Marine Ecology Enhancement Fund (MEEF)
Declaration

To: The Secretariat of the MEEF

Reference No.: MEEF2017009

Project Title: Contributing to Marine Spatial Planning: working with fishing communities to map areas of dolphin and active fishing gear overlap

Name of Project Leader: Dr Lindsay Porter

I hereby irrevocably declare to the MEEF Management Committee and the Steering Committee of the relevant Funds including the Top-up Fund, that all the dataset and information included in the completion report has been properly referenced, and necessary authorisation has been obtained in respect of information owned by third parties.

Signature: _____
Project Leader, Dr Lindsay Porter

Date: 17/4/2019

Contributing to Marine Spatial Planning: working with fishing communities to map areas of dolphin and active fishing gear overlap

協助規劃海洋資源—
與香港漁業合作辨識海豚與漁業作業交疊的區域

MEEF2017009

Final Report December 2018

Prepared: Lindsay Porter

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Approved:

SMRU Hong Kong

17F Tower One, Lippo Centre, Admiralty

Indo-Pacific humpback dolphins, locally known as Chinese white dolphins (Sousa chinensis) feeding in association with a purse seine fishing vessel in western Hong Kong waters, May 2018.

Contributing to Marine Spatial Planning: working with fishing communities to map areas of dolphin and active fishing gear overlap

This is a collaborative project with Hong Kong fishing communities to map fine scale interactions between fishing nets and dolphins in Hong Kong waters with a view to identifying areas of overlap.

協助規劃海洋資源─與香港漁業合作辨識海豚與漁業作業交疊的區域

與香港漁業合作，研究捕魚作業時與海豚的精細的相互作用，從而辨識海豚與漁業作業交叠的區域，以用作協助計劃運用海洋資源。

Acknowledgements

This project is extremely grateful to the leaders of the fishing associations of Tai O and Cheung Chau for so willingly participating in this project and for introducing project researchers staff to the two fishing communities. Interview data from fishermen in Tai O, Cheung Chau and Tuen Mun has been invaluable in providing the first insights to current opinion on fishing practises and cetacean conservation in Hong Kong and the project thanks all participants for the time and energy they devoted to answering our many questions. The researchers have learned many new perspectives on the social and cultural activities within Hong Kong remaining fishing communities and hope, in turn, that the we were able to share some useful knowledge of current research and dolphins with the fishermen.

The input and information provided by the all datasets and information presented in the report have been properly referenced and necessary authorisation for information owned by third parties has been obtained.

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Executive Summary

By-catch and the entanglement of dolphins in fishing gear is a known cause of injury and mortality the Indo-Pacific humpback dolphins, locally known as Chinese white dolphin (Sousa chinensis) that reside in Hong Kong waters. The level of risk this poses to the population may be quantified by collecting systematic data on fishing activities in tandem with dolphin presence/absence data around active fishing gear. To obtain such data, the co-operation of fishermen is essential, not only to collect the data but also to find positive and collaborative solutions to minimise risk to dolphins. This project, therefore, has three main objectives:

- *To collaborate with fishing communities to collect data on the occurrence of dolphins around several different types of active fishing gear.*

- *To gather the verbal history of fishing patterns with the fishermen who operate in the western waters of Hong Kong and to share the collected collaborative data on a regular basis with the wider fishing community.*

- *To work together with fishing communities to develop spatially explicit maps which quantify areas of highest active fishing gear and dolphin habitat use overlap.*

The occurrence of dolphins and active fishing gear were quantified by deploying autonomous acoustic devices (AAD) on or around fishing gear. Small AAD devices have been developed that are streamlined, lightweight and easy to deploy and after some practise, Hong Kong fishermen were increasingly comfortable to deploy these devices on their fishing nets. Data were obtained from nine gillnet fishermen and six purse seine vessels. In total, fifty two (52) AAD deployments were made around 35 active nets, resulting in more than 26 hours of acoustic recordings. Thirty one individual nets were monitored, net set times ranged from approximately 3 to 230 minutes, and of these, more than 50% recorded dolphins feeding in close proximity. The greatest overlap of dolphins and active fishermen was recorded at Fan Lau, however, dolphins were recorded where ever fishing occurred, with the exception of a single trip to the Soko Islands.

From fishermen interviews and ongoing discussion around the maps complied of fishing effort and dolphin occurrence, the first four recommendations for a draft actions plan have been suggested:

- *Identify a key fisherman in each village and formally establish them as the liaison for the project and allow them to manage fishing effort monitoring and AAD deployments. In this way, fishermen will quickly grow more confident with AAD deployment and the data obtained,*
- *Involve more fishing vessels in fishing effort mapping. Now that a simple GPS tracking device has been tried and tested, which does not require fishermen to activate or actively manage data, provide devices to all the Tai O and Cheung Chau who have now volunteered to participate in fishing effort mapping,*
- *Once effort data has been gathered from multiple fishermen, continue to refine fishing effort maps and hot spots. Arrange seasonal meetings in each community to update all participants on effort maps. It is anticipated that these areas will shift over time and information on the temporal importance of fishing and feeding areas will also be determined by analysing fishing effort patterns and with the continued input of the fishermen's expert knowledge.*
- *Fishermen believe that ghost fishing nets pose a risk to dolphins, perhaps more so than active fishing gear do. Ghost gear also interferes with ongoing fishing activities. Therefore, a ghost gear clearance should be arranged (Fan Lau was suggested as a high priority as the fishermen agree that the data gathered during this project, plus their own knowledge, indicates that there is a potential risk of entanglement) in collaboration with suitable management authorities, e.g., AFCD, and a local diving group. There is an ongoing net clearance programme at Tung Ping Chau that can be used as a framework for a similar activity at Fan Lau.*

All three project objectives have been largely been fulfilled. The project would have been improved by further extending the time frame in which fishermen collected effort and acoustic data and by identifying a more suitable strategy with which to engage with the fishing community at Tuen Mun. Both fishermen and researchers recognise the benefits already realised by this project. It is recommended that this project continues as more fishermen are willing to participate now that the initial project results have been discussed and that there are clear advantages to both the fishing community and to the dolphins. Data gathered from this project could benefit both a fisheries management policy and dolphin risk assessments.

It is highlighted that these data are preliminary and more information, both on fishing effort and dolphin occurrence, is required before conclusions can be made with certainty.

1. Project description

Globally, all cetacean species are impacted by interactions with fisheries and the increasing incidence of bycatch in fishing gear is of concern, particularly to small cetaceans (Read *et al* 2006; Read 2008; Reeves *et al* 2013). Small cetaceans that have a restricted coastal distribution are particularly vulnerable to bycatch and, for some species, entanglement in fishing gear has been the sole contributor to population collapse (Jaramillo-Legorreta *et al*, 2017; Thomas *et al*, 2017). Entanglement in active and abandoned fishing gear is a known cause of injury and mortality for Hong Kong cetaceans[1] (Jefferson *et al*, 2009) but it is unknown to what degree this impacts the population or what the factors are that influence entanglement rates. Recent reviews list the species *Sousa chinensis* as "vulnerable" (Jefferson and Smith, 2016) and recommend that within Hong Kong waters, where the population is at risk, a better understanding of cumulative threats is essential if management plans are to have any effect (Jefferson*,* 2018). The overarching aim of this project therefore, is to better understand potential interactions between fishing nets and the Indo-Pacific humpback dolphin, popularly known as the Chinese white dolphins (*S. chinensis*) in Hong Kong waters.

The project had three objectives;

- To collaborate with fishing communities to collect data on the occurrence of dolphins around several different types of active fishing gear,
- To gather the verbal history of fishing patterns with the fishermen who operate in the western waters of Hong Kong and to share the collected collaborative data on a regular basis with the wider fishing community,
- To work together with fishing communities to develop spatially explicit maps which quantify areas of highest active fishing gear and dolphin habitat use overlap.

Several projects have worked with fishing communities to monitor fishing effort and marine megafauna bycatch rates which have led to the establishment of risk maps and the identification of vulnerable populations and species (Moore *et al*, 2010; Lewison *et al*, 2014; Metcalfe *et al*, 2017; Navarrete-Forero *et al*, 2017). In other areas of the South China Sea, local ecological knowledge obtained from Chinese fishermen has also provided information on bycatch of marine mammals (Liu *et al*, 2017). The basis of this project is to develop partnerships with fishing communities, as has been successfully

[1] *https://www.opcf.org.hk/en/conservation-research/local-conservation-efforts/local-cetacean-stranding-investigation#local-threats-to-cetacean*

established elsewhere, so that Hong Kong fishing effort and its overlap with dolphins occurrence could be quantified. During project initiation, several community events took place in Tuen Mun, Cheung Chau and Tai O where researchers were invited to present project objectives and progress. Throughout the project, regular communication was maintained with the villages, particularly Tai O. It proved difficult to find a primary contact within the Tuen Mun area, although it was possible to obtain information on dolphins and fishing effort from fishermen during interview sessions.

As initially hoped, more fishermen became interested in the project as the results of the first maps of fishing effort were made available and after the December meetings in Tai O and Cheung Chau, when draft final maps were presented on fishing effort and acoustic occurrence of dolphins, fishermen from both villages expressed interest in participating fully in the project, if it were to continue in 2019.

1.1. Completed Activities Against Proposed Work Schedule

Originally, this project was to be conducted between June 2017-May 2018. Considerable effort had been conducted prior to project commencement, establishing links with key fishing community members at Tuen Mun and Cheung Chau. Unfortunately, the SMRU Hong Kong staff member who had developed the initial collaboration with the fishermen was unable to continue with the project due to health issues. In December 2017, an application was made for a six month extension so that a new staff member could be recruited and links with the fishing communities established anew. The project activity timeline was therefore, revised and, subsequently, a budget reallocation was requested so that research staff could spend more time on the water with fishermen to better establish collaborations and to more fully understand fishermen effort and activities (Figure 1).

Activity	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
Deployment of AAD												
Fishing Community Liasion Meeting				Moved from March							Final Meeting	
Data Analyses												
Reporting												
Presentation												

Figure 1. Revised Project Timeline for MEEf Project "*Contributing to Marine Spatial Planning: working with fishing communities to map areas of dolphin and active fishing gear overlap*" (MEEF 2018009)

Autonomous Acoustic Devices (AAD) were deployed on both gillnet and purse seine nets between July-December 2017, although purse seine fishing rarely occurred in western waters at that time (as reported in the interim report for this project). The data obtained were useful in developing AAD attachment strategies and for better understanding the limits of noise recordings around certain fishing vessel types, i.e., purse seine vessel engines are extremely noise when setting and pulling in the net.

Under the revised timeline and with a new staff member recruited, AAD deployment occurred consistently between April and December 2018, weather permitting, and nine (9) gillnet fishermen and six (6) purse seine vessels participated in the project. One gillnet fishermen trialled several tracking devices with a view to establishing which was the best for monitoring fishing effort and also tested different types of AAD deployment strategies. Initial meetings were held in all villages prior to January 2018, and formal meetings occurred in April and May 2018 in Tuen Mun, Tai O and Cheung Chau. The Tai O fishing community was the most willing of the communities to participate in this project and as the project progressed, informal meetings occurred there on a bi-weekly basis. Meetings at Cheung Chau were less frequent, however, regular communication occurred between the Tai O and Cheung Chau fishing associations and researchers from this project. At time of writing, the formal presentation of the final project findings has not occurred in each village but is planned for January 2019, at the fishermen's request, however, the draft maps of fishing effort and dolphin occurrence have been presented in person to both Tai O and Cheung Chau fishing association leaders. This is the final report of this project and on its finalisation, a request will be made to the Marine Mammal Conservation Working Group (MMCWG) to present these findings at its next meeting. As such, all project activities were achieved, albeit in a longer timeframe than initially proposed, and with the exception of fulltime participation of fishermen from Tuen Mun.

2. Methods

The project was conducted in the waters adjacent to the Third Runway System (3RS), the Marine Parks at Sha Chau and Lung Kwu Chau, the Brothers Islands, Tai O, Fan Lau and the Soko Islands, all located within Hong Kong western aquatic habitat. The project involved the participation of fishermen, who provided data on fishing practises and allowed their fishing activity to be monitored and recorded. Some fishermen deployed archival acoustic devices (AAD) near their fishing nets, so that the occurrence of dolphins or finless porpoise (*Neophocaena phocaenoides*), Hong Kong's two resident cetacean species, could be recorded. In addition, some fishermen also allowed AAD to be deployed by researchers near active nets. Fishing community leaders also trialled different tracking devices to quantifying fishing events, to establish which was the most convenient for fishermen to use. Of the three fishing communities proposed to be included in this study, Tuen Mun was the largest and, arguably, is no longer strictly a fishing village as there is many and diverse industries within the larger Tuen Mun area. A different strategy may have to be employed to better engage with fishermen from this area. The communities in Tai O and Cheung Chau remain very much focused on fishing as a primary industry and were the two communities most interested in marine research initiatives. Although some data was gathered from Tuen Mun fishermen, the majority of the information in this report comes from Tai O and Cheung Chau fishermen.

2.1. Acoustic Data Collection Around Active Fishing Gear

Between April – December 2018, a gillnet fisherman from Tai O was provided with AAD (SoundTraps Model ST300 HF: Ocean Instruments, New Zealand) to deploy on active fishing gear. AAD were attached to floats using nylon rope (*Figure 2*) and suspended underwater at a depth of 0.5-2.0 metres and these were attached to the headline floats of deployed gill nets. Researchers accompanied the fisherman during normal fishing activities on several occasions in April, October and December 2018 to allay any concerns the fisherman had about AAD operation (Figure 3). The AAD were configured to record continuously at a sampling rate of 576kHz with a high gain setting, which necessitated exchanges every one to two weeks due to battery and memory constraints.

Figure 2. ***The fisherman demonstrating the attachment of the AAD (SoundTrap) to floats with nylon rope (left) before being deployed with on a gillnet (right).***

Figure 3. A researcher assisting the fisherman with deploying a SoundTrap with a gill net

AAD were also deployed by researchers on dedicated surveys targeting active gillnets (Figure 4) and purse seine nets (Figure 5). A small fishing boat was used to search for active fishing gear around northwestern, western and southwestern Lantau. When active fishing gear was encountered, researcher sought permission to deploy AAD on the nets and on agreement, the engine was turned off and an AAD was suspended at 0.5-2.0 metres depth. The AADs were deployed as close as possible to the active fishing gear, however, as it was not possible to maintain a fixed position with the engine off, AAD were retrieved and re-deployed as necessary if the boat drifted more than 300m from the active fishing gear.

Figure 4. An AAD being deployed near a gillnet at Yi O, Lantau, during a dedicated survey

Figure 5. An AAD deployed close to a purse seine vessel at Fan Lau, Lantau, during a dedicated survey

2.1.1. Acoustic Data Processing and Analysis

Dolphins are known to vocalise all year round and during various behavioural activities (Munger *et al,* 2016). Acoustic data from the AAD were downloaded and decompressed using SoundTrap Host Software 3.2.2. (*Ocean Instruments*, New Zealand) and analysed using PAMguard 1.15. (http://www.pamguard.org/).

A click detector was configured to detect dolphin and porpoises clicks with energy in the 8kHz to 288kHz band, covering transient vocalisations for the target species. A digital pre-filter with a 4th-order Butterworth 4kHz high-pass filter was applied to avoid interference from lower frequency noise. A trigger filter of 4th-order Butterworth 8kHz high-pass filter was then applied to detect sounds that were 10dB above background noise level. Click classifiers were configured to categorise the marine mammal clicks from the expected large number of false detections, which can be obtained in waters which have high background noise levels derived from both biological sources, e.g, shrimp, and anthropogenic activities, e.g., boat echo sounders (Figure 6). In total, four

classifiers were used, with the first three classifying clicks with peaked frequency 30-50kHz, 50-70kHz, 70-110kHz respectively and a higher frequency porpoise classifier. Click trains were identified manually, with the aid of the classifiers, into “good” and “fair” events. Three criteria were used to assess each detection;

- The presence of a clean waveforms (Figure 7),
- Click trains that consisted of at least four clear clicks (Figure 8),
- A similar inter-click interval (ICI) within click trains (Figure 9).

A “good event” met all three criteria and a “fair” event met any two of the criteria. Thus, classification of valid detections was standardised and only “good” and “fair” events were used to identify ‘dolphin positive minutes’ in further analyses. Only clicks were used, rather than whistles or other vocalisation types as a) clicks are more often associated with feeding events (Ruxton, 2002) and b) the sound of a high frequency click can only travel a limited distance underwater so by using clicks it was known that dolphins could be no more than 300m-500m away from the recorder and therefore in the vicinity of the active net being recorded. Whistles and other lower frequency vocalisations can travel some kilometres underwater and would not be a reliable indicator of dolphins feeding in close proximity to the AAD.

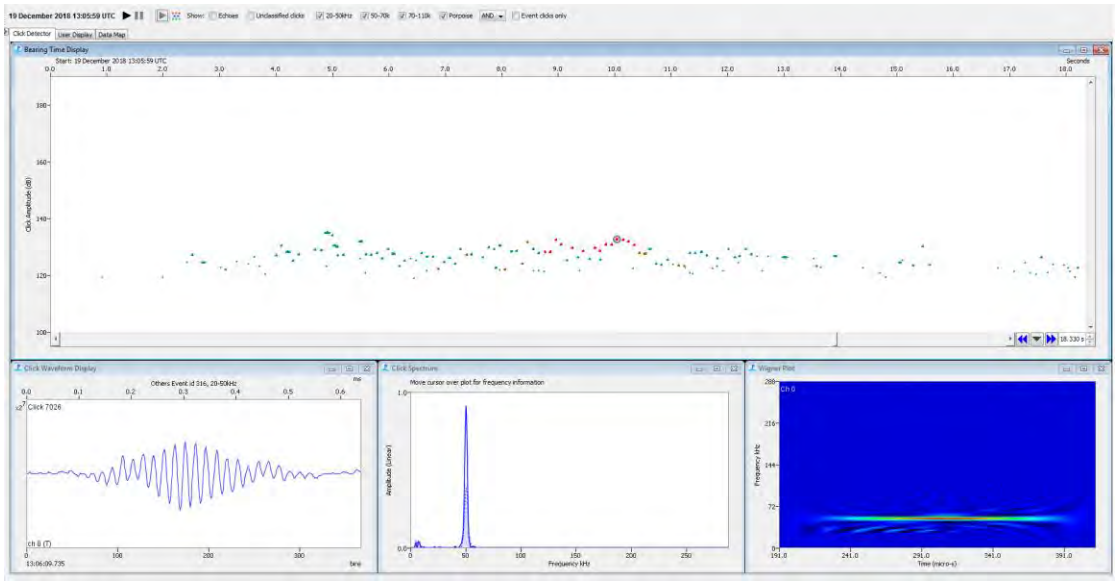

Figure 6. An ping from an echo sounder on a non-operating purse seine vessel, which can result in a false click detection, if not properly analysed.

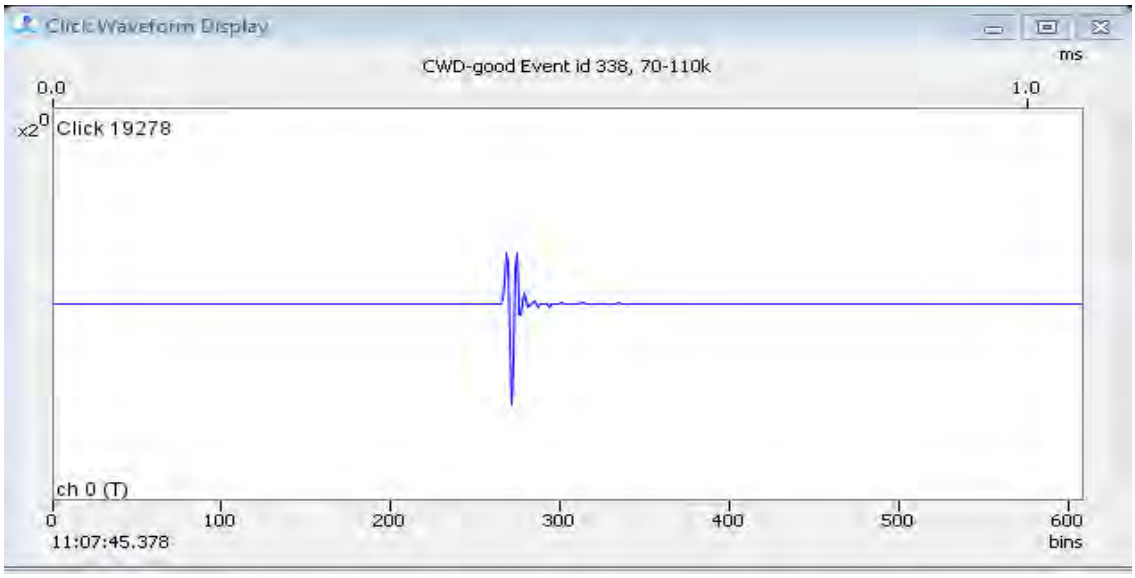

Figure 7. Clean waveform of a typical Chinese white dolphin (Sousa chinensis) click recorded in northern Lantau waters.

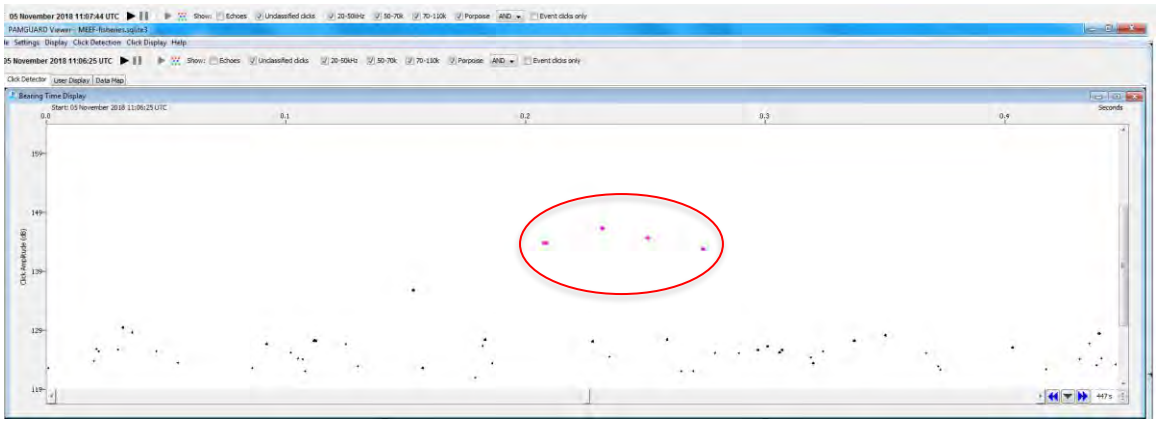

Figure 8. Bearing time display showing four clear clicks within a click train

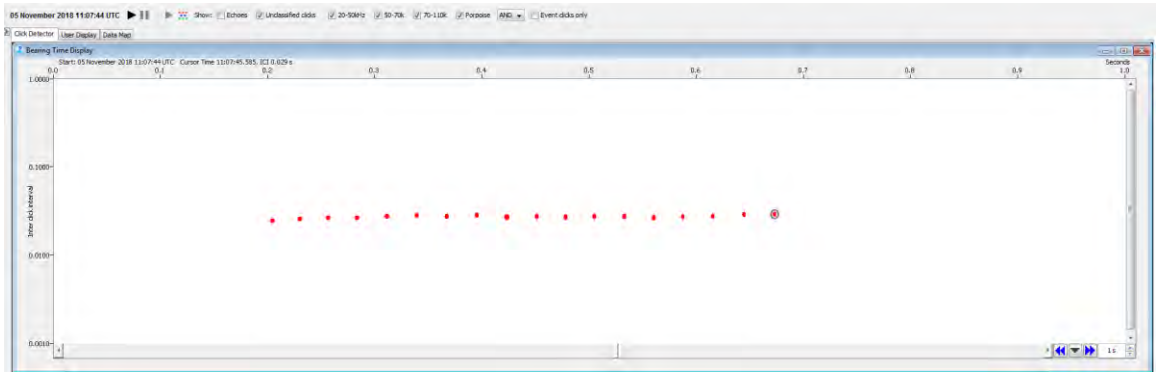

Figure 9. A click train demonstrating a similar inter-click interval (ICI)

Net deployments could be easily identified within the AAD data and were matched to GPS data using time, which provided the location of acoustic recordings. In instances where the fisherman did not deploy the AAD, discrete fishing activity could be identified from the GPS data using speed (calculated using the distance and time between waypoints) as preliminary analyses from accompanied fishing trips indicated that gill net operation (*i.e.* deployment and retrieval) requires fishing boats to operate at speeds below 8 kmh^{-1}, much slower than observed travelling times.

2.1.2. Calculating Overlap between Active Nets and Dolphin Detections

To map the overlap of fishing effort and dolphin activity close to active fishing nets, the area was divided into 1km x 1km grids and the total duration of all acoustic recordings from the nets set by fishermen was summed per grid as was the total duration of dolphin-positive minutes (DPM). The percentage of DPM was then calculated relative to the total duration of acoustic recordings and mapped per grid cell.

2.2. Fishing Community Interviews and Discussions

Verbal histories of Hong Kong fishermen were recorded formally, using semi-structured interviews (Figure 10), and informally, during meetings both on and off the water (Figure 11; Figure 12). Semi-structured interviews were conducted in Tuen Mun, Tai O and Cheung Chau and was targeted towards fishermen that had regularly observed marine mammals. The questionnaire contained 49 questions: 7 on the demographic profile of the interviewees, 15 on fishing practises, and 27 on marine mammal interaction with fishermen and fishing gear. The interview took approximately 40 minutes to complete, or longer if the fishermen was particularly chatty (Appendix I)

Figure 10. A fisherman from Cheung Chau being interviewed using the semi-structured questionnaire.

Figure 11. An informal interview with fishermen during dedicated surveys.

Figure 12. An informal interview with a fisherman during the regular community visits to Tai O

2.3. Mapping Fishing Effort

Between April and December2018, a fisherman was provided with several GPS devices to record his fishing effort. Multiple devices, both remote and archival, were trialled to identify which would be intuitive and simplistic enough for the fisherman to use independently, without adding to the burden of tasks during fishing trips and which also provided GPS data of an acceptable quality. Trialled devices included a SPOT Satellite GPS Messenger (*SPOT LLC*, United States), a Garmin GPS map 76S (*Garmin Ltd*, United States), a SPOT Trace (*SPOT LLC*, United States), and an iGotU ST-600 (*Mobile Action*, Taiwan) (Table 1; Figure 13). The quality of GPS data was assessed by comparing the accuracy of the distance travelled with "control" GPS data recorded simultaneously during accompanied fishing trips using a Garmin GPSmap 76CSX (*Garmin Ltd*, United States). The quality of GPS data was also assessed by quantifying the number of delayed waypoints, as defined by the time between waypoints greater than that of the configured recording interval of respective GPS devices (see Table 1). This was to identify any potential "dead zones". All GPS data were processed and analysed using *R* 3.5.1. "Feather Spray" (R Core Team 2018) and QGIS 3.4.2 "Madeira" (QGIS Development Team 2018).

Table 1. The specifications of the various tracking devices deployed between April – December 2018

GPS Device	Data Acquisition	Recording Interval	Deployment Dates	Deployment Days	Recorded Days
SPOT Satellite GPS Messenger	Remote	10 minutes	25/04/2018 – 31/05/2018	37	5
Garmin GPSmap 76S	Archival	≤ 1 minute	31/05/2018 – 05/10/2018	128	0
SPOT Trace	Remote	5 minutes	05/10/2018 – 25/10/2018	21	11
		2.5 minutes	25/10/2018 – 21/12/2018	58	31
iGotU GT-600	Archival	≤ 1 minute	02/11/2018 – 07/11/2018	6	4

Figure 13. The tracking devices trialled between April and December 2018 (from left to right): a SPOT Satellite GPS Messenger, a Garmin GPS map 76S, a SPOT Trace and an iGotU ST-600.

2.4. Documenting Dolphin Behaviour Around Fishing Nets

A drone was used on two occasions to test the feasibility of using a small vessel as a drone launch pad and to record the clarity of footage obtained by drones of dolphins around fishing nets. Small vessels were shown to be a suitable platform for using drones and the footage obtained of dolphins feeding around a purse seine fishing vessel clearly showed the dolphins behaviour 2-3m underwater (Frontispiece). The drone footage is attached to demonstrate the feasibility of using drones to further understand dolphins interacting with fishing nets.

3. Results

3.1. Acoustic Recordings Around Active Fishing Gear

Initially, it was anticipated that fishermen would deploy the AAD once they were familiar with the devices and after only one accompanied fishing trip, however, fishermen were reluctant to use the devices as they were concerned that they would lose an expensive piece of equipment. Despite assurances from researchers that there would be no bad feelings if an AAD was lost, the fishermen were much happier and more willing to deploy the AAD when researchers accompanied them on fishing trips. Researchers therefore, dedicated more time than anticipated attending fishing trips, which added another layer of complexity to fieldwork as fishermen often arranged to go fishing as weather and current changed and there was often limited time for researchers to get to fishing villages to join trips. In the final months of the project, however, fishermen were much more confident deploying the AAD and would do so themsleves. One fisherman also left the AAD deployed overnight on an unattended fishing net and successfully retrieved it the next day. It is anticipated that introducing AAD to new fishermen will be a slow but worthwhile process, given the amount of data that can be gathered over a short time period.

In total, fifty two (52) AAD deployments were made around 35 active nets, resulting in 26.1 hours of acoustic recordings. Of these, 24.1 hours (48 deployments around 31 active nets) had associated GPS data. The average duration of an AAD deployments was 30.1 ± 39.1 minutes, but ranged from 2.7 minutes to 232.5 minutes, depending on the amount of time a fishing net was set for. AAD were throughout Lantau waters, including Fan Lau, Sham Wat Wan, the Soko Islands, Southwest Lantau, Tai O and The Brothers and around both gillnets and purse seine vessels (26 gillnets = 21.3 hours of acoustic data and 6 purse seine fishing vessels - 2.7 hours acoustic data). Acoustic effort in terms of the number of deployments, nets and minutes of recordings was concentrated in the

Tai O on gillnets (Table 2). Dolphins were detected during 35.4% (*n* = 17) of the AAD deployments and in all fishing areas, with the exception of one deployment in the Soko Islands. The deployments were around 31 individual nets (some nets had more than one deployment) and 51.6 % of set nets recorded dolphins feeding in close proximity (Table 3; Figure 14). It is interesting to note that a dolphin (or dolphins) was detected in the Brothers area, where sightings have been rare in recent years. This detection occurred at night.

Examples of acoustic recordings around fishing nets are provided as supporting materials.

Table 2. A Summary of the Acoustic Data Collected by Fishermen between April – December 2018

Fishing Area	Number of Active Nets			Acoustic Recordings		Positive Dolphin Detections		
	Gill	Purse Seine	Total	Deployments	Minutes	Deployments	Nets	Minutes
Fan Lau	5	2	**7**	15	302	6 (40%)	5 (71.4%)	77 (25.5%)
Sham Wat Wan	3	1	**4**	5	195.1	2 (40%)	2 (50%)	81 (41.5%)
Soko Islands	1	0	**1**	1	87.2	0	0	0
Southwest Lantau	0	3	**3**	3	55.9	1 (33.3%)	1 (33.3%)	18 (32.2%)
Tai O	12	0	**12**	20	459.7	7 (35%)	7 (35%)	156 (33.9%)
The Brothers	4	0	**4**	4	343.9	1 (25%)	1 (25%)	4 (1.2%)
Total	**25**	**6**	**31**	**48**	**1443.8**	**17 (35.4%)**	**16 (51.6%)**	**336 (23.3%)**

Table 3. A Summary of collected acoustic data, by fishing gear, between April – December 2018

Fishing Gear	Number of Active Nets	Acoustic Recordings		Positive Dolphin Detections		
		Deployments	Minutes	Deployments	Nets	Minutes
Gill Net	25	35	1280.7	14 (56%)	13 (37.1%)	300 (23.4%)
Purse Seine	6	13	163.3	3 (50%)	3 (50%)	36 (22%)

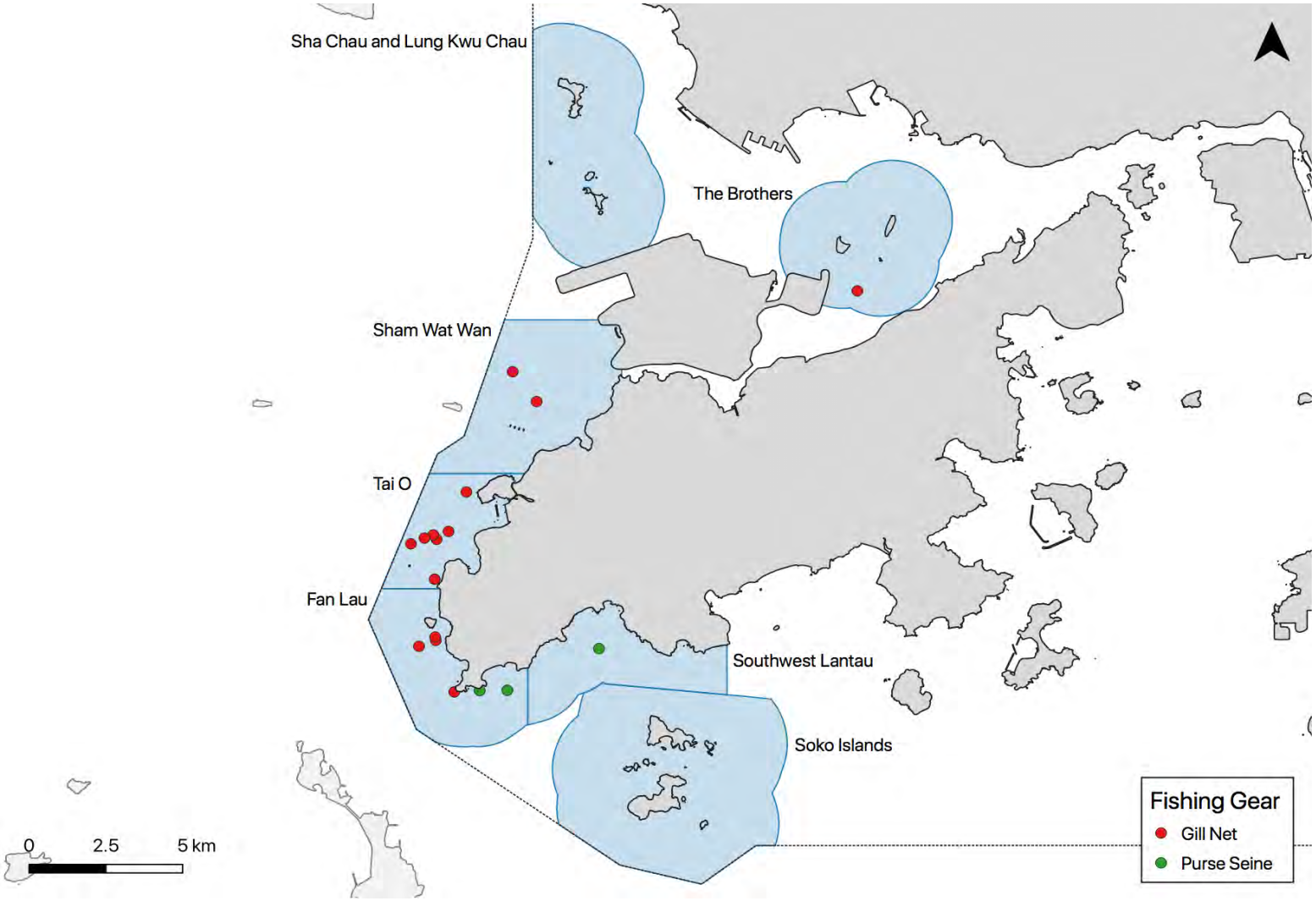

Figure 14. A Summary of Acoustic Detections of Dolphins from AAD Deployments between April – December 2018

3.2. Verbal History of Fishermen

All fishermen interviewed operated vessels of less than 40hp and, generally, had been fishing for more than 20 years within Hong Kong waters. Most had learned their craft from their fathers and few had had more than six years in a formal education system. Two of the oldest fishermen interviewed, aged in their 70's, recalled fishing with sailing vessels and hand stitching their nets. All had seen both dolphins and porpoise and some recalled times when dolphins were seen regularly to the east of Lamma Island, and beyond, in Hong Kong eastern waters. None of the fishermen interviewed recalled personally entangling a dolphin or porpoise, however, it was known to occur. Fishermen strongly believed that abandoned fishing gear was more dangerous to dolphins than active gear. In the distant past, porpoise were thought to consumed if they were incidentally caught but today, any entangled marine mammals are said to be released. Footage from a local facebook page lends support to these statements as it shows the release of a live finless porpoise after it was discovered entangled in abandoned fishing gear[2]. All fishermen were aware that it is illegal to harm or injure, including incidentally catch, marine mammals within Hong Kong waters. Most fishermen agreed that the 1970s marked the end of profitable fishing in Hong Kong waters. Despite the increase in fishing effort at that time, and the accepted practise for Hong Kong fishermen to fish outside Hong Kong waters, and vice versa, the commercial industry declined and smaller fish and other species were increasingly exploited. This general summary of fishing status is somewhat supported by a previous study which included the interview of fishermen, divers and government fisheries officers (Cheung and Sadovy, 2004). Fishermen explained they targeted different species for a variety of reasons, including expertise and skill with certain gear, a preference for a certain species, shifting market prices, seasonal weather and current conditions and different cultural or social occasions, e.g., weddings and festivals. The variety of reasons, and variables that most fishermen interviewed consider when deciding on where and when to fish, made it challenging for fishermen to fill in the fishing effort map included with the questionnaire. That is, all areas may be fished but this varies with environmental (natural and anthropogenic) as well as various social factors on what might be a daily basis. Any accurate quantification of fishing effort, over time and area, will likely only be obtained by using tracking devices (see section 3.3). All interviewed fishermen stated that the different coastal construction which has occurred and is ongoing, particularly reclamation, has impacted fishing success. The fishermen also stated that as fishing

[2] https://www.facebook.com/chunho.poon.94/videos/570503279949602/

stocks have shifted, so have the dolphins. Some fishermen stated they would trial new or different fishing gear, if it was as good as their current gear and if it was thought to reduce bycatch, however, they would not be willing to pay for this but would rather it was introduced as part of a research or government project. Most fishermen felt that the management authorities paid more attention to the dolphins needs when compared to the fishermens needs. The fishermen who collected effort and acoustic data for this project were happy to do so as they believed that the data was 'real', it was easily visualised and truly reflected the occurrence of fishing and dolphins in the area. Some fishermen suggested that the semi-structured questionnaire was too long and, indeed, some fishermen spoke to the questions for an hour or more. In general, the fishermen were happy to talk about previous and current fishing practises and each felt that their fishing situation was unique. All expressed hopes that this project could continue so that accurate fishing data could be obtained.

3.3. Fishing Effort Mapping

Of all the devices, the iGotU GT-600 performed best in terms of accuracy and the proportion of delayed waypoints (Table 4). The iGotU was not the most intuitive GPS device for the fisherman to use independently, however, as it required to be switched on and off and had internal batteries (that only lasted 3 to 6 days), which needed to be charged via a USB port. Although the SPOT Trace was the least accurate and had the highest proportion of delayed waypoints, it was the most suitable for the purposes of this study and its objectives. The SPOT Trace has external batteries (that lasted up to 21 days), which took little time and effort for the fisherman to replace. The SPOT Trace also operated automatically *i.e.* it turned on when it sensed movement and turned off when it had been stationary for a set period of time, which meant GPS data collection was not dependent on fishermen activating it and did not interfere with normal fishing activities. Fishermen used the SPOT Trace more frequently and consistent GPS data was easily obtained. Furthermore, the SPOT Trace allowed the fisherman to concentrate solely on deploying the AAD as shown by the corresponding increase in the quantity and consistency of AAD data obtained when the SPOT Trace was used. Another advantage of the SPOT Trace was that GPS data could be acquired remotely, i.e., downloaded via the SPOT website or APP (https://www.findmespot.com). As such, there were no tracker memory constraints and there was a minimal chance of data loss due to a damaged or lost device. The status of the SPOT Trace battery levels could also be monitored remotely, further minimising the chances of data loss due to battery constraints as the fishermen could be alerted in sufficient time to change the batteries. The iGotU is

archival, requiring data to be downloaded directly from the device, leaving it subject to memory constraints and vulnerable to data loss. The SPOT Satellite GPS Messenger was intermediary in terms of accuracy and the proportion of delayed waypoints. It shared several of the SPOT Trace's intuitive features, i.e., external batteries and remote data acquisition but like the iGotU GT-600, it required the fisherman to manually turn the device on and off. Furthermore, the SPOT Satellite GPS Messenger was only capable of recording GPS coordinates at 10-minute intervals and preliminary analyses from accompanied fishing trips indicated this was too coarse a resolution to observe discrete fishing events, thereby rendering it unsuitable for the purposes of this project and its objectives. The Garmin GPSmap 76S collects extremely detailed positional data, however, it is bulky, archival and required the fishermen to switch it on and off during fishing trips. The fishermen who trialled the devices, by far, preferred the SPOT Trace and were also able to monitor their own activity instantly by using the web platform or app. Further, data analyses were expediated as locational information could be downloaded remotely.

Table 4. A Comparison of GPS Tracking Devices Trialled between April and December 2018

Device	Total Days Recorded	Distance Travelled (km)		Waypoints	
		Device	Control	Total	Delayed
SPOT Satellite GPS Messenger	5 **(13.1%)**	3.6	12.9	56	6 (10.7%)
SPOT Trace	42 **(53.2%)**	34.8	47.5	1805	510 (28.3%)
iGotU GT-600	4 **(66.7%)**	28.7	28.8	7000	50 (0.7%)

The distribution of delayed waypoints suggested there may be some "dead zones" around Fan Lau, west of the Hong Kong International Airport and northeast of the Soko Islands where all GPS devices did not consistently acquire a location, however, the missed waypoints could be manually inserted when necessary and calculations of total fishing effort could still be calculated (Figure 15).

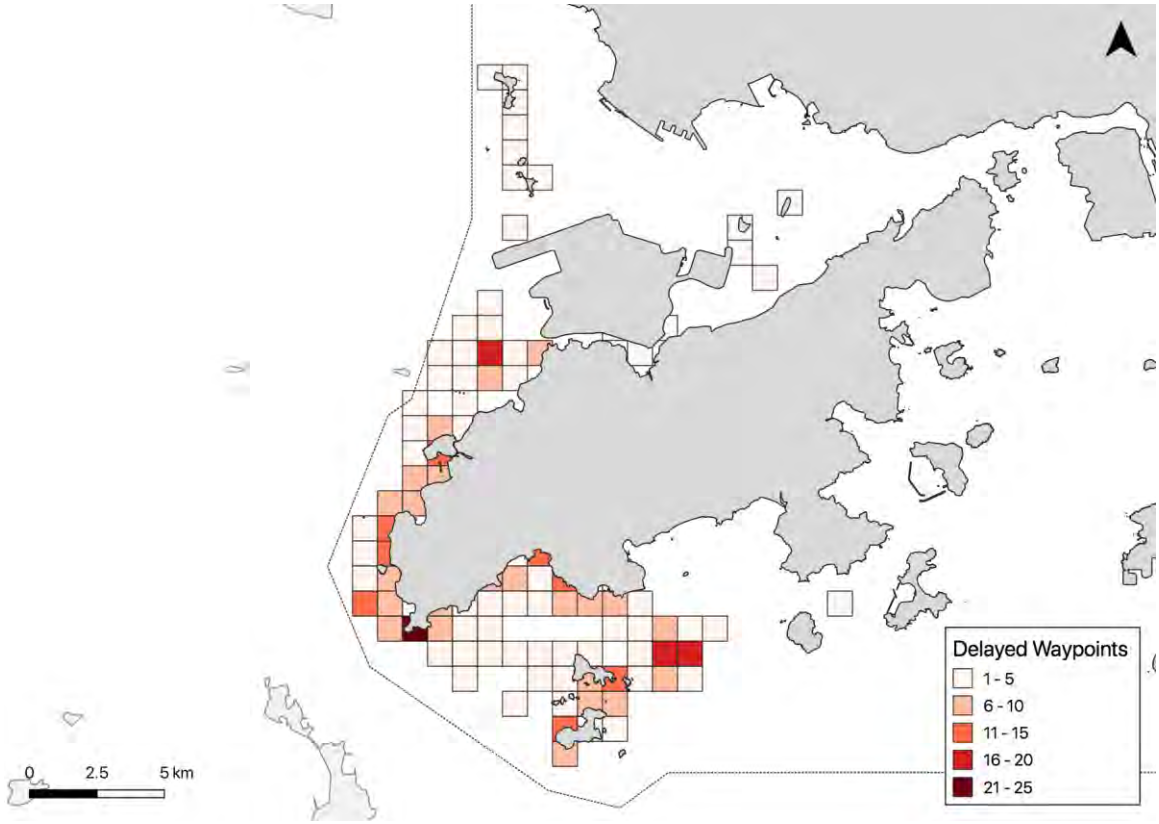

Figure 15. The distribution of delayed waypoints from the SPOT Satellite GPS Messenger, SPOT Trace and iGotU.

A total of sixty four (64) fishing trips over forty six (46) days were recorded from the GPS devices. A single fisherman recorded **145.3** hours and **407.9** km of fishing effort (excluding travel to and from fishing sites). His fishing effort focused in northeast, northwest, west and southwest Lantau across seven discrete areas: The Brothers, Sha Chau and Lung Kwu Chau, Sham Wat Wan, Tai O, Fan Lau, Southwest Lantau and the Soko Islands (Figure 16). Relative fishing activity (in terms of the number of trips) was greatest in Fan Lau (Table 5; Figure 17).

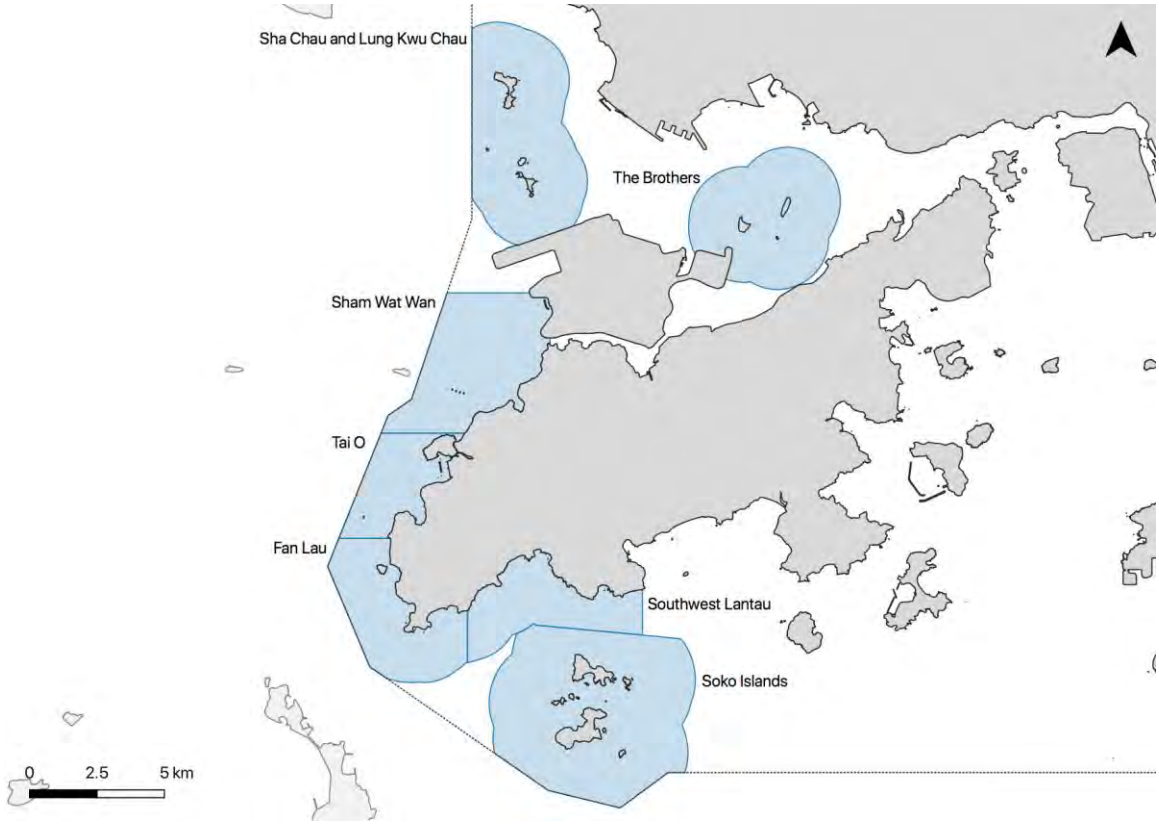

Figure 16. Fishing Effort and Areas Identified from Tracking Devices used by Tai O fishermen in Lantau Waters between April-December 2018.

Table 5. A Summary of Fishing Effort, by fishing area, of a Fisherman from Tai O between April – December 2018

Fishing Area	Trips	Time Spent (hours)	Distance Travelled (km)
Fan Lau	24	29.5	48.5
Sha Chau and Lung Kwu Chau	6	11.6	46.8
Sham Wat Wan	16	40.7	100.3
Soko Islands	19	36.9	127.9
Southwest Lantau	20	14	54.3
Tai O	12	6.8	10.7
The Brothers	2	5.8	19.4

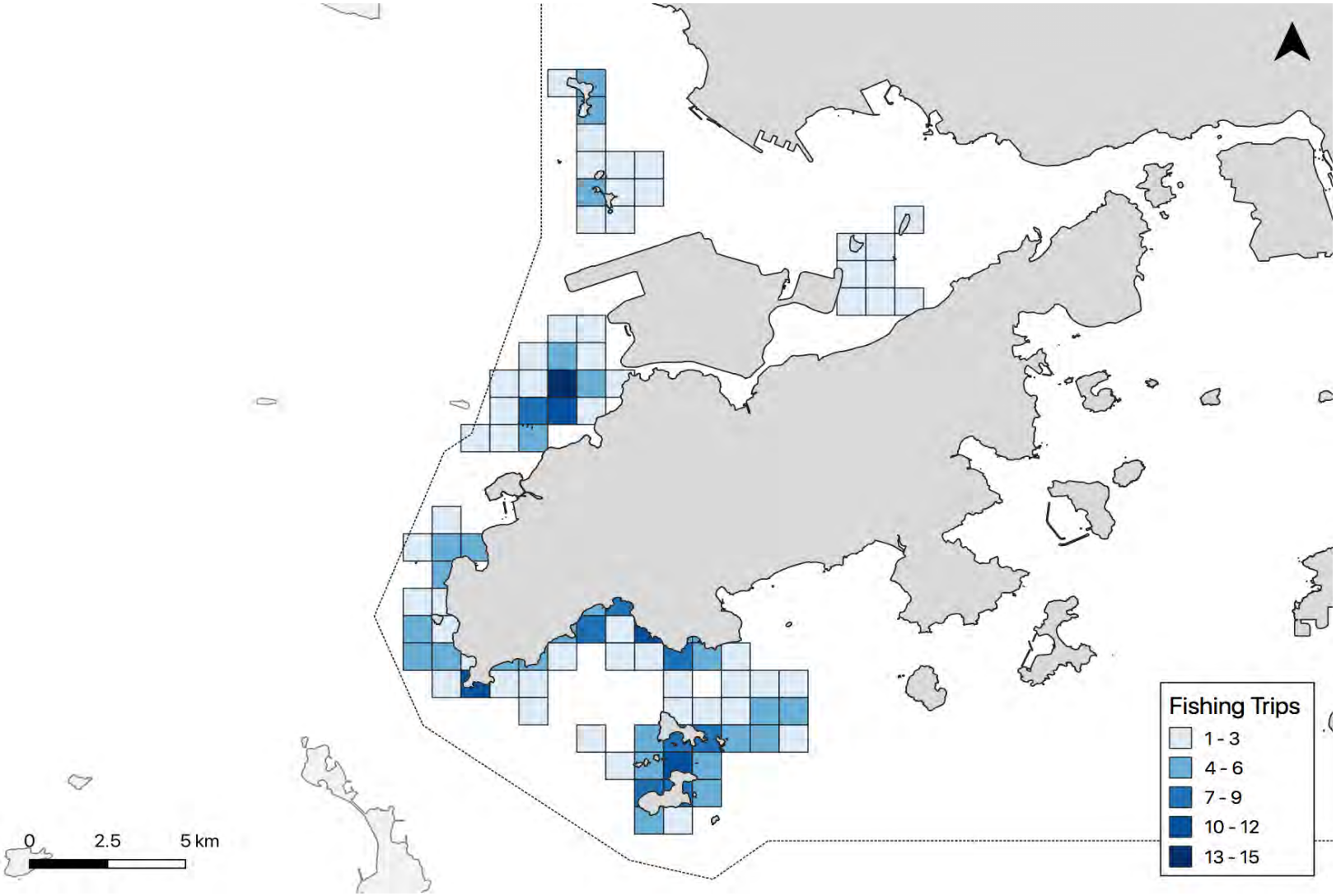

Figure 17. A Summary of Fishing Activity (based on the number of fishing trips) for a Tai O Fisherman between April – December 2018

The overlap of dolphin positive minutes relative to total fishing effort was mapped using 1km x 1km grid squares (***Figure 18***). Of the twenty 1km x 1km grids in which fishing activity was logged, here were four areas in which dolphins were detected for more than 50% of the total net deployment time, that is, dolphins occurred close to active fishing nets in these areas for more than half the time the net set time. In two areas, dolphins occurred around active fishing gear for more than 90% of the total net set times. One of these high overlap areas is within the proposed Marine Park for South Lantau and while the other is to the north of Tai O and adjacent to the Hong Kong ZhuHai Macau Bridge. It is also noted that the minimal fishing effort expended in the area adjacent to the Brothers Marine Parks also overlapped with dolphin occurrence. There has been a marked reduction in dolphin encounters within the North East Lantau area, however, these data points show that the habitat is still frequented and remains in use as a foraging area. There are still significant data gaps in understanding both fishermen and dolphins habitat use and its overlap, in the waters of Lantau. There is considerable variation in individual fishing boat effort and distinct seasonal fishing patterns, and this work would benefit from a longer time series of data plus the involvement of more fishermen. The initial data provided by this study indicates that the proposed Marine Park Area for South Lantau has a high degree of overlap between fishing activities and dolphins feeding and that the Brothers Marine Park area is still used as a foraging area for some dolphins.

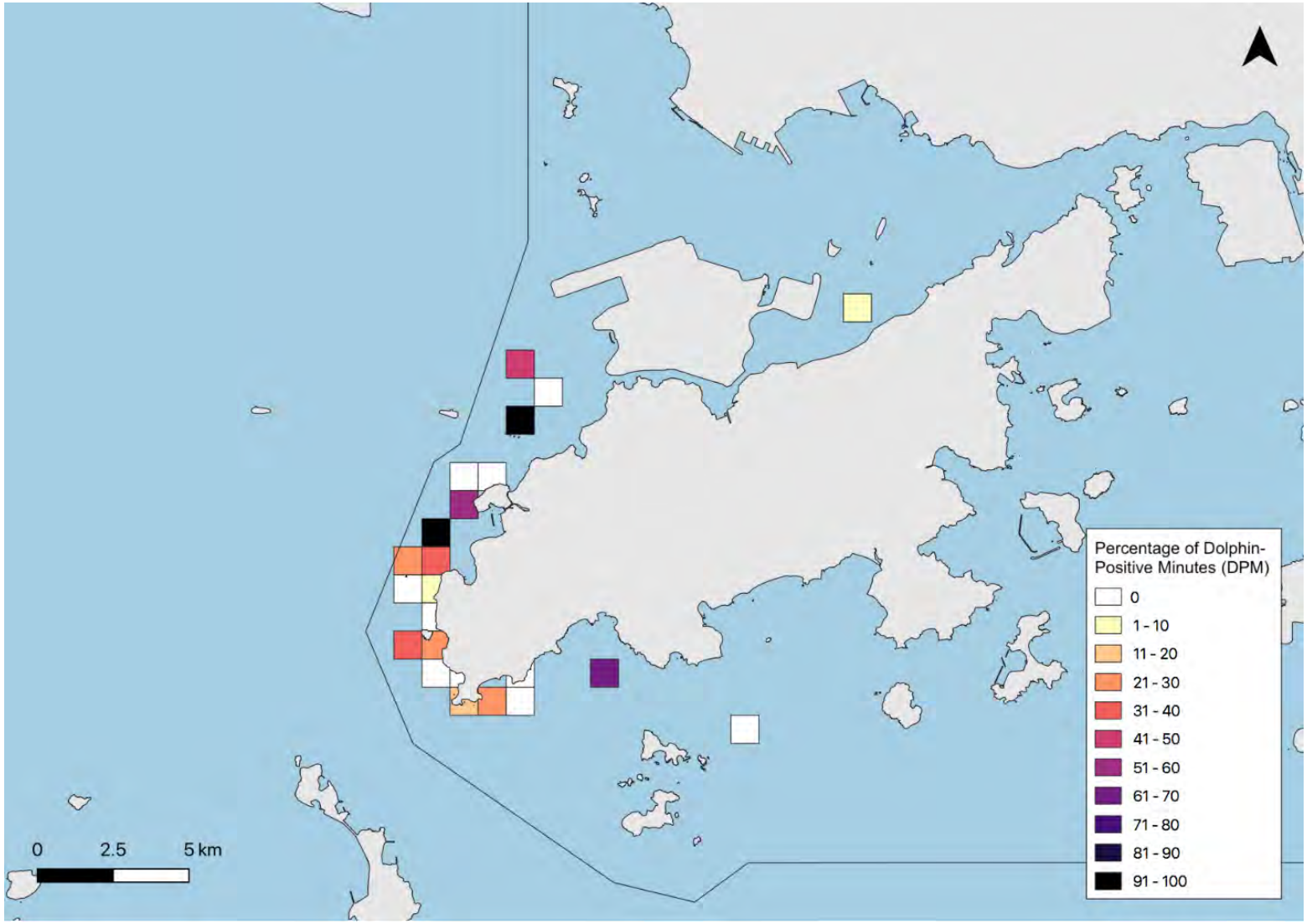

Figure 18 The Overlap of Dolphin Occurrence and Fishing Activities, using the Percentage of Dolphin Positive Minutes (DPM) to Indicate Areas of Potential Entanglement Risk

4. Evaluation of Project Effectiveness

The original project proposed several benefits. The most important of these was to develop a better understanding between researchers and fishing communities. This was achieved and demonstrated by the increased participation of the fishermen in the project, once the first mapping results were available and by the request of some fishermen to participate in the project in 2019, if it were to continue. Both fishermen and researchers are beginning to more fully understand the relationship between active fishing nets and dolphins and, importantly, both groups discussed the priority needs of each stakeholder community for the common goal of maintaining viable fish stocks in Hong Kong. Maps of the extent of overlap between active fishing gear and dolphin activity are emerging and both researchers and fishing communities agree on the reliability of the data. Indeed, partnerships between western Hong Kong waters stakeholders have been strengthened. The effectiveness of the project is indicated by the growing number of participants and number of AAD deployments. Although the initial deployment of the AAD was slow, once the fishermen had more confidence in deploying the devices, the number of deployments increased markedly at the end of the project and fishermen were ultimately sufficiently confident to leave the AAD un-supervised on set nets over a 10 hour plus period. The number of participants grew from one gillnet fishermen and one purse seine vessel in June 2017, to nine (9) gillnet fishermen and six (6) purse seine vessels by December 2018.

This project also proposed to draft a collaborative action plan that incorporated practical solutions that aimed to minimise risk to dolphins while still recognising the importance of the fishing community needs. From interviews and discussion, plus initial review of maps, the first four actions points suggested are:

- Identify a key fisherman in each village and formally establish them as the liaison for the project and allow them to manage fishing effort monitoring and AAD deployments. In this way, fishermen will quickly grow more confident with AAD deployment and the data obtained. The use of other technology should also be trialled and funding has been secured to fit cameras to two fishing vessels to augment the acoustic data set.
- Involve more fishing vessels in fishing effort mapping. Now that a simple GPS tracking device has been tried and tested, which does not require fishermen to activate or actively manage data, provide devices to all the Tai O and Cheung Chau who have now volunteered to participate in fishing effort mapping,

- Once effort data has been gathered from multiple fishermen, continue to refine fishing effort maps and hot spots. Arrange seasonal meetings in each community to update all participants on effort maps. It is anticipated that these areas will shift over time and information on the temporal importance of fishing and feeding areas will also be determined by analysing fishing effort patterns and with the continued input of the fishermen's expert knowledge.
- Fishermen believe that ghost fishing nets pose a risk to dolphins, perhaps more so than active fishing gear do. Ghost gear also interferes with ongoing fishing activities. Therefore, a ghost gear clearance should be arranged (Fan Lau was suggested as a high priority as the fishermen agree that the data gathered during this project, plus their own knowledge, indicates that there is a potential risk of entanglement) in collaboration with suitable management authorities, e.g., AFCD, and a local diving group. There is an ongoing net clearance programme at Tung Ping Chau that can be used as a framework for a similar activity at Fan Lau. Funding has been secured to initiate a marine debris programme where fishermen will be incentivized to return broken gear to shore for recycling.

As yet, a common strategy to identify risk to dolphins from fishing activities and fishing gear is underway, with a suggestion to include fishermen as key members of an integrated research team; to increase the number of fishermen that carry tracking devices to map fishing effort and; to reduce the risk from ghost or abandoned fishing gear in areas of key dolphin occurrence, by initiating an active net removal programme.

5. Summary and Recommendations

A good collaboration was established between fishermen in Tai O and Cheung Chau. All researchers were involved in interviews and boat survey and the project no longer relies on one individual to continue. A different strategy will be required to better collaborate with Tuen Mun fishermen, although it is hoped that the success of this project with the other fishing communities will provide the first steps towards working with Tuen Mun

Objective 1: "Collaborate with fishing communities to collect data on the occurrence of dolphins around several different types of active fishing gear."

Data was gathered from nine different gillnet fishermen and six different purse seine vessels. It took time for individual fishermen to be confident enough to deploy the AAD and in future, any such data collection strategy should consider using an already

collaborating fishermen to help teach device attachment and deployment techniques to new fishermen. In addition, a longer time frame should be allowed to get fishermen comfortable with the AAD. The independent collection of data around active fishing gear should also continue as this provides a consistent and direct link with many members of the fishing community and provides data which is also independently verified. This also provides an opportunity for researchers to photograph and identify individual dolphins and possibly also a platform for drones to record detailed behaviour around fishing nets. It is also proposed to place a series of static acoustic recorders in the areas identified in this study as high overlap between dolphins and fishing activities so that baseline dolphin activity, regardless of fishing effort, can be established.

Objective 2: "Gather the verbal history of fishing patterns with the fishermen who operate in the western waters of Hong Kong and to share the collected collaborative data on a regular basis with the wider fishing community."

The use of semi-structured interviews has provided much local ecological knowledge in other areas. This objective should be expanded, the questionnaire refined and the expertise of a social scientist solicited to perform a more thorough analyse of the data obtained. Currently, much of the local fishing knowledge is not recorded, with only a few examples found in literature (Ago and Anderson, 2009). With reference to entanglement of dolphins in fishing gear, the interviews and discussion provided insights to the risk of entanglement in abandoned fishing gear and led fishermen to agree that removal of these derelict nets would reduce risk to dolphins and may prevent existing nets from being snagged in these older nets, thus may help break the cycle of net abandonment. This is an interesting, if untested, hypothesis. Funding has been secured to continue meeting with the fishing community, the primary aim of which is to discuss the various mechanisms that could be implemented to establish 'area closures'. The results of these meetings will be presented to AFCD, who will also be invited to formal community meetings. To better understand how the Ocean Park Strandings team diagnose entanglement as a cause of death, meetings with the veterinary experts at OP will be conducted and the OP team will be invited to join formal community meetings. Images of live entanglements will also continue to be assessed in conjunction with OP.

Objective 3: "Work together with fishing communities to develop spatially explicit maps which quantify areas of highest active fishing gear and dolphin habitat use overlap."

An appropriate tracking tool has been trialled and accepted by the fishing communities in Tai O and Cheung Chau. The first maps of fishing effort and acoustic detections of

dolphins have been shared and accepted by participating fishermen and the leaders of the fishing associations. The continued and expanded collection of quantitative fishing effort data, in addition to the concomitant recording of acoustic data, will allow for a more detailed mapping of fishing and dolphin. Elsewhere in Asia, a few studies are ongoing hat investigate small cetacean bycatch (Whitty 2015; 2018) and a variety of useful tools have been developed to better analyse the data derived from local ecological knowledge and location data (Getting to the Bottom of Bycatch, 2018). The systematic data provided by the AAD will add to the usefulness of existing tools and provide increasingly detailed risk maps as more data is collected.

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Appendix I Semi-Structured Interview

NO: _____ DATE: _____ LOCATION: _____ INTERVIEWER: _____
Time start: _____ Time End:_____

QUESTIONNAIRE

Target Group:

Fishermen that have seen Chinese white dolphins (CWD), finless porpoise (FP) and any other species of marine mammals.

Introduction:

This project focuses on fishing and the marine mammals, particularly CWD and FP in the western waters of Hong Kong. The project leader is Dr Lindsay Porter who has worked in Hong Kong since the early 1990s researching marine mammals. This semi-structured interview should take approximately 20 to 30 minutes for to get through. The results will be analysed by our team, SMRU Hong Kong, and presented back to your community for discussion. Your name will be kept solely for our records.

The objective of the questionnaire is to:

1) Understand current fishing practices.

2) Understand historical and current occurrence and distribution of CWD and FP.

3) Understand the interaction between fishermen and CWD/FP.

Part A: Demographic profile

1) Name: _____ 2) Sex: Male ☐ Female ☐ 3) Age: _____

4) Ethnicity: _____ 5) How long have you been living here?

_____ years ☐ ☐

6) Occupation: ☐ *Fisher* ☐ *Farmer* ☐ *Other: Please specify:*

_____

7) Educational level: Primary Secondary No educational background

Part B: Fishing practice

1) *How many years have you been fishing? _____ years*
2) *What kind of boat (type and horsepower) do you use?*

_____

3) *What has the fishing season been like in the last year (2017-18)? Please describe target species and any good or bad fishing.*

Oct 17		*Apr 18*	
Nov 17		*May 18*	
Dec 17		*Jun 18*	
Jan 1		*Jul 1*	

8		8	
Feb 18		Aug 18	
Mar 18		Sep 18	

4) How many times a week do you go fishing?

☐ 1 ☐ 1-2 ☐ 3-4 ☐ 5-6 ☐ 7

Other:_____

5) When you go fishing ☐ Da ☐ Night

Other :_____

6) When you go fishing, how many people are usually with you? _____ people

7) Using the attached map (Map #1), please label:

A. Where do you go usually go fishing?

B. Do you ever fish outside this ar ☐ ☐ No

If Yes, please state the area on the map

8) What kind of fishing gear do you use?

_____

(trawl nets, dredges, beach seines, purse seines, gillnets, trammel nets, lift nets and cast nets ,hook traps, longlines, handline, trollline)

9) Have you noticed any changes in fishing in these areas over the last 5 years?

	Increase	Decrease	No	Not	Other

	d	d	ch an ge	s u r e	s
Fisherme n					
Fish					

10)How many hours (on average) per fishing trip do you normally fish?

_____ hours ☐ ☐

11)Do you harvest all size of fish? Yes No

Reason :_____ ☐ ☐

12)Have you received any training? Yes No

If yes, please state the training organisations: ☐ ☐

_____

13)If you could no longer fish, would this be a problem for you? Yes No

If yes, please state the reason/what else would you do?_____

14)Have you faced any problems or challenges when fishing? (Please list all.)

_____

_____

_____

_____

(pollution, more competitor, habitat destruction, development, etc.)

15) *Do you have any suggestions or comments you would like to make about fisheries in Hong Kong?*

_____

_____

Part C: Occurrence of marine mammals and interaction with fishermen

1) *How often do you see CWDs?*

Life		*Per Year*		*Per Month*		*Per Week*	
1		*1*		*1*		*1*	
2-4		*2-4*		*2-4*		*2-4*	
10+		*10+*		*10+*		*10+*	

2) *Did your father or grandfather talk about seeing CWD/FP? If yes, please detail: Year(s) seen:*_____

_____

3) *By using the attached map (Map #1), please indicate:*
   I) Where different fishing areas are.
   II) CWD and FP areas of distribution.

4) *If you've seen CWD or FP between October 2017 and September 2018 (in the last year), please answer the questions below:*

Number of times seen	*Size (All same size or different size?)*	*Months*

5) Do CWD or FP only appear when you are fishing? ☐ *Yes* ☐ *No*

(indicate which species Y/N)

6) Do you see CWD or FP around fishing nets? ☐ *Yes* ☐ *No*

If Yes, state what kind of fishing nets: _____

(trawl nets, purse seines, gillnets, trammel nets)

If Yes, state how close CWD get to fishing nets: _____ meter(s)

If Yes, state how close FP get to fishing nets: _____ meter(s)

7) What kind of fish do CWD eat?: _____

8) What kind of fish do FP eat?: _____

9) Do you see CWD or FP when you aren't fishing? ☐ *Yes* ☐ *No*

10) Do you see any of the behaviours in Figure 1? ☐ *Yes* ☐ *No*

If Yes, please detail on the figure:

_____ ☐ ☐

11) Do you ever find CWD or FP entangled in your fishing net or other gear? Yes No

If yes, frequency

Life	*Per Year*	*Per Month*	*Per Week*	*Never*

1		*1*		*1*		*1*		
2-4		*2-4*		*2-4*		*2-4*		
10+		*10+*		*10+*		*10+*		

12) Have you noticed any changes in distribution or number of CWD or FP in the last five years?

	Increased	*Decreased*	*No change*	*Not sure*
Occurrence of CWD				
Group size CWD				
Occurrence of FP				
Group Size FP				

13) If the answer is CWD or FP have Decreased in Q11, why do you think this is?

☐ *Accidental entangling in fishing net* ☐ *Construction work* ☐ *Shipping*

☐ *Dolphin watching* *Others:* ☐

_____

14) Do you find CWD or FP in the same places as you did last 5 years ago

☐ *Yes .....No .....*

15) Have you ever seen any floating dead CWDs? ☐ *Yes* ☐ *No*

16) If CWDs are caught accidentally, what kind of fishing methods are used?

_____

(trawl nets, dredges, beach seines, purse seines, gillnets, trammel nets, lift nets and cast nets)

17) If have or do accidentally catch a CWD, what do you do with it?

_____

18) In the past, were CWD or FP ever hunted? ☐ *Yes* ☐ *No*

If yes, do you have any details?

_____

_____

_____

_____

19) In the past, were CWD or FP ever sold in the market?

Where?	
Which parts of dolphins?	
For what reason?	

20) Do you know of any superstitions, myths or stories about CWD or FP?

_____

_____

_____

21) Are you aware of any laws or regulations associated with CWD or FP?

☐ *Yes* ☐ *No*

If Yes, please detail: _____ ☐ ☐

22) Do you know any local groups that are helping to protect CWDs? *Yes* *No*

If Yes, please detail: _____

23) Who do you think should be responsible for CWD and FP conservation?

_____

_____

24) Is it a benefit to have CWD or FP around Tai O or in Hong Kong?

YES	*NO*	*Not Sure*	*Why*

25) Is this the first time you have been interviewed about CWD or FP? ☐ ☐

Yes *No*

If Yes, please detail (group/project):

_____

26) Do you see any other animals except CWDs?

☐ ☐ ☐ ☐ ☐

Whales *Shark* *Sea turtle* *Other marine mammals* *Other:*

_____

27) Any other comments?

_____

_____

----------☺ The End of questionnaire. Thank you for your cooperation ☺----------


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Appendix II Images and Supporting Material

Drone Footage and Audio via Google Drive (link sent)

Files: *Appendix II Supplementary Material Entangled.pdf*

Appendix II Supplementary Material Fishing.pdf


6020


6025


YAMAHA 15

Appendix III Statement of accounts

Project expenditure details are not disclosed due to confidentiality reason.

I hereby irrevocably declare, warrant and undertake to the MEEF Management Committee and the Steering Committee of the relevant Funds including the Top-up Fund, that I myself, and the Organisation:-

1. do not deal with, and are not in any way associated with, any country or organisation or activity which is or may potentially be relevant to, or targeted by, sanctions administered by the United Nations Security Council, the European Union, Her Majesty's Treasury-United Kingdom, the United States Department of the Treasury's Office of Foreign Assets Control, or the Hong Kong Monetary Authority, or any sanctions law applicable;

2. have not used any money obtained from the Marine Ecology Enhancement Fund or the related Top-up Fund (and any derived surplus), in any unlawful manner, whether involving bribery, money-laundering, terrorism or infringement of any international or local law; and

3. have used the funds received (and any derived surplus) solely for the studies or projects which further the MEEF Objectives and have not distributed any portion of such funds (including any derived surplus) to members of the recipient organisation or the public.

Signed by Dr. Lindsay Porter
as the duly authorised representative
For and on behalf of the Recipient
Organisation

SMRU (Hong Kong) Ltd
海洋哺乳動物研究組(香港)

Date: 29 April 2019