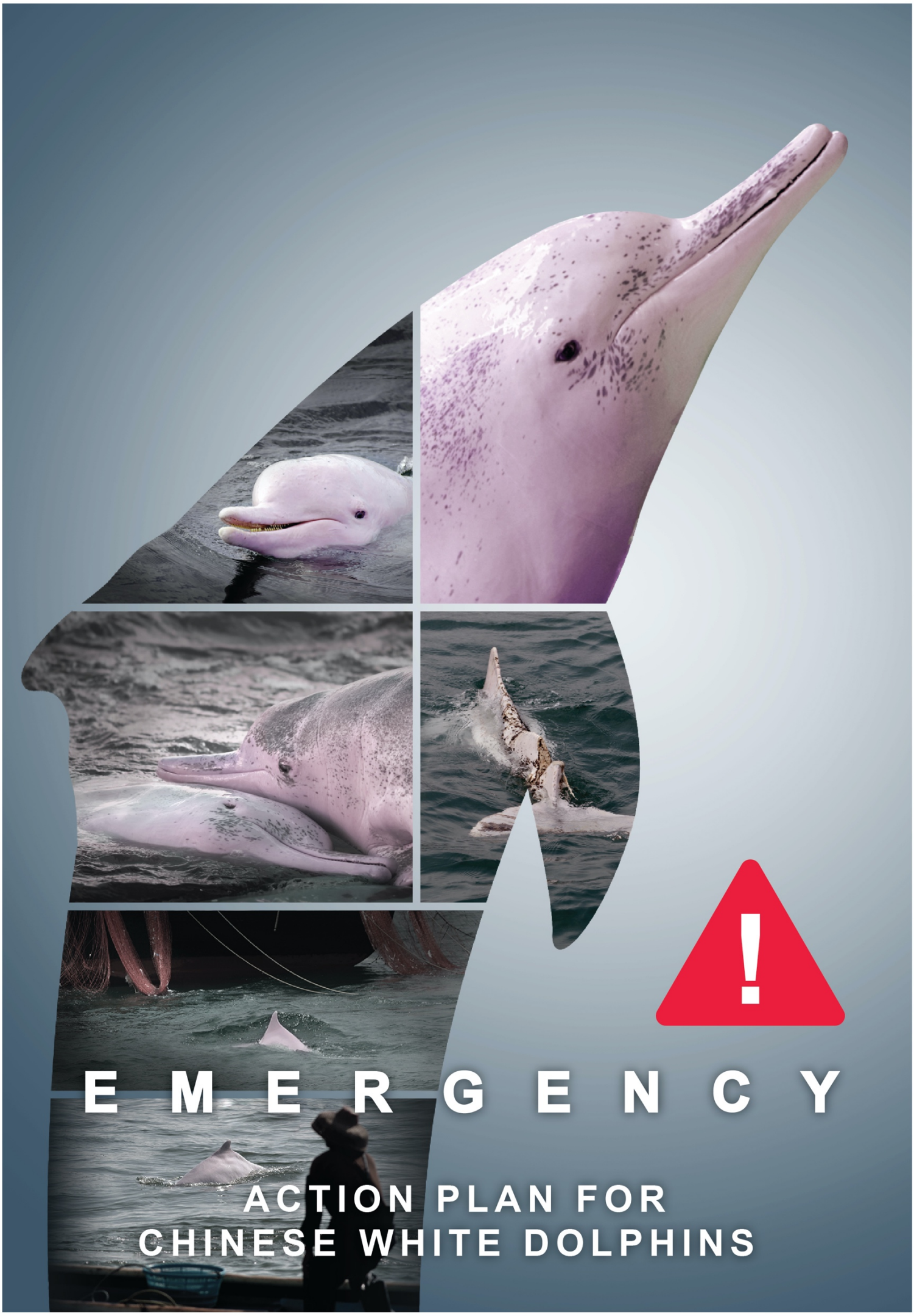
核心區

9. 東平港區
10. 廟灣——滘洲區
11. 內伶仃島區
12. 索罟群島區
13. 大小磨刀(歷史核心區)

*有研究指出陽江的白海豚同屬珠三角種群，因此本地圖同時識別了該處水域的重要白海豚生境。

現有及擬定的海岸公園 / 自然保護區

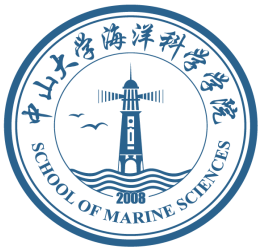
A. 西南大嶼山海岸公園
B. 廣東江門中華白海豚省級自然保護區
C. 沙洲及龍鼓洲海岸公園
D. 擬定的南大嶼山海岸公園
E. 廣東珠江口中華白海豚國家級自然保護區
F. 擬定的海岸公園以補償興建香港國際機場第三條跑道
G. 大小磨刀海岸公園



EMERGENCY

ACTION PLAN FOR CHINESE WHITE DOLPHINS

Contributing Organizations (In Alphabetical Order)



Urgent Conservation Action for the Pearl River Delta Population of the Chinese White Dolphin (*Sousa chinensis*) 2020

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About WWF: Founded in 1961, WWF (World Wide Fund for Nature) is an independent conservation organization with over 30 million followers and a global network active in nearly 100 countries. WWF's mission is to stop the degradation of the Earth's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

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Executive Summary

The globally significant population of the Chinese white dolphin (*Sousa chinensis*) in the Pearl River Delta region is under critical threat of collapse. This report provides an emergency plan for urgent and robust conservation action to prevent population loss.

The Pearl River Delta population of Chinese white dolphins may be the largest identified population of the species globally, with the most recent estimate of abundance as low as 2,000 individuals (excluding estimates from the Moyang River Estuary, Yangjiang). It is experiencing a dramatic decline in population, primarily due to human activities and anthropogenic threats, including habitat loss and degradation, prey depletion, underwater noise disruption, boat strikes, toxins and pollutants, and entanglement in fishing gear. Key dolphin habitat has been degraded and fragmented by coastal and offshore development projects and impacted by intense fisheries activities.

Long-term monitoring of dolphins in Hong Kong's coastal waters points to a drastic declining trend, with a drop of over 80% in estimated local abundance in the past 15 years. In the absence of up-to-date monitoring for the entire Pearl River Delta region, there is no reason to expect the broader population to be safe. The rapid increase in human threats throughout the region is most likely causing critical declines in population viability.

The trajectory of loss is dire. Now is the time for meaningful action, at scale, to secure a future for this iconic species in the region. Immediate action to diminish and mitigate the most significant threats is critical to give the dolphin population a chance to stabilize and recover. Many of the most critical threats, such as degradation and loss of key foraging grounds, noise disturbance, and boat strikes, can be addressed immediately, although others, such as health impacts of bio-sequestered toxins, may take years to tackle effectively.

Here we present an emergency action plan to stabilize the shrinking dolphin population and put it on a good footing for recovery in the longer term. Further and ongoing conservation action will be necessary to secure a future for the population. This emergency action plan is proposed by a body of concerned dolphin specialists, including academics, marine resource managers, government representatives, and conservationists who are active throughout the broader Pearl River Delta and Greater Bay region. The plan is the outcome of a workshop held in August 2019 to discuss and identify priority actions which can help turn the tide for the dolphin population.

There are three major elements of the proposed Emergency Action Plan:

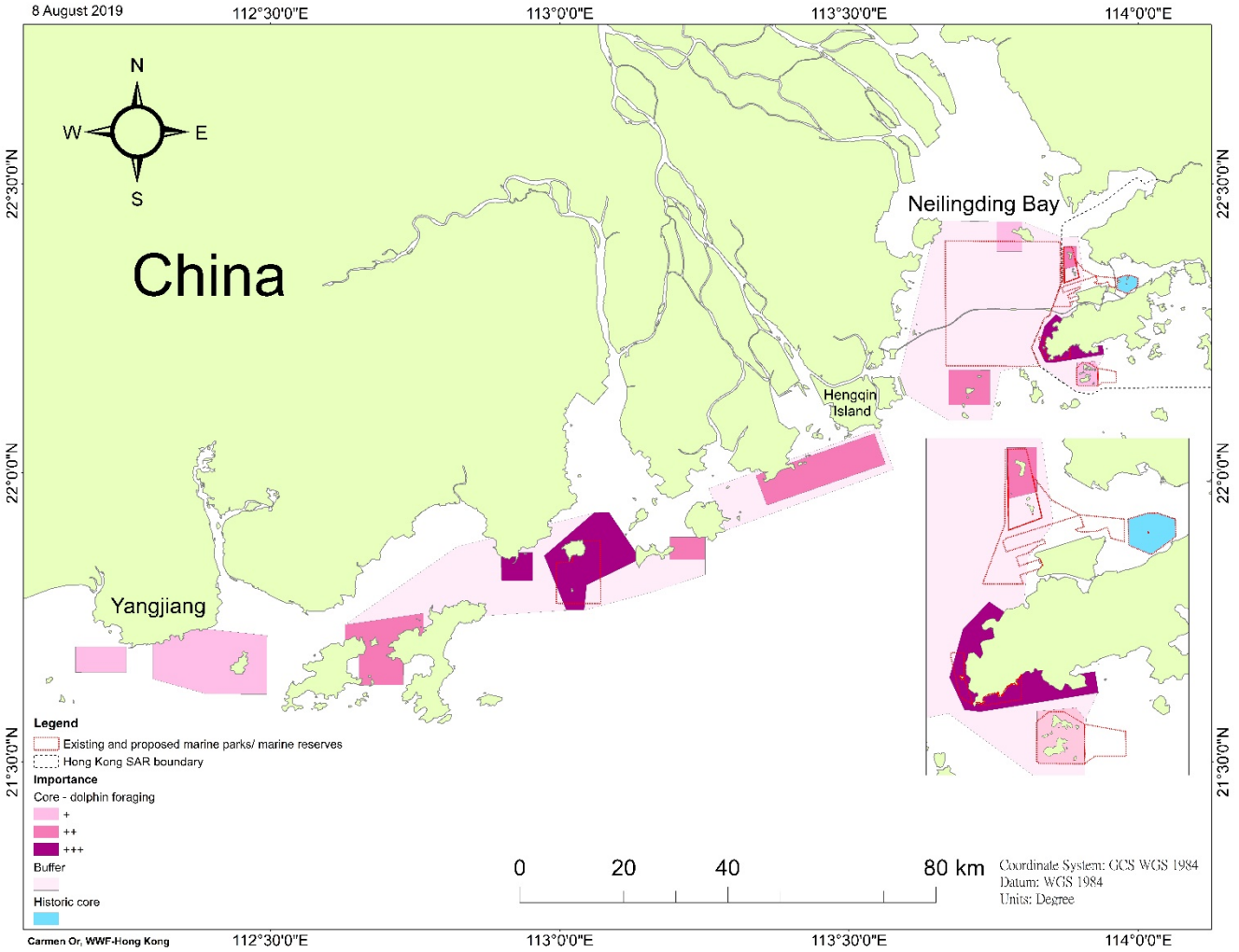
1. Protect Key Habitat – Protect critical habitat areas and buffer areas for dolphin foraging, resting and nursery activities and manage those areas to enable dolphins to carry out their life history without undue disturbance from the major threats mentioned above. The map below shows the recommended locations of core and buffer protection areas; detailed breakdown of protection measures required for each area type are listed in the report;

2. Reduce Risks in remaining habitat areas – Specific dolphin-friendly practices to be followed outside of key dolphin habitat areas are identified in the report;

3. Adaptive Management – Integrate urgent 'do no harm' management with research to address key knowledge gaps: commit resources to conduct research necessary to rapidly and adequately answer outstanding uncertainty and allow refinement of these emergency conservation actions.

This report lays out a framework of recommended actions to kick-start an urgent process, by which Governments can take the lead in the process of formulating and activating emergency conservation actions, followed by development of a comprehensive, ongoing Greater Bay management plan. Such a plan must incorporate input from academics, industries and affected members of the general public such as fishers. This report does not attempt to summarize all the available information on the species, to exhaustively examine the impacts of various threats on the dolphins in the Pearl River Delta region, nor to thoroughly evaluate existing actions to address these threats. Previous reviews have provided much of that information. However, contributors and partners of this conservation action plan are committed to assisting managers to timely and effectively implement the recommended management measures.

We strongly urge the Guangdong and Hong Kong Governments to seriously consider activating and implementing the proposed emergency actions to help stabilize and recover the Chinese white dolphins in the Pearl River Delta area. Further, we hope that the recommendations here can inform the development and implementation of a management plan for the Pearl River Delta population of the Chinese white dolphin.



Core Habitat Areas and Buffer Habitat Areas Identified by Experts and Recommended for Immediate Action to Stabilize and Recover the Chinese White Dolphin Population in the Pearl River Delta and near Yangjiang. Refer to Fig. 1 and Table 1 for identification of core and buffer areas.

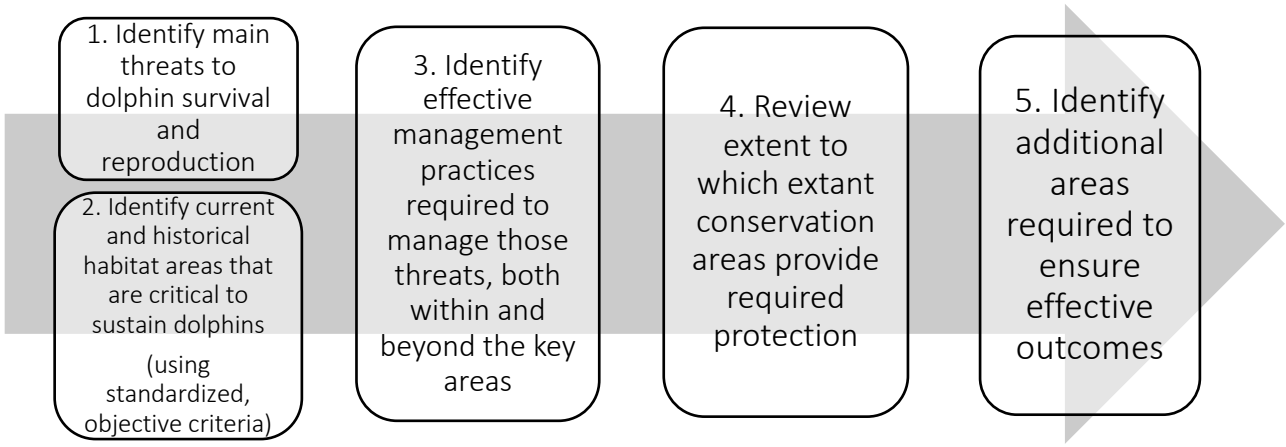
Pearl River Dolphins in Crisis

The situation for Chinese white dolphins (hereafter, CWD) in the Pearl River Delta[1] (PRD hereafter) is dire, with rapid declines in the population (that is, about 3% annually, ***Annex 1*** *refers*). In response, a group of dolphin specialists, marine resources managers, and conservationists based throughout the broader Pearl River Delta and Greater Bay region[2] came together in August 2019 to discuss and recommend a set of emergency actions and measures to give the dolphin population a chance to stabilize and recover. The plan outlined here is the outcome of that workshop, and the measures proposed need to be acted upon immediately.

We hope that this focused effort on urgent actions to aid dolphin recovery will generate momentum for conservation measures that will effectively stabilize and recover the dolphin population in the Pearl River Delta region. The rationale underlying our recommendations is that the dolphin population will stabilize and begin to recover (i) if key areas for important aspects of the dolphins' natural history are managed to minimize disturbance and (ii) if the threats begin to be addressed throughout the Delta. We argue that management based on best practices and policies, implemented through close cooperation with the private sector, fisheries, local communities, the public, and other key stakeholders, has the greatest probability of success in protecting these iconic creatures.

Developing an Urgent Action Plan for Dolphin Conservation

Developing an emergency action plan for CWD conservation involves the following steps:



To minimize human disturbance to dolphin viability, it is essential to protect *all of* the following activities and behaviours*:* foraging; calving; resting; socializing; and movement. The threats to these activities (step 1 above) may reduce either survival or reproduction. These threats have been well-documented in previous studies and reports. A summary of knowledge and references is provided in a later section of this report.

The following sections identify and demarcate key habitat areas based on best available scientific information (step 2 above), followed by the identification of management practices required within

[1] The Pearl River Delta refers to waters from Hong Kong to Shangchuan and Xiachuan Islands in this report.

[2] The Greater Bay Area (GBA) consists of nine Guangdong cities (Dongguan, Shenzhen, Huizhou, Guangzhou, Zhuhai, Jiangmen, Zhongshan, Foshan and Zhaoqing) and two special administrative regions (Hong Kong SAR and Macau SAR) in south China.

the key areas (step 3). While some dolphin protected areas do currently exist to help conserve CWDs in the PRD (***Fig. 3*** refers), most of the core habitat areas and buffer habitat areas recommended here fall outside of the extant protected areas (steps 4 & 5).

The dire situation of the PRD dolphin population demands a **precautionary, adaptive management approach**: although details of population dynamics and potential sub-structure remain uncertain, *all the available evidence suggests the population is in drastic decline overall, and in imminent threat of local extinction*. Thus, failure to provide *urgent* protection will almost certainly allow irrevocable ongoing decline or complete population collapse – that is, local extirpation. The solution is to provide precautionary, adaptive management, in which ongoing management actions are proactively adapted and revised in response to further research and monitoring of management effectiveness (further explanation in later section). Preventative or precautionary management is also known to be more effective and much more cost-effective than attempting to restore or reverse declines (Cooney, 2004). It is important to note that some workshop participants were concerned that implementing an 'emergency plan' risks compromising the implementation of a more refined and strategic long-term plan. As with any emergency response, *it is critical, therefore, that implementation of this plan serves as the first stage of a longer-term, well-designed strategic management plan*. It must not serve as a substitute or diversion from such long-term management. Further, this emergency plan is 'do no harm'. All the management actions and responses are carefully considered to optimize benefits to dolphins and other natural elements, while minimizing human economic impacts.

Identification of Key Habitat Areas for Dolphin Conservation: Core and Buffer Areas

In order to balance protection of dolphins with human uses of the sea areas, in this report we distinguish between *core areas*, which require very strong management interventions, and *buffer areas* which still require significant interventions, but less robust interventions than the core areas. This approach ensures the minimum disruption to current human uses and activities, whilst providing the strong interventions where they are required.

Core (key, critical) habitat areas include: (i) areas that CWDs frequent often for foraging, breeding, nursery and socializing purposes; or (ii) areas that are utilized for shorter periods of time but, nonetheless, are important for aspects of the dolphin's natural history. These areas are thus considered critically important for the long-term presence of PRD dolphin population and must be managed so as to minimize anthropogenic disturbance and threats. Identified core areas are not limited to areas currently being used by the CWD, but also areas known to have been used commonly in the past. This reflects the experts' assessment that such **historic core areas** would very likely again provide critical habitats in the future if threats and disturbance are sufficiently reduced. The Brothers Marine Park in waters of the Hong Kong Special Administrative Region (SAR) is one example of such historic core areas.

All core areas must be prioritized for immediate and effective conservation and management. Specifically, core areas should be managed and function as no-take and no-development zones, with limited boat traffic and other human activities, as suggested by Karczmarski and Or (2016). It is worth noting that such management will also provide conservation benefits for a broad spectrum of other marine species and, over time, may function to bolster local fisheries in surrounding waters.

Buffer areas are ecological corridors that connect the core areas and provide essential, low-disturbance transit habitats within which CWDs can move between discrete key habitats. Management

of buffer areas must manage threats to dolphins transiting the areas, but still allow appropriate non-impactful human activities and uses. We propose designation as marine parks or similar zones. The buffer areas should be large to maintain habitat continuity and population connectivity throughout the PRD region, thereby avoiding habitat partitioning.

Recommended Core and Buffer Conservation Areas for Chinese White Dolphins in the PRD

Fig. 1 shows the location of core habitat and buffer habitat areas for CWDs in the PRD and Yangjiang waters. Li *et al.* (2019) suggested that Chinese white dolphins recorded in the Moyang River Estuary off Yangjiang also formed part of the PRD population, and thus potential core areas there are also illustrated in Fig. 1. These areas are identified based on peer-reviewed and published records of dolphin distribution and habitat use throughout the whole region (for instance, by Or [2017]), along with *in-situ* field observations, research data, and expert knowledge provided by CWD specialists at the workshop. The final location and configuration of the areas are derived from extensive discussion and sharing.

A total of 12 core habitat areas and one historic core area are identified throughout the PRD region (*Fig. 1* & *Table 1*). All identified core habitat areas, together with existing and proposed dolphin protected areas in the PRD region, cover a total of 2,216 km^2 of the sea. It should be noted that the total area is still below the threshold *critical* habitat size for supporting minimum viable dolphin population (Karczmarski *et al.* 2017), which is 3,000 km^2 under stationary population structure and suitable environmental conditions. There is also a spatial discrepancy between existing/proposed protected areas and identified core areas, meaning that many *critical* dolphin areas are not under statutory protection. For instance, the Guangdong Pearl River Estuary Chinese White Dolphin National Nature Reserve should be expanded to also cover identified core habitat areas #8 and #9 at the periphery of the designated Nature Reserve.

South and West Lantau (Core Area #11 in *Fig. 1*) is considered to be currently the most critical dolphin habitat in the Pearl River Estuary[3] (AFCD, 2019; Karczmarski & Or, 2016; Or, 2017). More than half the total dolphin sightings made in the Estuary were recorded in this area (Or, 2017). This area has a very long, continuous natural rocky shoreline and thus abundant supply of prey resources (further protected since the implementation of trawl ban in Hong Kong waters in late 2012), which aligns with dolphins' strong preference for foraging in areas with natural coastline needs (Karczmarski *et al.,* 2019). As well as foraging, CWDs have been recorded resting, nursing, and socializing in this area. This core area has been more important for the occurrence and foraging needs of CWDs since 2015, when the range of dolphins shifted to south and west Lantau with shift in habitat use pattern in Hong Kong (Or, 2017). This shift is suggested to be caused by the dolphins avoiding near-shore construction and reclamation works off north and northeast Lantau (AFCD, 2015). Importantly, the accumulation of data from long-term monitoring studies allows very precise delineation of this area (Karczmarski & Or, 2016; Or, 2017). This, in turn, means that protection of this area will provide greatest certainty in terms of conservation benefits. The Hong Kong SAR government should prioritize South and West Lantau (Core Area #11) for immediate conservation and effective management given its profound importance to CWDs.

Nearshore marine areas off Sanxiakou, Dajin and Xiaojin Islands (Core Areas #4 and 5 in Fig. 1) are identified as very critical habitat for dolphins inhabiting in Jiangmen waters. With freshwater supply

[3] The Pearl River Estuary includes waters in Hong Kong, Lingding Bay and off Hengqin Island in this report.

through Hutiaomen and Yamen estuaries, and warm water released from Guohua Taishan Power Station, the abundance of prey fishes there is high. High fish abundance in these brackish waters not only supports frequent fishing activities, dolphins in these core areas also appear and forage in relatively large group sizes (usually more than ten individuals, D. Y. W. Ho, pers. comm. 2020).

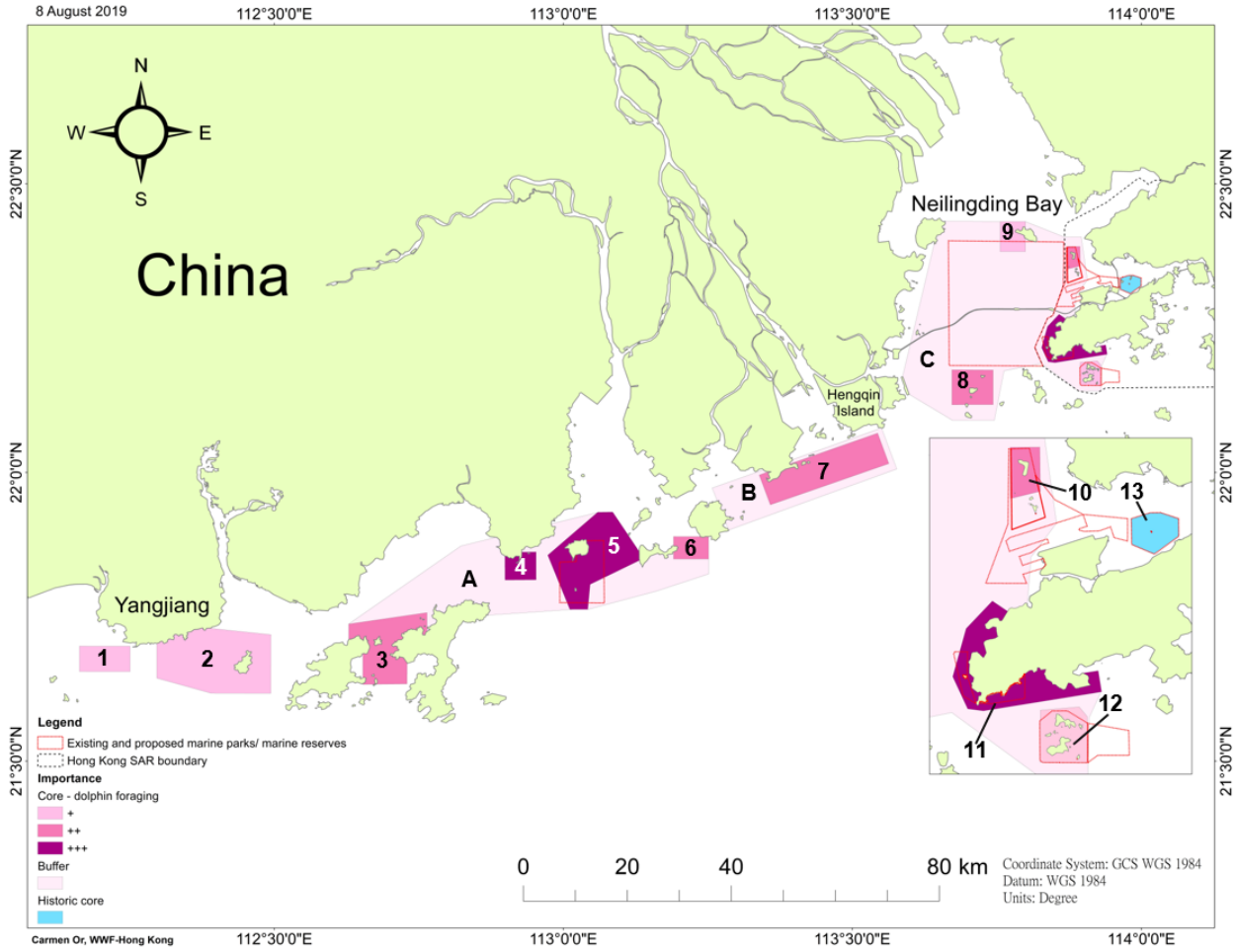


Figure 1| Core and buffer habitat areas, designated and proposed dolphin protected areas for Chinese white dolphins within the Pearl River Delta and in Yangjiang waters, based on expert evaluation of all available data, observations, and knowledge. Core habitat areas are shaded according to their relative ecological importance (see *Table 1*). Inset map: detail of Core Area #11, which spans from Tai O to Lo Kei Wan in Hong Kong SAR waters. This area is considered the most important foraging habitat for the dolphins throughout the Pearl River Estuary.

Table 1 |Core and buffer habitat areas within the PRD recommended by CWD specialists for immediate conservation and management to reduce anthropogenic disturbance and threats to CWDs.

		Assessment criteria		
Number	Core Habitat Areas	Frequent dolphin occurrence	Foraging	Nursery
1	Dongping Harbour Area	+	+	+
2	Miaowan-Mangzhou Area	++	+	++
3	Shangchuan-Xiachuan Area	++	++ (seasonal fish distribution with less frequent trawling activities)	++
4	Sanxiakou Area	+++	+++	+++
5	Dajin & Xiaojin Islands Area	+++	+++	+++
6	Gaolan-Hebao Area	++	++	++
7	Sanzao Island Area	++	++ (feed on fish abandoned by fishers, especially at night)	+
8	Green Island-Sanjiao Mountain Area	++	++	++
9	Neilingding Island Area	+	+	
10	Lung Kwu Chau Area	++ (more often at night)	++	+
11	South & West Lantau Area	+++	+++	++
12	Soko Islands Area	+	+ (particularly at night)	
13	The Brothers Islands (Historic)	++ (until 2015 when no dolphin sighting was made within and near the Brothers Marine Park)	++ (until 2015 when no feeding activity observed)	+ (until 2015 when no calf recorded)

Frequency: - None observed; + Moderate; ++ Frequent, +++ Highly Frequent

Three buffer areas are proposed (***Fig. 1***) to protect the transit and connectivity between the core habitats. Buffer Area A connects four core habitat areas (#3, 4, 5, and 6) with the Jiangmen Guangdong Chinese White Dolphin Provincial Nature Reserve (b, refer to the section *Current and Proposed Dolphin Protected Areas* below) (overlapping Core Area #5). Buffer Area B connects the Sanzao Island Core Habitat Area (#7) with surrounding coastal waters off Hengqin and Sanzao Islands. Buffer Area C links the five core habitat areas with the Guangdong Pearl River Estuary Chinese White Dolphin National Nature Reserve (a), Sha Chau and Lung Kwu Chau Marine Park (c), the proposed Marine Park to compensate for the construction of 3rd Runway at Hong Kong airport (e), proposed Southwest Lantau Marine Park (f) and proposed South Lantau Marine Park (g).

Core habitat areas are nested within these larger buffer habitat areas to encompass as much of the dolphins' range as possible for maintaining habitat connectivity and integrity, as well as minimizing 'edge effects' within the core areas. Although there appears to be limited connectivity between dolphin subpopulations (see ***Annex 1***), improving population connectivity also prevents demographic independence of the subpopulations and has an overall stabilizing effect on the PRD population viability (Chan *et al.*, 2019).

Following the urgent implementation of the identified core and buffer areas, a robust adaptive management plan should be developed, incorporating regular monitoring and assessment of management effectiveness within the designated areas, and a comprehensive marine spatial planning should be undertaken, covering the whole PRD region. Planning mechanisms should allow revision and adaptation of core and buffer area boundaries where required by the highly dynamic distributions of CWDs (Chan & Karczmarski, 2017) as they respond to oceanographic changes and anthropogenic disturbance[4].

Ultimately, a network of dolphin protected area is required to maximize population connectivity and integrity and should not only incorporate core and buffer habitat areas identified here, but also any other critical dolphin habitats subsequently identified by new research. This network of dolphin protected area needs to include at least 3,000 km^2 of *critical* dolphin habitats to support the long-term survival of the PRD dolphin population (Karczmarski *et al.* 2017). Ideally, with sufficient resources and logistic support, this network could be further expanded to connect existing nature reserves not specific to CWDs, such as the Guangdong Zhuhai Qi'ao Dangandao Provincial Nature Reserve, to form a more comprehensive network conserving a wider spectrum of marine species and ecosystem.

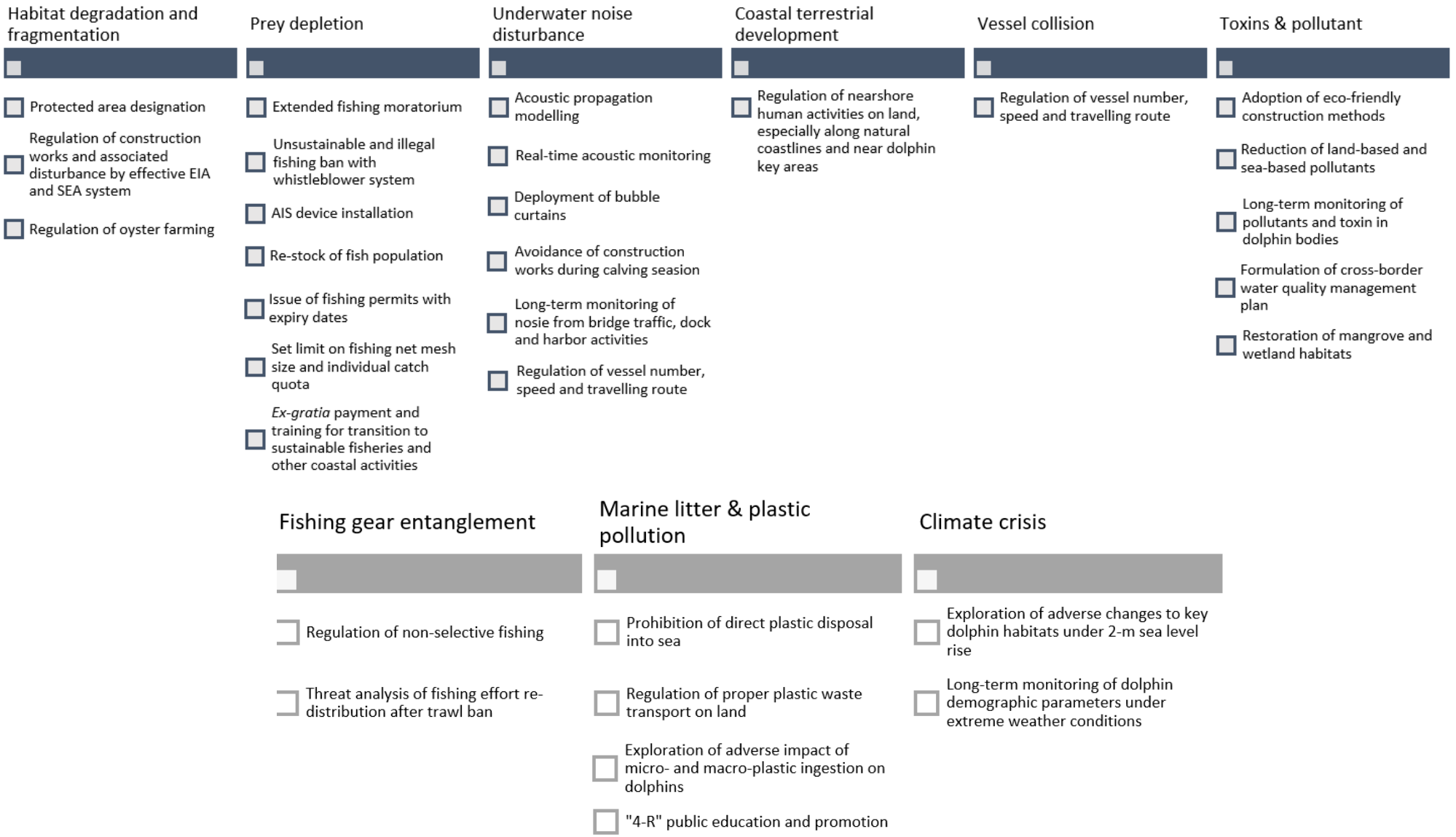
Key Management Actions Required for Core and Buffer Habitat Areas

Effective management must aim to systematically eliminate or minimize the major threats and disturbances to dolphin activities, and to secure habitat integrity, with very strong protection in the core habitat areas supported by moderate protection in the buffer habitat areas. Further, human activities that are *highly* destructive to CWDs, or their marine habitats, should be prohibited in waters *throughout* the range of the population, as maintaining the connectivity between identified key areas facilitates the stabilization of long-term viability of the PRD population (Chan *et al.*, 2019).

All the recommended management measures are only effective if law enforcement, regulations and relevant public education are in place. Compliance rates of these measures require regular, ongoing monitoring and evaluation.

[4] Protection should *not* allow for revision based on human development requirements if such revision would be detrimental to dolphin protection.

Threats and Disturbances to Chinese White Dolphins and Specific Responses Required



1. Threat / Disturbance: Habitat loss, degradation and fragmentation from coastal development

Causes and Drivers: Reclamation, dredging (including marine sand extraction), dumping, coastal development, watershed development and dam construction, infrastructure construction, oyster farm and other aquaculture development

Urgency: High

Management and Mitigation Strategies:

- Designate dolphin protected areas aimed at protecting and restoring core and buffer habitat areas, such as the Pearl River Estuary National Park suggested by the provincial administration. The protected areas should at least cover a total of 3,000 km^2 of *critical* dolphin habitats (Karczmarski *et al.,* 2017)
- Strictly prohibit construction works in any form, including reclamation, within and adjacent to the core and buffer areas, and stringently regulate noise pollution and vessel traffic impacts in nearby waters. The development-free zone should at least cover the core and buffer areas, while the spatial coverage in adjacent waters must account for the type of construction works involved and the estimated zone of influence
- Ensure that construction and operational impacts from nearby development are assessed and evaluated in all environmental impact assessments (EIAs) to not adversely affect CWDs within the protected areas
- Strategic Environmental Assessment (SEA) should be conducted to evaluate cumulative environmental impacts from concurrent projects, and as a process to analyze and evaluate broader environmental implications of policies, plans and programs at an early stage of the decision-making process
- Ban oyster farming in designated dolphin protected areas, and minimize the length and number of oyster farms nearby in Chinese waters

2. Threat / Disturbance: Prey depletion

Causes and Drivers: Overfishing, habitat destruction by development (see above), unsustainable and damaging fishing practices, illegal fishing and aquaculture activities, depletion of fish by discarded fishing gear

Urgency: High

Management and Mitigation Strategies:

- Maintain adequate food supply for dolphins within Guangdong waters:

Consider to extend the duration of seasonal fishing moratorium to four months (currently two to three months) and provide *ex-gratia* payment to affected fishers to keep their fishing vessels during suspension. Increase the penalties for illegal charters with confiscation of fishing vessels. Some experts however are concerned that *ex-gratia* payment

- Ban trawling and other destructive and non-selective fishing methods[5] throughout all core and buffer habitat areas. Strong evidence shows poor compliance with existing bans on trawling and destructive fishing activities. Thus, regulations should be effectively enforced with more frequent at-sea and coastal patrol and heavier penalties
- Apply the ban also to non-motored trawling and other unregulated small-scale fisheries activities, and extend the ban to spatially cover all coastal waters, at least within 1km from shore

- Maintain adequate food supply for dolphins within Hong Kong SAR waters:
  - Ban snake cage fishing in identified core and buffer habitat areas, as well as in designated and proposed marine parks
  - Upgrade enforcement and patrols of current fisheries management, including of the trawling ban
- Maintain adequate food supply for dolphins jointly in Guangdong and Hong Kong administrations, that is, Fisheries Department of the Agriculture, Fisheries and Conservation Department (AFCD) of Hong Kong SAR and the Fishery Administration under Department of Agriculture and Rural Affairs of Guangdong Province
  - Strengthen patrols and law enforcement at sea, at port and along the coast to combat illegal fishing and aquaculture activities (especially the small-scale ones), particularly during any fishing moratorium to ensure the low-disturbance conditions of key foraging habitats for CWDs. In particular, strengthen coordinated patrols and enforcement to combating illegal fishing near the China-Hong Kong SAR boundary
  - Require compulsory automatic identification system (AIS) devices for all fishing vessels operating near the China-Hong Kong SAR boundary, including small fishing boats, and integrate AIS system with automated shore-, marine- and aerial-based real-time monitoring by local authorities
  - Provide monetary rewards to whistle-blowers of illegal fishing, and establish a user-friendly reporting system (for example, on Wechat or Whatsapp) facilitating voluntary whistleblowing
  - Regulate small-scale fisheries such as issuing fishing permits with expiry date to all fishers, including handlining and cage-trap operators, to gradually phase out all fishing activities in the core and buffer dolphin areas. The regulation measures can be accompanied with the introduction of a vessel buy-out scheme to purchase fishing boats by the governments
  - Regulate the mesh size of fishing nets and set individual and species-specific fishing quota based on total allowable catch to prevent overfishing during fishing season
  - All the afore-mentioned regulations should be integrated with community education specifically targeting local fishers, aimed at raising their awareness, followed by developing positive attitude towards sustainable fishery

[5] Destructive and non-selective fishing includes electric fishing, dynamite fishing, gillnetting and snake-cage fishing. According to China Fisheries (2002), these fisheries activities are currently banned in inshore and coastal waters within 40 m in water depth.

- Strengthen cross-boundary cooperation between AFCD and the Administration of Ocean and Fisheries of Guangdong Province for the formulation of a comprehensive Greater Bay Area[2] (GBA) fisheries conservation and management plan. A pragmatic approach might be to start with formulating a management plan for Hong Kong, followed by linking it with management measures adopted by the Forestry Bureau of Guangdong Province (especially Guangdong Pearl River Estuary Chinese White Dolphin National Nature Reserve Management Office and Jiangmen Guangdong Chinese White Dolphin Provincial Nature Reserve Management Office) and the Administration of Ocean and Fisheries of Guangdong Province to form a joint cross-boundary management plan to be implemented across the whole PRD area
- Restock fish populations in PRD waters by releasing fish fry of the prey species for CWDs, following by the monitoring of fish movement and distribution by fish tagging and fish survey. This will be more effective if fish restocking is complemented by other fisheries management measures, such as the designation and effective management of 'no-take' zones in core habitat areas

- Encourage the transition to sustainable fisheries, aquaculture, mariculture, and other coastal activities in Guangdong and Hong Kong SAR
  - Provide *ex-gratia* payment to fishers transforming their livelihoods. Organize free vocational and conservation training programme for fishers to equip them with skills and knowledge for sustainable operations such as nearshore aquaculture, recreational fishing, oyster reef cultivation and harvest, restoration and management of mangrove habitat
  - Dolphin-watching tourism may connect the public to CWDs and the marine environment and help raise public awareness of regional dolphin conservation. However, experts advise that such tourism may contribute stress and disturbance to the dolphins in their key habitats. If permitted, dolphin watching must be stringently regulated to minimise disturbance. Some experts feel that any level of tourism would be unacceptable.

3. Threat / Disturbance: Underwater noise (acoustic) disturbance

Causes and Drivers: Underwater noise from coastal development works, marine traffic and dolphin-watching activities, and, indirectly, from bridge traffic

Urgency: High

Management and Mitigation Strategies:

- Acoustic propagation modelling (Farcas *et al.*, 2016; Faulkner *et al.,* 2018) must be compulsorily incorporated in Environmental Impact Assessment (EIA) for all marine development projects that will generate significant noise disturbance to CWDs. The modelling should quantify the impact of underwater noise to cetaceans and, thereby, predict the severity of actual impacts from construction noise (Southall *et al.*, 2007). It should ensure that the predicted zone of severe influence (for example, resulting in significant acoustic masking, hearing loss, injury, or even death) does not spatially overlap with any identified core or buffer dolphin areas, or designated or proposed

marine parks/marine reserves, in addition to minimising zone of acoustic disturbance and incorporating acoustic mitigation measures

- Current practice of visual monitoring of dolphin occurrence within project areas must be complemented by compulsory deployment of real-time acoustic monitoring as part of environmental mitigation within the EIA framework. Acoustic detection of dolphins within dolphin-exclusion zones must trigger immediate halt to construction work, to prevent any potential auditory disturbance or injury to dolphins
- Bubble curtains should be deployed, particularly for piling works, to reduce low- and mid-frequency noise (Würsig *et al.*, 2000). Other underwater noise mitigation measures should also be implemented during construction phase, as necessary.
- Any construction works should avoid the peak calving season of CWDs, that is, from March to June
- Underwater noise from human activities at docks and harbours, and indirectly from bridge traffic should also be monitored
- Vessel traffic noise impacts must be minimized through:
  - regulate the numbers and speed of large and particularly small, commercial, private, and recreational vessels near the identified core and buffer areas. Reducing vessel speed is found to alleviate auditory masking by decreasing the reduction in marine mammal and fish listening space (Pine *et al.*, 2018)
  - standardize vessel components, such as the avoidance of use of damaged propeller blades, to better regulate shipping noise
- Larger vessels, such as ferries, barges, and container ships, should be largely diverted from traveling through CWD core habitat areas; any residual traffic transiting these areas must reduce speeds to 10 knots (as stated in Cap.476A Marine Parks and Marine Reserves Regulation, The Department of Justice, 2015)

4. Threat / Disturbance: Rapidly expanding coastal and watershed development

Causes and Drivers: Rapid expansion and urbanisation of human population in the GBA

Urgency: High

Management and Mitigation Strategies:

- Regulate coastal human activities along shore and in watersheds, especially those along natural coastlines (given CWDs show strong preference for natural rocky shorelines, ***Annex 1*** refers) and/or in the proximity of core and buffer habitat areas. Alleviate the degradation of key dolphin habitats and watersheds (such as the watersheds of southwest Lantau Island) and maintain the intactness and continuity of natural shorelines (see 1. Habitat loss, degradation and fragmentation… above).

5. Threat / Disturbance: Vessel Strike

Causes and Drivers: Frequent vessel traffic activities

Urgency: High

Management and Mitigation Strategies:

- Regulate the number of both large and small operating boats and vessel travelling speed near the identified core and buffer areas. As a priority, reduce ferry numbers off south Lantau (Hong Kong) at night, when passenger travelling demand diminishes

- Re-route fast-moving boats, especially high-speed ferries in Hong Kong, away from identified key and buffer dolphin areas
- Larger vessels should be largely diverted from traveling through CWD core habitat areas, and, at a minimum of reducing speeds to 10 knots while transiting through the key areas.

These measures will complementarily reduce both noise disturbance (above) and boat strike. Although notification and an awareness notice campaign should precede enforcement, this must be implemented with great urgency

6. Threat / Disturbance: Toxins and pollutants

Causes and Drivers: Reclamation, dredging, dumping, land-based pollution from untreated industrial and agricultural effluent, urban runoff, domestic sewage, pollutants discharged from ships, anti-fouling paints used in port facilities

Urgency: High

Management and Mitigation Strategies:

- Minimize water and chemical pollution from construction works
  - Adopt eco-friendly best practice construction methods, such as pre-cast concrete construction method for bored pilings and deployment of double layer silt curtains for dredging works
  - Implement emergency response plan for hazardous chemical spills
- Strengthen existing measures to minimize land-based and sea-based pollutants from entering the marine environment, especially those that are known to have a high propensity to bioaccumulate in cetaceans. For instance, non-biocide anti-fouling hull coatings with similar performance and cost-effectiveness should be used to replace heavy metal-containing coatings for boat hull painting to ensure the well-being of CWDs and the marine environment (refer to below section for more detailed discussion of potential toxins and sources)
- Conduct long-term monitoring of the level and trend of key or indicator pollutants and toxins in found CWD carcasses with consequent tracing and combating the major source of the chemicals (refer to below section for more detailed discussion of potential toxins and sources)
- Formulate a cross-boundary water quality management plan by the Pearl River Delta Water Quality Protection Special Panel of the Hong Kong/Guangdong Joint Working Group on Sustainable Development and Environmental Protection
- Restore, and conduct long-term monitoring of, nearshore marsh, inter-tidal mudflat, mangrove, seagrass bed and other wetland habitats where these habitats have been lost. Wetland habitats serve as filters that help to improve marine water quality

7. Threat / Disturbance: Fishing gear entanglement

Causes and Drivers: Fisheries activities spatially overlap with key dolphin areas

Urgency: Moderate

Management and Mitigation Strategies:

- Fisheries practices that most commonly result in bycatch should be phased out and banned in identified core and buffer dolphin habitat areas, as part of the cross-

boundary fisheries conservation and management plan. These non-selective fishing methods with high-entanglement risk that should be regulated are trawling and gillnetting (WWF, 2019)

- Conduct a rapid threat analysis of fishing effort throughout the PRD region to map the patterns of non-selective fishing practices in core habitat areas and beyond. Comparison of the spatial overlap between key dolphin areas with intense fishing pressure will allow evaluation of the risk of bycatch and ghost gear entanglement by CWDs, followed by targeted measures to prevent such impacts
- Organize free vocational and conservation training programme for fishers to equip them with skills and knowledge for sustainable fishing including the proper disposal of damaged fishing net

8. Threat / Disturbance: Marine litter and plastic pollution

Causes and Drivers: Excessive use of plastics, improper disposal of land-based waste, accidental product loss during transport

Urgency: Moderate

Management and Mitigation Strategies:

- Formulate regulations to prohibit direct disposal of plastic waste into the sea and ensure proper transport of plastics on land
- Ensure ecotourism operators, fishers, oyster farmers, and other stakeholders who visit CWD key areas dispose of rubbish and fishing gear on land in a proper fashion
- Evaluate any adverse ecological impacts of microplastic pollution and plastic ingestion by CWDs or other cetaceans
- Conduct public education to promote the plastic '4R' concept (reduction, reuse, recycling, recovery of plastic waste), highlighting the benefits of a waste- and pollutant-free marine environment for both humans and wildlife

9. Threat / Disturbance: Climate crisis and global heating

Causes and Drivers: Excessive emission of greenhouse gases by human activities, global heating, sea-level rise, more frequent severe storm events

Urgency: Moderate

Management and Mitigation Strategies:

- Evaluate any major changes to key CWD habitat areas due to the projected 2 m rise in sea level from melting icecaps, monitor dolphin mortality after major storm events and include trends within demographic models for CWDs
- Prioritize reduction of Hong Kong greenhouse gas emissions and implement policies to support business and finance sector to provide global leadership in supporting a low-carbon future

By securing habitat integrity and improving the effectiveness of conservation measures, dolphin survival rates could be increased which then lowers the required threshold critical habitat size and make the conservation plan more economically affordable and tractable.

Global Importance and Population Status of PRD Chinese White Dolphins

The global abundance of CWDs remains uncertain due to the lack of systematic and standardized studies on their fragmented distribution throughout their range (Jefferson *et al.*, 2018). The global population is estimated at about 5,600 individuals (Jefferson *et al.*, 2018). Based on an inferred reduction in global population size (that is, an annual population decline of 3.7% for dolphin populations outside of the PRD), the IUCN conservation status for CWD was re-assessed and upgraded from 'Near Threatened' to 'Vulnerable' in 2017 (Jefferson *et al.*, 2018).

Figure 2| Map showing the locations of the nine identified populations of Chinese white dolphin (*Sousa chinensis*) along the coast of China (based on Chen *et al.*, 2018). The Pearl River Delta population (PRD, in red) is the largest of the nine. DRE and SC: Dafengjiang-Nanliujiang River Estuary community and Shatian-Caotan community. PRD: Pearl River Delta. The dolphin population along the eastern Taiwan Strait consists of subspecies *S. chinensis taiwanensis* (refer to *Annex 1* for more information). Map produced using Google Map

The PRD population may be the largest identified population globally (***Fig. 2***), and certainly the largest in China, with an estimate of about 2,000 individuals (Chan *et al.*, 2019) excluding estimates from the Moyang River Estuary, Yangjiang. This constitutes roughly one third of the estimated global population. Data from the Bay of Bengal suggests the presence of possibly a larger "super-population" (Smith *et al.*, 2015) if deemed to be taxonomically similar to *Sousa chinensis* (Mendez *et al.*, 2013). The PRD dolphin population is the only population with long-term and quantitative data on population trends (for instance, 15 years of monitoring in Hong Kong waters) (Jefferson *et al.*, 2018). Jefferson and colleagues (2012) estimate that about 60% to 75% of this well-documented PRD population consists of mature individuals. This is important, because it suggests some resilience to anthropogenic impacts and, perhaps, the potential for recovery if threats are mitigated effectively.

Among the estimated 2,000 CWDs in the PRD region, The Pearl River Estuary[3] may currently be home to about 900 dolphins, based on abundance estimates of 1,273 dolphins for the Estuary estimated in 2010 (Chen *et al.*, 2010), with annual declining rate of about 2.5% (Huang *et al.*, 2012). Over 50% of CWDs recorded by Or (2017) were sighted in the coastal waters off west and south Lantau in the Hong Kong SAR. More than half of the PRD population (that is, roughly 1,100 dolphin individuals) inhabit the western portion[6] of PRD (W. Lin, pers. comm. 2019), including the around 500 individuals in the Moyang River Estuary (Li *et al.*, 2019). Apart from covering a wider region of coastal waters, the western PRD experiences less disturbance from major human activities, such as offshore developments and shipping operations.

There is very strong evidence indicating that the population of CWDs is dramatically declining, certainly within specific areas (for example, Hong Kong SAR) and almost certainly throughout the PRD (Chan *et al.*, 2019). Long-term monitoring of dolphins in Hong Kong SAR's coastal waters points to a drastic loss trajectory with a drop of over 80% in estimated local abundance in the past 15 years (AFCD, 2019). Monitoring and observations in several key habitats show decreasing numbers of animals, both in Guangdong (Wang *et al.*, 2019) and HK SAR waters (AFCD, 2015). Across the PRD, the population is estimated to be declining at around 3% annually (***Annex 1*** refers, Chan *et al.,* 2019). Critically, this CWD population appears to be at the minimum number needed to viably sustain in the longer term, that is, across 32 generations (about 800 years) under *stationary* population structure (Karczmarski *et al.*, 2017). The most recent population estimate for PRD CWDs, at about 2,000 individuals (Chan *et al.* [2019]), is the estimated minimum viability threshold for this population. The dolphins are, therefore, susceptible to even minimal population fluctuation and are facing imminent risk of stochastic extinction of this population.

It should be noted that many of the population estimates stated above are around 10 years out of date and, thus, are likely to be overestimates because the anthropogenic threats to dolphins, such as severe degradation and fragmentation of the already very restricted coastal estuarine habitat, are exacerbating rapidly and drastically in recent years. The exact situation is currently uncertain, but there is little doubt that the population is in serious decline.

Current and Proposed Dolphin Protected Areas

Current dolphin protected areas targeting conservation of PRD CWDs and their habitats include one National Nature Reserve and one Provincial Nature Reserve in Guangdong waters, two designated and three proposed marine parks in Hong Kong SAR waters (see ***Fig. 3***). These include:

a) *Guangdong Pearl River Estuary Chinese White Dolphin National Nature Reserve,* established in 1999, which covers about 460 km^2 of Lingding waters. Vessels engaging in activities which could adversely impact on fisheries resources are prohibited in the core area (Guangdong Pearl River Estuary Chinese White Dolphin National Nature Reserve Institution, 2012);

[6] The west portion of PRD includes coastal waters from Hengqin Island to Yangjiang, as illustrated in Fig. 1 of the Final Report: A Population Viability Analysis for the Chinese White Dolphin (*Sousa chinensis*) in the Pearl River Estuary (IUCN SSC CBSG, 2017).

b) *Jiangmen Guangdong Chinese White Dolphin Provincial Nature Reserve,* designated in 2003, which occupies around 108 km^2 of waters off Dajin and Xiaojin Islands. Bottom trawling, drift gillnetting, high-speed motorboat operation, destructive fishing, water skiing, and activities threatening the CWD are forbidden within the Reserve (Jiangmen Guangdong Chinese White Dolphin Provincial Nature Reserve, 2011);
c) *Sha Chau and Lung Kwu Chau Marine Park,* established in 1996, which covers approximately 12 km^2 of north Lantau waters. Waters within marine parks are protected under Marine Parks Ordinance (Cap. 476, which stipulates the procedure for designation of marine parks and marine reserves, purpose and functions), and Marine Parks and Marine Reserves Regulations (Cap. 476A, which regulate activities therein including fishing, mariculture, marine traffic and recreational activities in marine parks and reserves) (The Department of Justice, 2015a, 2015b);
d) *The Brothers Marine Park,* designated in 2016 occupying about 9.7 km^2 of northeast Lantau waters. It is also protected under Cap. 476 and Cap. 476A. Within this Marine Park, designated Core areas ban all fishing activities and provide mooring sites (AFCD, 2018b);
e) Proposed *Marine Park to compensate for construction of 3rd Runway at Hong Kong airport,* will be designated with covering about 24 km^2 of north Lantau waters. Fish fry restocking and deployment of artificial reefs are proposed as enhancement measures (ERM, 2015);
f) Proposed *Southwest Lantau Marine Park* covering 6.5 km^2 of Lantau waters off Fan Lau has been proposed. The management plan for this Marine Park will be similar to that for existing marine parks (AFCD, 2017);
g) Proposed *South Lantau Marine Park* occupying a total of 20.7 km^2 of Lantau waters off the Soko Islands will be designated, to be managed similarly to the current marine parks (AFCD, 2017a).

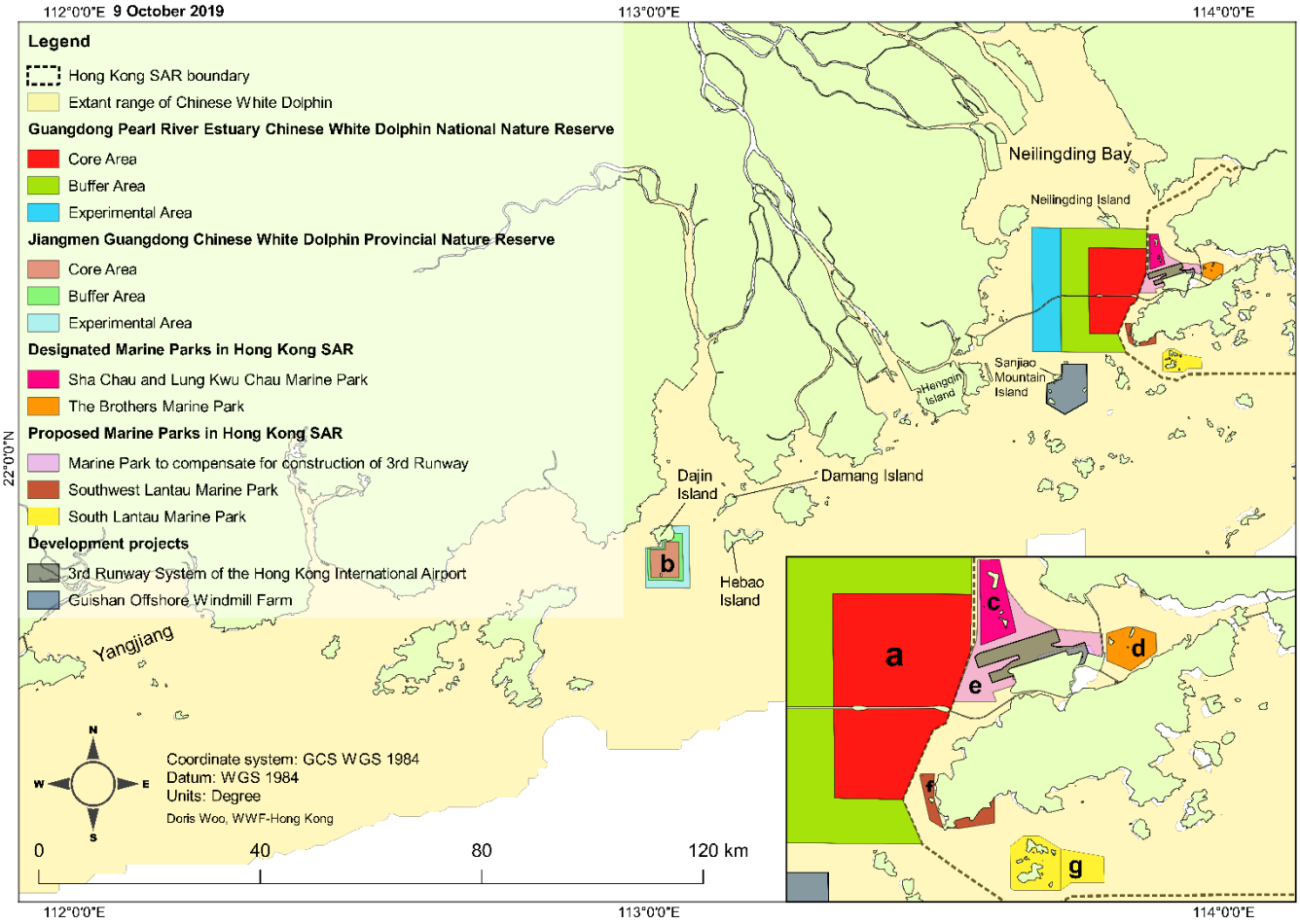


Figure 3| The map approximates the area under consideration of this analysis and existing and proposed dolphin protected areas

Threats to Chinese white dolphins in the Pearl River Delta

Chinese white dolphins in the PRD predominantly inhabit nearshore waters, which is where human activities are most intensive. Residing in an estuary surrounded by one of the most highly developed and industrialized landscapes in the world, with increasingly reclaimed and developed shorelines, the animals face significant and pervasive threats (AFCD, 2019; Huang *et al.*, 2012; Jefferson *et al.*, 2009; Karczmarski *et al.*, 2016). Some of the threats may cause immediate loss of individuals, while others reduce fitness, survivorship, and longevity or reproduction success. Five major threats requiring urgent action by governments and other stakeholders have been identified:

1. **Loss and degradation of shallow water habitat from coastal and river development**: Extensive dredging and coastal construction works are rapidly reducing the effective size and structure of the key foraging habitats for CWDs in shallow estuarine waters (Karczmarski *et al.*, 2017), where habitats are naturally limited in distribution. Offshore reclamation works also destroy intact and natural shorelines and key foraging habitats (Karczmarski & Or, 2016). Coastal development projects, such as the on-going expansion of Three-Runway System at the Hong Kong International Airport, have

reclaimed >2,600 ha of marine area in total around the Lantau Island in the Hong Kong SAR since the mid-1990s (EPD, 2019), and have resulted in the loss of continuous natural coastlines. Evidence shows CWDs within the Hong Kong SAR have undergone a major shift in their distribution range and habitat use, from the once favoured waters of north and northeast Lantau, predominantly to south and west Lantau waters with alteration of their pattern of habitat use. The dolphins have not returned to their previously preferred habitats in north and northeast Lantau waters, including the Brothers Marine Park, subsequent to completion of major construction works, such as the Hong Kong-Zhuhai-Macau Bridge (AFCD, 2015, 2016, 2017c, 2018a, 2019).

Chinese white dolphins inhabiting waters beyond the Hong Kong SAR have also been excluded from preferred habitats. Development of oyster farms off north-western Dajin Island, eastern Damang Island, northern Hebao Island and around Neilingding Island has partitioned optimal habitats for dolphins and reduced habitat integrity.

Changes in upstream flow dynamics are also likely to have compromised the quality of habitats in the Pearl River Delta. Previous studies indicated dam establishment and channel dredging along the Yangtze River would result in reduced freshwater discharge, sediment supply and altered hydrologic processes in the downstream section (Chen & Zong, 1998; Wang *et al.*, 2005; Wu *et al.*, 2016). These in turn change the nutrient load to the deltaic coastal system, and possibly lead to coastal erosion, saltwater intrusion, and eventually alter the estuarine ecological system in the Delta region. Given the seasonal variations in dolphin distribution observed in the Pearl River Estuary (including Hong Kong SAR waters) are probably associated with the seasonal shifts in prey movement (Chan & Karczmarski, 2017; Or, 2017), in turn influenced by the estuary discharge (Hung, 2008; Jefferson, 2000), human activities along the Yangtze and Pearl Rivers are likely to have indirectly changed the distribution and quality of the very limited foraging habitat areas for CWDs in the PRD.

2. Prey depletion by overfishing and unsustainable fishing: Overall fisheries production, marine catch of high-value fishes and mean trophic level of marine capture fisheries have been decreasing throughout Chinese waters (Cao *et al.*, 2017; FAO, 2001), as the productions of both marine capture fisheries and mariculture fisheries have exceeded the sustainable fisheries limit (***Fig. 4*** refers).

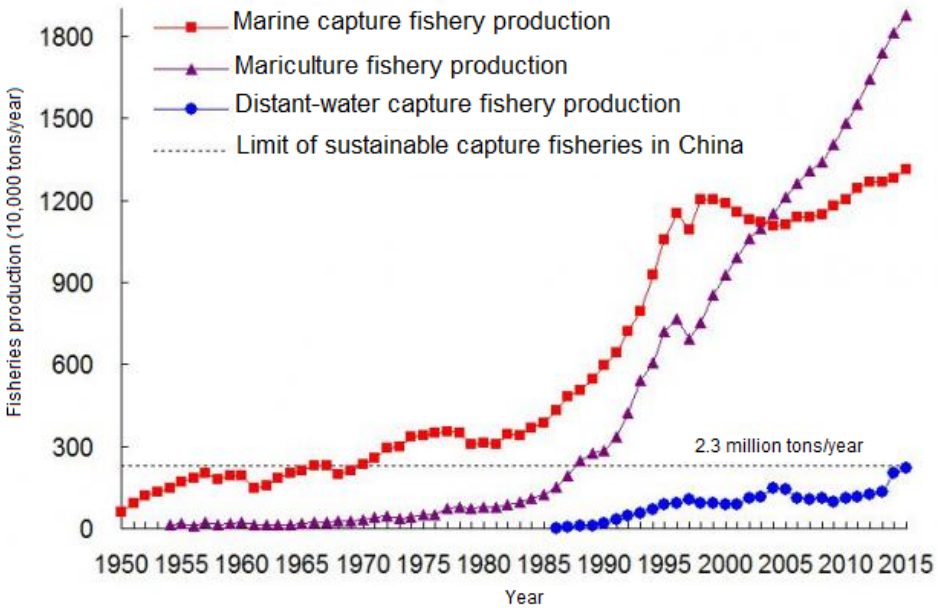


Figure 4| Productions of marine capture fisheries, mariculture fisheries and distant-water capture fisheries in China from 1950 and 2015. Marine capture fisheries production and mariculture fisheries production have been exceeding the limit of sustainable capture fisheries respectively since 1970 and 1987. Data obtained from the China Fishery Statistical Yearbook by the Fishery Administration of the Ministry of Agriculture (2015)

Overall, fisheries capture per unit effort in the northern part of the South China Sea (including the PRD) decreased by over 43% from 1970 to 2008, while large demersal and pelagic fishes have been either overexploited or fully exploited (Christensen *et al.*, 2003; Funge-Smith *et al.*, 2012; Lehmköster, 2013) due to the expansion of intensive fishing into marine areas. Shifts in catch composition towards low-value and small fish species has been identified in northern South China Sea (Teh *et al.*, 2016). Stomach content analysis of stranded CWDs in the Pearl River Estuary indicated that the dolphins also exhibit a profound diet shift over the past two decades to less diverse and smaller-sized prey items, indicating the animals are feeding on prey of lower trophic levels, likely because of insufficient food supply (D. Y. W. Ho, pers. comm. 2019). Although fisheries resources in the PRD are currently under the protection of the Closed Fishing Area for Bottom Trawl Fishery by Motorboats, Pearl River Estuary Commercial Fish Nursery Protected Area and South China Sea Fish Juvenile Nursery Protected Area (China Fisheries, 2002), law enforcement and compliance within these designated areas and during the seasonal fishing moratorium appear to be largely ineffective (Shen & Heino, 2014). There is limited effort in fisheries management in the PRD to regulate destructive fishing (for example, electric fishing, fixed gillnetting, dynamite fishing) and small-scale fishing activities, or to control overall fishing effort or total catch. Illegal fishing and aquaculture activities typically remain unreported, without effective statutory regulations and long-term monitoring.

3. Underwater noise disturbance by marine traffic, development works and bridge traffic: Marine construction works often generate underwater noise detectable by CWDs (Hung, 2008; Jefferson, 2000; Wang *et al.*, 2014), such as through percussive piling

operations (Würsig *et al.*, 2000). Strong underwater noises may interfere with cetacean acoustic communication, interrupt foraging and navigation, or even cause hearing loss or death in dolphins. Noise from the propulsion systems of marine traffic can mask dolphin whistles as recorded in west Hong Kong waters (Ocean Acoustics Ltd., 2016; Sims *et al.*, 2012). Marine traffic noise especially fast-moving vessels and mid-sized fishing boats (Karczmarski *et al.*, 2016; Li *et al.*, 2015; Sims *et al.*, 2012) contributes appreciable sound levels to ambient environment, and interrupts dolphin acoustic behaviour. The noise generated by outboards and smaller vessels is believed to be particularly disruptive to the acoustic fishing behaviour of dolphins (L. Karczmarski, pers. comm. 2019), as non-jet boat noise spans wider frequency range and is more likely to mask prey fish calls acoustically. Prolonged exposure to vessel noise could even cause chronic auditory damages and stress on CWDs. Low-frequency underwater noise (≤ 100 Hz) from train and vehicle traffic passing over bridges (Marley *et al.*, 2016) could also be a potential noise source altering dolphin behaviour near the established bridges in the PRD, such as the Hong Kong-Zhuhai-Macau Bridge.

The PRD has exceptional exposure to all these sources of marine noise as it is one of the world's busiest areas for marine traffic, has massive port facilities, and, over recent decades, has seem enormous construction and reclamation for the Hong Kong International Airport and the Hong Kong-Zhuhai-Macau Bridge. Together, this noise disturbance will have had extensive impact on the habitat suitability for dolphins.

4. Vessel Strike and Traffic: Multiple, high-traffic shipping lanes overlap with key dolphin habitat along the PRD coast. Given that CWD habitat use in the PRD appears more highly dependent on prey availability than shipping intensity (Pine *et al.*, 2017), frequent vessel operations in or near key foraging sites is likely to greatly increase the risk of CWDs being hit, injured, or killed by vessels. Scars and other injury marks consistent with boat propellers are commonly observed on the fins or bodies of CWDs (Chan & Karczmarski, 2015; Chan & Karczmarski, 2019). Blunt trauma by boats was identified as one of the major causes of death in cetacean stranding cases (in which cause of death could be determined) in Hong Kong (OPCFHK, 2014, 2015, 2016). Previous virtopsy studies also identified blunt force trauma on about 39% of studied carcasses of local cetacean species (Kot, 2019). Some participants in the expert workshop suggested that smaller vessels are responsible for a large proportion of vessel strike on CWDs, as the travelling routes of small boats are more random and unpredictable compared to those of large vessels operating along major shipping lanes.

   The presence of oncoming vessel and heavy marine traffic also induce avoidance behaviour with altered behavioural budget in CWDs (Marcotte *et al.*, 2015)—the dolphins were found changing direction of movement, increasing dive times, and changing travelling speed along major shipping lanes (Ng & Leung, 2003) or in the presence of operating dolphin-watching boats (Tse, 2010; Wong, 2017). Behavioural disruption will increase energy expenditure and reduce time for foraging and reproductive behaviour, in turn, causing reduced survival and reproductive success in the population overall.

5. Pollutants & toxins: Diverse pollutants and toxins from a wide range of anthropogenic sources, including agricultural and industrial activities, are identified in the PRD waters. These chemicals bio-magnify through coastal food chains and bio-accumulate in the top predator CWDs, causing multi-organ damage and detrimental health effects on the animals. Regional studies showed that the dolphins not only contain very high levels of legacy Persistent Organic Pollutants (POPs, such as DDT and triphenyltin compounds TPT) (Sham *et al.,* 2020) and heavy metals (such as As and Cr), but are also exposed to the highest levels of emerging POPs (such as per- and polyfluoroalkyl substances, PFASs) currently found in cetaceans worldwide (Gui *et al.*, 2019; Wilson *et al.*, 2008; Xie *et al.*, 2020). Despite a global ban of perfluorooctane sulfonate (PFOS), it is still used and found in the marine ecosystem of the PRD, and there is a recently increasing trend of PFOS in CWDs. This warrants serious concerns about adverse chemical impacts on the Delta's whole dolphin population (Gui *et al.*, 2019). Long-term exposure to these chemicals could potentially disrupt immune and reproduction systems of marine mammals, making them vulnerable to diseases and causing dwindling birth rates. For instance, organochlorides can bio-accumulate in CWDs and be transferred to calves through parturition and lactation. Sequestration of toxins in cetaceans has been implicated in high dolphin neonatal mortality rate (Jefferson *et al.*, 2006), immunosuppression and reproductive anomalies (Cagnazzi *et al.*, 2020), and impacts on health and survivorship in adults in other species (Martineau *et al.*, 2002).

There are several additional threats to CWDs, considered less significant as drivers of population declines, but which nonetheless compound the overall pressures. These include:

6. Marine litter and plastic pollution: Land- and sea-based marine litter, especially plastics, could be a potential threat to CWDs in the PRD. Autopsies of stranded CWD suggest that plastic ingestion by CWD is low compared to many other cetacean species. However, microplastics were previously recorded in the intestines of adult and calf CWDs, indicating that consumption of prey and unintentional ingestion are potential pathways of microplastic accumulation in the dolphins (D. Y. W. Ho, pers. comm. 2019; Zhu *et al.*, 2019). Further studies are needed to assess the adverse impacts of microplastic pollution on CWDs.

7. Entanglement in fishing gear and by-catch: The risks to dolphins of entanglement in fishing gears is important, although quantitative data are lacking. Further, these risks are likely to be changing due to changes within fisheries and their management. Mid-water and bottom trawling has been banned year-round in Hong Kong waters since late 2012 (AFCD, 2018c), potentially leading to redistribution of fishing effort to include increased trawling outside the Hong Kong SAR, and increased small-scale fishing activities in Hong Kong SAR and/or the rest of the Pearl River Estuary. Either or both shifts may contribute to increased gear entanglement. Non-selective fisheries other than trawling, such as gillnetting, are operating throughout the year in the PRD. Chinese white dolphins in the PRD are frequently seen following fishing boats for food, mainly trawlers, gill netters and purse seiners (Hung, 2008; Karczmarski *et al.*, 2016), greatly

increasing their risk of being accidentally caught (that is, by-catch). Such by-catch has been observed to occur in both Hong Kong (Peng Chau and Tai O fishers, pers. comm. 2020) and other waters in the PRD (Karczmarski *et al.*, 2016), although the patterns or magnitude of consequent mortality is largely unknown. Dolphin by-catch was also recorded around Hainan Island where gillnets were the primary fishing gear used in local fisheries (Liu *et al.*, 2017). The potential threat of dolphin entanglement is also indicated by the lesions observed on CWDs stranded on the coast (Chen *et al.*, 2010; Jefferson & Parsons, 2000; Kot, 2019). These lesions often show clear patterns of fishing gears. Although fishing gear entanglement is a less severe threat compared to those listed above, exceptionally high rates of fatal gillnet entanglement in CWDs have been found in other areas where CWDs are exposed to intensive small-scale fisheries, such as in Bangladesh (Smith *et al.*, 2015) and western Peninsular Malaysia (Jefferson *et al.*, 2018).

8. Climate change: Model estimates predicted that global heating and consequential changes in sea levels and rainfall patterns are likely to alter hydrological processes and nutrient input in the form of increased sediment and nutrient loads into the lower Pearl River Basin and accelerated eutrophication in the coastal area (Li *et al.*, 2011). A projected 1-2 m rise in sea level over the next several decades will alter the distribution of shallow water habitats preferred by CWDs, but the nature and extent of these changes remains uncertain (Kulp & Strauss, 2019). Warming waters and more extreme storm events may shift favoured water conditions for CWDs and their prey species. Given the extensive coastal development in the PRD, it is highly probable that these changes will cause further loss of total available habitat.

Knowledge Gaps, Areas of Uncertainty and the Need for Adaptive Management

During the workshop, and in this report, the participants distinguished between knowledge gaps that have important and/or urgent consequences for implementing conservation actions, and other areas of uncertainty or differences of perspective between different experts.

Gaps in Knowledge important for conservation actions

Although Chinese white dolphins are relatively well-studied (especially in Hong Kong SAR waters) compared to other marine fauna species in China, human-dolphin interactions and how its prey species respond to anthropogenic impacts remain poorly understood. Little is known about the social interaction of dolphins utilizing different core areas, as there are few studies examining individual habitat use, residency and movement patterns, and the community structure of a particular social cluster (except for the social groupings in Hong Kong and PRE waters [Or, 2017, Karczmarski *et al.*, 2019]). Recent studies (Chan *et al.,* 2019; Karczmarski *et al.*, 2019) indicated that the PRD population consists of socially distinct and spatially discrete subpopulations (or communities). Due to the long-term moderate-to-strong fidelity to key habitats, long-distance movement (several tens of km) of dolphin individuals is infrequent yet important. Further information is important for determining whether a large

and continuous buffer area connecting all core areas identified in the PRD region should be proposed and managed accordingly. In this context, it must be emphasized that the core and buffer habitat areas suggested in this plan provide the *minimum* well-managed areas required during the *early* stage of regional dolphin conservation.

Distribution and behavioural patterns of CWDs during the night remain poorly known throughout most of the species' range in the PRD waters. Well-designed acoustic monitoring research is required for the identification of key nocturnal habitats and behaviours. Incomplete data on fisheries resources in the PRD region also hampers the identification of potential key foraging sites for CWDs.

The spatial coverage of core dolphin habitat areas in the western Pearl River Delta region should be reviewed as more research studies on CWD distribution, habitat use, and behavioural patterns become available. The uncertainty inherent in current knowledge of CWD habitat use and distributions, and the need for precautionary management, dictate that this plan includes relatively large core habitat areas (refer to ***Fig. 1***). More precise information on spatial use patterns by the CWD may allow more precise, and hence reduced areas of protection, in turn allowing less limitation on human activities.

There is still a lack of quantitative evidence about demographic responses of CWD to the various human threats, especially impacts of climate change or toxins, and the extent to which impacts accumulate, although Wilson *et al.* (2008) provided an initial assessment and categorization. This lack makes it more challenging to formulate robust conservation strategies and management plans.

Areas of Uncertainty

The baseline profile of dolphin habitat use, distribution, and abundance in the PRD region with minimal human impacts remains essentially unknown, given the lack of historical data (50 to 60 years ago) before the massive development of the Pearl River coastal areas and catchment. The westward boundary of the PRD population is believed to be the Moyang River Estuary (Li *et al.*, 2019), although some participants suggested that dolphins in the western portion of the PRD could constitute a separate demographic unit. The migration rate of dolphins between the eight identified CWD populations (***Fig. 2*** refers) along the coast of China is poorly understood, although the specialists consider that such movement is limited.

Long-term monitoring and hydro-ecological studies are needed to examine any potential indirect impact of human activities along the Yangtze and Pearl Rivers to seasonal movement of prey and in turn dolphin distribution in the Pearl River Estuary, including Hong Kong SAR waters. The severity of marine plastic ingestion in CWDs and sediment pollution impacts on dolphin echolocation is also unclear, as are the impacts of toxin bioaccumulation on health and survivorship. This threat may be a major driver of population decline but we have little evidence for its importance or lack of, or the sources, or impacts involved.

Most core habitat areas shown in ***Fig. 1*** are areas with frequent dolphin occurrence. It should, however, be noted that spatial distribution of this highly adaptive dolphin species may change drastically and rapidly in response to prey availability, anthropogenic impacts, and

environmental stochasticity. An alternative approach suggested was to designate core areas to cover areas with rich fisheries resources for CWDs instead, given that dolphins prefer waters with sufficient prey availability, regardless of the intensity of human disturbance there (Pine *et al.*, 2017).

Participants' opinion was divided regarding the ecological importance of the existing Guangdong Pearl River Estuary Chinese White Dolphin National Nature Reserve. Moderate and primarily steady numbers of dolphin sighting were previously recorded within the designated Nature Reserve in the past decade, yet there is evidence indicating that CWDs observed within the Nature Reserve are in fact predominantly travelling, as distinct to using the area for foraging, etc. Therefore, the Nature Reserve, together with the southern part of the Sha Chau Lung Kwu Chau Marine Park, are regarded here as buffer habitat area as illustrated in ***Fig. 1,*** and all the management measures recommended for buffer habitat areas should also be implemented within this existing Nature Reserve. The spillover effect brought by the conservation of these waters could benefit the core habitat areas and nearby marine areas ecologically. Opinion on the ecological importance of coastal waters off Gaolan Island was similarly divided.

The Critical Need for a Precautionary and Adaptive Management Approach

The dire situation of the PRD dolphin population demands a precautionary and adaptive management approach. Precautionary management requires the *prevention* of ongoing harm or loss, in recognition that the consequences of failing to act will be more difficult, and more expensive, to reverse than any potential consequences of imperfect management actions (IUCN Council, 2007). Thus, for PRD CWDs, we know with confidence that the actions recommended in this plan, such as protecting key habitats, reducing vessel strike, and supporting fisheries sustainability in the PRD, are 'do no harm' actions, which:

- provide the best prospects for dolphins, given current knowledge;
- are resilient to potential future improvements in knowledge (see below);
- minimize social and economic impacts on current and future human activities.

The workshop participants recognize that current knowledge of PRD CWDs is imperfect (previous sections), but it is *extremely likely that the dolphins are declining seriously and will continue to do so without urgent action.* Thus, lack of action is *most likely* to result in further declines when the population is already at a tenuous level for long-term sustainability (Karczmarski *et al.*, 2017; Thompson *et al.*, 2000). Further, delayed mitigation of the anthropogenic threats risks the threats being too costly, or impossible, to reverse.

Technically, it remains *possible* that observed population declines, such as seen in the long-term monitoring by the AFCD of the Hong Kong SAR, in fact represent population shifts within the broader PRD region, and that overall populations are not in major decline, given insufficient standardized monitoring across the whole region. However, given that habitat degradation, fisheries declines, increased pollution, indeed *all* the threats to dolphins, have been severe throughout the region, it is highly plausible that the overall population is stressed. Further,

given the consistent increases in all threats across most of the PRD, dolphin population is certain to suffer future declines without the measures proposed here. Thus, waiting for 'conclusive' knowledge risks failure, whereas precautionary urgent implementation of the proposed measures poses negligible risks and is all but certain to provide excellent return on investment.

Similarly, emerging information on possible population sub-structure within the PRD population will likely be valuable for fine-tuning the spatial design of core and buffer areas (***Fig. 1***), but it is very unlikely that the measures proposed here would be anything but beneficial overall. It is difficult to conceive *any* population structure in which the measures proposed here are not a significant improvement on the current lack of adequate protection.

It is critically important that the recommendations in this report are recognized as the first steps in an ongoing, adaptive upgrade to PRD dolphin management, and are *not seen as final or sufficient in the long-term*. Some workshop participants are particularly concerned that the 'first-aid' approach here risks long-term complacency in policy implementation and that government agencies will fail to follow through with the longer-term strategies (ongoing 'health care') outlined below. In such eventualities, CWDs are likely to collapse anyway, despite successful implementation of the interim measures.

The concept of *adaptive management* (***Fig. 5***) provides an effective tool for achieving conservation outcomes in the face of incomplete or uncertain knowledge. The cycle involves regular review of both system status and management effectiveness (Holling, 1978; Walters & Hilborn, 1978), supporting implementation of improved management on an ongoing basis. Comprehensive assessment of the system response to management actions provides the basis to adapt and improve those actions. Importantly, this approach allows for the changing nature of ecosystems or species populations, and the threats to them, and allows for proactive implementation without delays due to information gaps: research is integrated with management, to the benefit of both (Holling, 2004; Hughes et al., 2007; McCook *et al*., 2010). Formally, adaptive management provides a structured, iterative process to optimize decision making in the face of uncertainty, with the aim of reducing uncertainty over time via system monitoring. Importantly therefore, lack of information, is specifically addressed by monitoring the system in response to management actions – it avoids the risks of delaying action to acquire information, which often amounts to no management at all.

Figure 5| Adaptive management cycle (copied with permission from McCook *et al.*, 2017). The cycle involves phases of (i) conceptualising the current population status and threats and other management challenges; (ii) planning, including both actions (based on current best knowledge) and targeted monitoring and research; (iii) implementation of actions and monitoring; (iv) assessment and review of system condition and management effectiveness; (v) reviewing and revising system knowledge as affected by management; (vi) adaptation and revision of plans feeding pack into implementation of improved actions, ongoing review and improvement

Thus, for management of PRD CWDs, our workshop and this report address phases (iv) (analysis and review of current population status and management effectiveness), (v) (updating, collating and integrating current understanding) and (vi) (providing recommendations for management upgrades). Importantly, *implementation of the improved management*, that is critical for preventing the eventual local extinction of CWDs in the Pearl River Delta region.

Challenges for Management

Several key challenges were identified regarding the existing management practices for the Chinese White Dolphin Nature Reserves situating within the PRD region. These include: (i) a lack of standardized management guidelines and regulations; (ii) insufficient skilled and trained staff; and (iii) inadequate funds, for achieving the conservation goals.

More broadly, within the PRD region and dolphin conservation community, key aspects identified as requiring improvement include:

1. facilitation by provincial management (Guangdong) of coordination between administration sectors of different cities for dolphin conservation at population level;
2. shared database and a common platform to facilitate the exchange of research and conservation data, such as stranding and necropsy data, among cetacean institutes, administrations, and other relevant stakeholders;
3. cooperation between cetacean academics and specialists of other expertise, such as hydrologists, maritime and logistic experts;

4. sufficient *extra-gratia* payment for affected fishers for the implementation of extended seasonal fishing moratoriums.

A minimum level of survey effort and research, using standard and comparable monitoring techniques is needed to be adopted and employed by CWD researchers and surveyors. Timely sharing of data among researchers and dolphin managers throughout the region is important. Coordination of efforts to set standards, carry out surveys in well-targeted locations (perhaps within core habitat areas), and streamlined sharing of data, are all critically important at this juncture.

Some technical challenges were identified for the implementation of these conservation measures. For example, there is a lack of machine-learning research and development capacity for the establishment of a completely automated patrol and monitoring system to be applied in Marine Protected Areas (MPAs). Underwater acoustic research is often hindered when underwater hydrophones, deployed for acoustic monitoring, are lost or damaged by illegal and destructive fishing operations taking place in study areas.

One of the greatest challenges for saving the Pearl River Delta's iconic dolphins will be the urgency required in establishing, and making stakeholders aware of, CWD core and buffer habitat areas and the management actions to be implemented within them. To make a real difference to the plight of the dolphin populations, considerable resources need to be available to engage and inform stakeholders, to change ongoing economic and leisure activities within core areas, and to ensure adequate monitoring and enforcement of informal best practices and formal regulations.

Finally, there is uncertainty as to whether setting-up and managing core and buffer habitat areas for dolphins will be enough to turn the tide for the crashing dolphin population. Health and demographic impacts from sequestered toxins or ongoing vessel strike outside of key areas may doom the PRD dolphins despite our best efforts to protect key habitat areas. Certainly, implementation of core and buffer areas must be supported by further, complementary measures, as indicated. Further, protection and management of these core areas will at least give the dolphins a better chance to stabilize and recover and will have major benefits for the broader biodiversity and ecosystem services of the PRD. What is needed is clear and feasible, given enough government will, investment, and effective engagement with stakeholders and implementation in a timely fashion. We may not be able to save the dolphins of the PRD, but we must give it our best try.

Conservation Strategies

The coastal and marine spatial planning approach for CWD conservation should be implemented with treating the continuous spatial range of CWDs in the PRD (as shown in ***Fig. 3***) as a single conservation unit. A recommended chronology is as follows:

1. Core and buffer dolphin areas recommended above should first be protected and managed effectively to ensure the integrity of the key dolphin habitats in the PRD. This should be followed by:

2. Designation of more marine protected areas around the existing Jiangmen Guangdong Chinese White Dolphin Provincial Nature Reserve, given the high ecological importance of waters around the Dajin and Xiaojin Islands (that is, Core Area 5 mapped in ***Fig. 1***).

3. Designation of a large and continuous MPA connecting the proposed and designated Marine Parks in Hong Kong, the Guangdong Pearl River Estuary Chinese White Dolphin National Nature Reserve and other statutory Nature Reserves, such as the Qi'ao-Dangan Island Provincial Nature Reserve for the conservation of mangrove habitat, to maximize the marine area under protection within Lingding Bay.

A government commission (including a PRD CWD working group) should be established for cross-boundary dolphin conservation planning and management, with involvement of:

- The Environmental Bureau, AFCD and the Environmental Protection Department from the Hong Kong SAR Government
- The Forestry Bureau of Guangdong Province (especially the Guangdong Pearl River Estuary Chinese White Dolphin National Nature Reserve Management Office and Jiangmen Guangdong Chinese White Dolphin Provincial Nature Reserve Management Office)
- The Administration of Ocean and Fisheries of Guangdong Province from the National.

The commission should first evaluate the effectiveness of all existing cross-boundary governmental communication arrangements and consider the necessity of creating new communication channels specifically to facilitate regional dolphin conservation. Consistent with the recommended management measures in this plan, the commission should formulate conservation policy papers reviewing the enforcement effectiveness and comprehensiveness of extant CWD conservation policies respectively in Guangdong and Hong Kong SAR (IUCN SSC CBSG, 2017). These papers should also evaluate the feasibility of improving relevant legislation guiding management planning for cross-boundary dolphin conservation, as well as the management of fisheries resources. Commission members should work together and develop guidelines for regular evaluation of the conservation effectiveness of protected dolphin areas throughout the PRD.

Establishment of a cetacean stranding response system, accompanied by improved sanctuary and release facilities for stranded individuals, is crucial for effective dolphin conservation. It is also important to establish a cross-boundary stranding programme database for long-term monitoring of dolphin death and potential major human threats in the Delta region.

In addition to the recommendation here to establish and effectively manage core habitat areas and buffer habitat areas for CWDs, we advocate close cooperation among academic institutes, administrations, conservation groups and other relevant stakeholders within the Greater Bay Area. Formulation of coastal and marine spatial planning strategies could be achieved, for instance, by facilitating knowledge and idea exchange among members of the Chinese White Dolphin Conservation Alliance via regular, discussion-oriented workshops. Mechanisms and incentives encouraging the sharing of data and information on dolphin conservation among academic institutes (such as collaborative photo-ID analysis), within decision makers and between researchers and other relevant stakeholders, should be created. For instance, direct

communication channels with relevant government officials working on the conservation of threatened marine species and/or the management of marine/coastal protected area should be established (IUCN SSC CBSG, 2017).

Experience globally shows that to be effective, management needs to integrate both 'top-down' government involvement and 'bottom-up' approaches that engage local stakeholders, such as fishers and shipping companies, in the formulation and implementation of MPA management strategies aimed at balancing biodiversity conservation and sustainable socio-economic development (e.g. Great Barrier Reef Marine Park Authority, 2014). Good compliance with management and regulations requires investment in both enforcement (for example, patrols) and engagement to ensure that public and stakeholders are aware of, understand, and ideally support, the management and regulations. Along with proposing new and improving existing cetacean conservation policies, the governments (for instance, AFCD and the Environmental Protection Department from the Hong Kong SAR) should establish more consultative and transparent processes that give stakeholders opportunities to review, critique and enhance planned action subject to permitting or approval by the governments, such as MPA designation. Regular meetings (both informal and formal) between government representatives and other relevant stakeholders (such as conservation groups, ferry companies, fishers and local villagers) will ensure inputs from various parties are embedded within the policy development and legislation processes.

Developing an education strategy for communities and different industries is also crucial to gain public support for dolphin conservation measures, by raising public awareness on the value of marine ecology and CWDs, and the potential compatibility of effective dolphin conservation with successful business and sustainable development. For example, technical workshops targeting fishers and intended to reduce by-catch and fishing gear entanglement, should be organized regularly so that fishers are aware of their sector's impacts on the dolphin population and habitat.

The CWD population in the PRD may disappear within a few short years if immediate and meaningful conservation action is not taken at scale across the region. Specialists who know these animals best have proposed here a practical 'first aid' approach to stem the loss of dolphins and put them on a path to recovery. It is now up to government, the private sector, local communities, and the public to gather the will and act in time to keep the Chinese white dolphin in our waters. Like the pandas in terrestrial Chinese forests, the Chinese White Dolphin is an iconic animal, representative of Guangdong and Hong Kong's maritime heritage.

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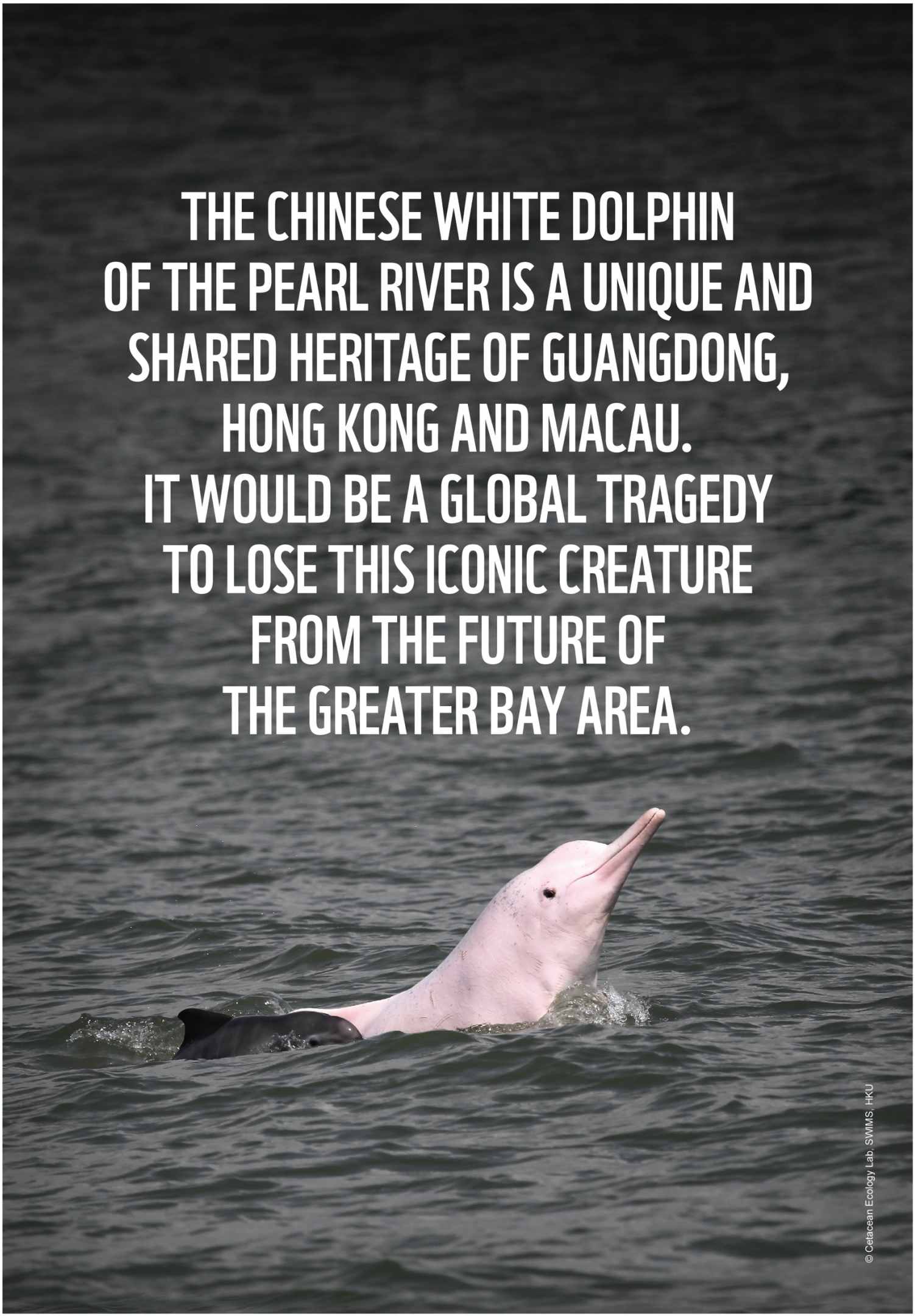
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