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Expansion of Hong Kong International Airport into a Three-Runway System ("3RS")

Update on the Implementation of Marine Ecology Mitigation and Enhancement Measures in association with the 3RS Project

PURPOSE

This paper presents an update to Members on the status of implementation of the marine ecology mitigation and enhancement measures for the 3RS Project.

BACKGROUND

2. A range of mitigation measures has been proposed in the 3RS Environmental Impact Assessment ("EIA") to avoid, minimize and compensate for the potential impact on Chinese White Dolphins ("CWD") and marine ecology during the construction and operational phases of the project. Furthermore, a Marine Ecology and Fisheries Enhancement Strategy ("MEFES") is also recommended in the 3RS EIA Report to enhance the marine ecology (including CWD) and fisheries resources.

3. The Airport Authority Hong Kong ("AAHK") has been actively pursuing these marine ecology mitigation and enhancement measures and some of them have been implemented since the commencement of construction of the 3RS Project. AAHK has been updating the Advisory Council on the Environment ("ACE") on the implementation of some of these measures since 2015, including the Marine Travel Routes and Management Plan for High Speed Ferries of SkyPier ("SkyPier Plan"), the

proposal for the 3RS marine park, and the marine ecology and fisheries enhancement measures directly funded by AAHK.

MITIGATION MEASURES FOR POTENTIAL DISTURBANCE OF MARINE TRAFFIC ON CWDS

4. The route diversion and speed restriction for high speed ferries travelling between the Hong Kong International Airport ("HKIA") and Zhuhai / Macau have been implemented under the SkyPier Plan since December 2015. A SkyPier Plan effectiveness report was presented to ACE in May 2017 using a full year of CWD monitoring data for the period December 2015 to December 2016. An update of the effectiveness report after analysing the CWD monitoring data for two years (December 2015 to December 2017) is presented in **Annex 1** of this paper. The results reflect that the implementation of the SkyPier Plan does not impose negative impacts on CWD's use of the Northwest Lantau waters. Nonetheless, AAHK will continue to carry out the monitoring works to collect more information about CWD.

5. For proper management of construction marine traffic, AAHK voluntarily set up a Marine Traffic Control Centre ("MTCC") in August 2016 to monitor the locations, travel routes and speeds of 3RS construction vessels, making use of vessel-installed Automatic Identification System ("AIS") equipment. To further strengthen the monitoring work, a Marine Surveillance System ("MSS") was launched by the MTCC in March 2017. The MSS automatically identifies cases of potential deviation such as speeding over 10 knots within works areas and CWD hotspots, encroachment into specified no-entry areas, or failure to use designated marine works access gates. The system facilitates effective real-time monitoring of construction vessel activities as well as timely follow-up on identified deviation cases.

6. The Environmental Team ("ET") has been regularly reviewing data collected by the MTCC / MSS to check construction marine traffic compliance with requirements, with deviation cases accurately identified and properly followed up. Besides, training has been provided to construction vessels skippers to help them better understand all vessel operation requirements and controls in and around the 3RS marine works area. In addition, the Independent Environmental Checker has also been performing routine audits on compliance aspects and concluded that the on-site construction vessels were properly managed.

MARINE ECOLOGY ENHANCEMENT FUND AND FISHERIES ENHANCEMENT FUND UNDER MEFES

7. The Marine Ecology Enhancement Fund and the Fisheries Enhancement Fund ("the Funds") were successfully established in 2017, with ten projects approved during the first year of funds operation (Fiscal Year 2017/18) with total funding of more than $8 million. Successful applicants include tertiary institutions, research groups and fisheries industry associations. The second round of applications for these two funds for Fiscal Year 2018/19 closed earlier this year, and eight projects with a total funding of nearly $10 million have been approved.

8. Information on the approved projects can be found on the dedicated 3RS Project website[1]. AAHK will continue to publicize the Funds in order to encourage applications that may contribute to conserving marine life, supporting a sustainable fishing industry and enhancing fisheries resources.

ENHANCEMENT MEASURES DIRECTLY FUNDED BY AAHK UNDER MEFES

9. AAHK provides funding and management for several potential marine ecology and fisheries enhancement measures in Lantau waters. These include eco-enhancement of seawall designs, voluntary surveillance of marine parks, and deployment of artificial reef ("AR") and fish fry release in Northwest Lantau waters.

10. AAHK has developed eco-enhancement designs for certain sections of the 3RS seawalls after considering the comments from stakeholders including ACE on potential measures that can enrich the biodiversity and ecological value of seawall structures. The final eco-enhancement designs have taken into account the projected hydrodynamic regime around the 3RS platform as well as a key airport operational safety constraint whereby eco-seawall installations must not attract bird-life. The designs incorporate concrete blocks and vertical seawall panels with rough surfaces, pits, holes and rock pools aim to facilitate and promote colonisation of epifauna and to increase microhabitat complexity and offer refuge for marine organisms. The eco-seawall blocks are being fabricated off-site for installation during seawall construction works in 2018 and 2019.

[1] http://env.threerunwaysystem.com/en/index.html

11. AAHK has initiated a six-month voluntary surveillance programme since May 2018 covering the Sha Chau and Lung Kwu Chau Marine Park ("SCLKCMP") and The Brothers Marine Park ("BMP"), intending to identify over time any activities suspected to be non-compliant with the Marine Park Ordinance restrictions (e.g., speeding over 10 knots, suspected anchoring or suspected fishing within the two Marine Parks). The programme comprises automatic monitoring of AIS-equipped vessel activities by the MTCC as well as voluntary patrols by the ET during both daytime and night-time. AAHK will review the effectiveness and share the information and experience with the Agriculture, Fisheries and Conservation Department ("AFCD") to support their marine park enforcement work upon the completion of the programme.

12. In accordance with recommendations from feasibility studies on fish restocking / fish fry release and AR deployment and taking into account comments from stakeholders including ACE, AAHK is progressing with the preparatory works for pilot tests on AR designs and on certain fish restocking methods and arrangements with pilot tests intended to better determine the value of AR deployment and fish fry restocking in suitable locations near the 3RS works area. The pilot tests are proposed within the existing Hong Kong International Airport Approach Area ("HKIAAA") to the west of HKIA's south runway. Monitoring will be conducted as part of the pilot tests to assess the effectiveness of these enhancement measures. It is anticipated that the pilot test for fish restocking would commence in late 2018, whereas the pilot test for AR deployment would commence in 2019 or 2020 (subject to gazettal under the Foreshore and Sea-bed (Reclamations) Ordinance and statutory authorisation).

PROPOSED MARINE PARK

13. As recommended in the approved 3RS EIA Report, a new marine park comprising an area of approximately 2,400 ha will be designated in north Lantau waters in 2024, tentatively, to tie in with the full operation of the 3RS Project, as compensation for the seabed habitat and open waters habitat loss associated with the 3RS Project. The new marine park is proposed to protect and conserve the marine environment around HKIA from various anthropogenic threats as well as to provide linkage between the current SCLKCMP and BMP. Designation of the Marine Park will result in over 4,400 ha of linked marine protected area in northern Lantau waters.

14. In accordance with the Environmental Permit ("EP") condition, AAHK has advanced the preparation works for the designation of the Marine Park. Based on the preliminary boundary identified for the proposed 3RS Marine Park (the details of which are presented in the Marine Park Proposal for the Project), AAHK commenced a detailed study in 2016 to refine the marine park boundary and management plan. AAHK has liaised with a number of stakeholders including government departments to solicit views on the goals, boundary and preliminary management plan for the 3RS Marine Park. Further consultations with stakeholders including green groups, fishery sectors, local communities and other consultative and advisory committees are planned in late 2018 / early 2019. AAHK will continue to work with AFCD in the preparation works for the designation of the proposed 3RS Marine Park, taking into account progress and development of other committed Marine Parks in western Hong Kong waters.

STAKEHOLDER ENGAGEMENT

15. To enhance transparency and communication with the community in a proactive way, AAHK has been organising forums meeting with Community and Professional Liaison Groups, comprising representatives in the neighbouring districts of HKIA and relevant professional / experts. The liaison groups provide platforms and hence, facilitate communications, enquiries and complaints handling between AAHK and community leaders and experts on the environmental issues related to 3RS Project.

16. AAHK is highly transparent in its works and the dedicated website (http://env.threerunwaysystem.com/en/index.html) continues to provide the general public with updated information on the 3RS Project, including environmental monitoring and audit data and results, updated plans and submissions in accordance with requirements in the EP, information and meeting materials for the liaison groups, and details and status on the Funds.

WAY FORWARD

17. AAHK will continue to pursue and implement the marine ecology mitigation and enhancement measures for the 3RS Project to ensure full compliance with the EP and EIA Ordinance requirements. With the established platforms, including the liaison groups, the dedicated 3RS website, and other stakeholder

engagement events, AAHK will proactively keep on engaging the relevant stakeholders on the 3RS Project, in particular environmental matters.

Airport Authority Hong Kong
July 2018

Annex 1 Summary of SkyPier Plan Implementation for 2017

SUMMARY OF SKYPIER PLAN IMPLEMENTATION

1. During the 2017 reporting period there were a total of 9,560 High Speed Ferry (HSF) movements between HKIA SkyPier and Zhuhai / Macau, and of these there were only 1 case when the average speed limit in the Speed Control Zone (SCZ) was exceeded. Daily movements of all SkyPier HSFs ranged between 1 and 97, well within the maximum daily cap number of 125 and the annual daily average number of SkyPier HSF movements was 88, also well within the annual daily average cap of 99 SkyPier HSF movements.

2. A total of five skipper workshops were held in 2017 with ferry operators and relevant ferry captains to refresh participants' understanding on SkyPier Plan requirements, including the diverted route and speed control requirements as well as discussion on deviation incidents, experience sharing and recommendations on normal practices to ensure adherence to SkyPier Plan requirements.

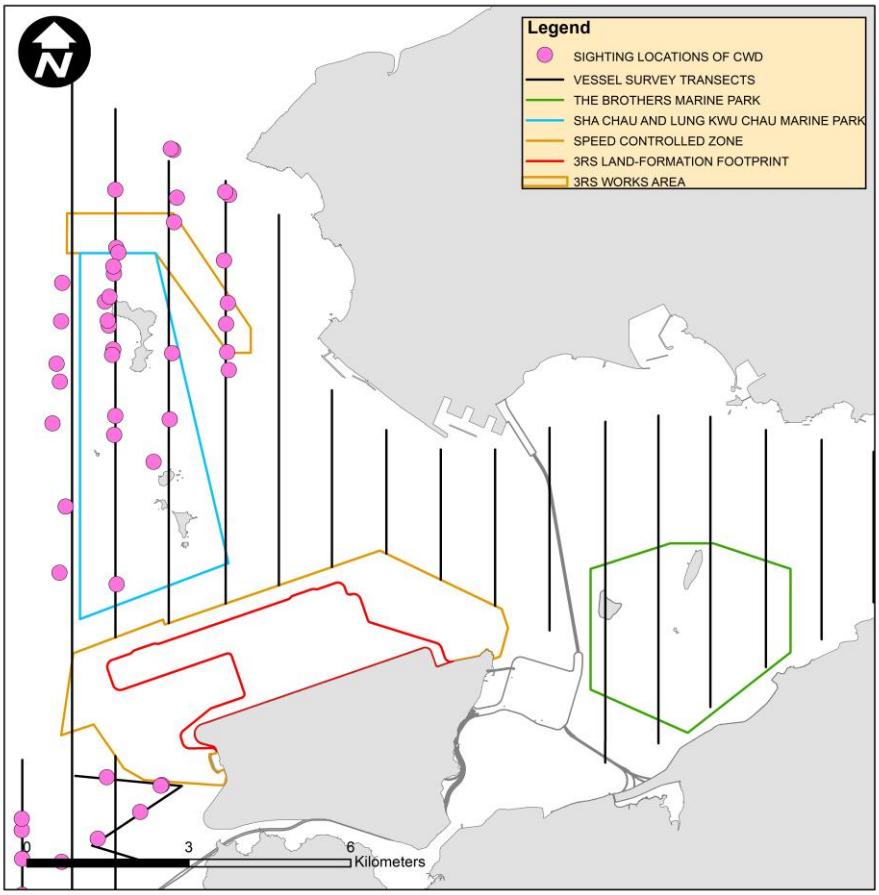
3. The SkyPier Plan will continue to be implemented during the construction period with monitoring carried out on an ongoing basis as part of the environmental monitoring and audit programme for the 3RS Project. Skipper workshops will continue to be conducted. Detailed SkyPier HSF monitoring data is presented regularly in Monthly EM&A reports, which are available for public viewing in the 3RS Project dedicated website (http://env.threerunwaysystem.com/en/index.html).

CWD VESSEL LINE-TRANSECT MONITORING FINDINGS

4. CWD monitoring data were collected by conducting vessel line-transect surveys in North Lantau waters between mid-December 2015 and December 2017 for the 3RS Project. The CWD sighting result in 2017 is summarised in **Figure 1**. Small vessel line-transect surveys provided data for estimating density and abundance and for other assessments making use of line-transect distance-sampling methodologies. The surveys involved small vessel line-transect data collection that is designed to be consistent with previous surveys undertaken by the AFCD for their long-term monitoring work on small cetaceans in Hong Kong. Surveys were designed to provide systematic, quantitative measurements of density, abundance and habitat use.

5. The CWD monitoring results in 2017 (both vessel-based and land-based surveys) for the construction phase monitoring, show that waters to the north of SCLKCMP especially waters to the north of Lung Kwu Chau and west of the Urmston Road channel including the SCZ, are still being used by CWDs as important habitats after the SkyPier Plan mitigation measures were implemented.

Figure 1: CWD Sightings Distribution in North Lantau Waters from January to December 2017 – one year after implementation of the SkyPier Plan



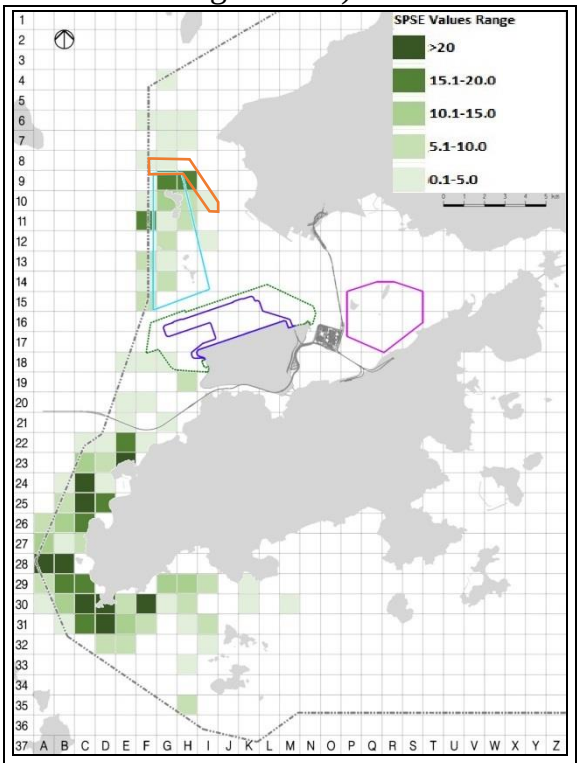
6. Quantitative grid analysis on habitat use was conducted using the 2-year 3RS sighting data-set. Sightings Per 100 units of Sighting Effort (SPSE) and Dolphins Per 100 units of Sighting Effort (DPSE) values were calculated for all grids in all survey areas (see **Figure 2** and **Figure 3**) with reference to the methodology adopted in AFCD Marine Mammal Monitoring Reports. The grid analysis findings from 3RS surveys in 2016 and 2017 revealed that the important habitat of CWDs in NWL waters with high dolphin densities slightly shifted from north to northwest off LKC.

7. Vessel survey data over the monitoring period did not detect any CWDs in the NEL area from both 2016 and 2017. There is an indication that Southwest Lantau (SWL) and West Lantau (WL) areas are being more heavily used by CWDs, and this may have resulted from CWDs shifting their activities to parts of their home range in SWL and WL waters to avoid the NEL area. Despite these changes, the survey data continue to show that some regions within North Lantau waters are still being used as important dolphin habitat, in particular the area around Lung Kwu Chau and the Urmston Road area near Castle Peak.

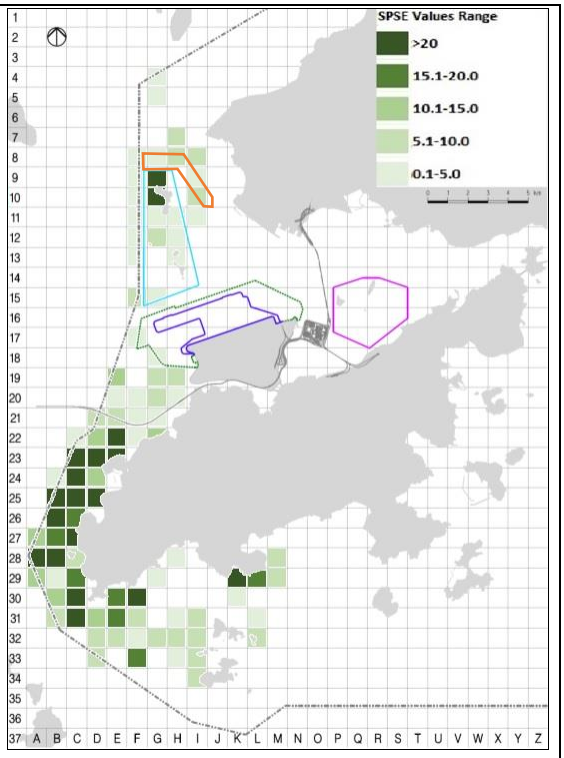
8. Photo-identification (photo-ID) data are collected on vessel surveys, and the purpose of photo-ID in Hong Kong CWD monitoring is to provide home range and life history information on individual dolphins. In 2017 monitoring period, the photo-ID work associated with the vessel surveys identified a total of 155 CWD individuals

grouped into three photo 'catalogues', namely North Lantau (NL), WL and South Lantau (SL), according to their first sighting locations. 88 CWDs were sighted more than once (56.8%) and 50 (32.3%) of the 155 identified animals showed cross area movement between different survey areas. Several individuals (NLMM027, NLMM028 and WLMM030) were re-sighted in both the north of Lung Kwu Chau and at WL waters (**Figure 4**). There were quite a number of individuals that continued their frequent use of Lantau waters or even greatly increased their use of Hong Kong waters in 2017 compared with 2016. With more re-sighting data to be collected in the future, we will be able to conduct more analyses on the change of individuals' home ranges and nature of residency (e.g., year-round resident, seasonal resident, visitor, etc.).

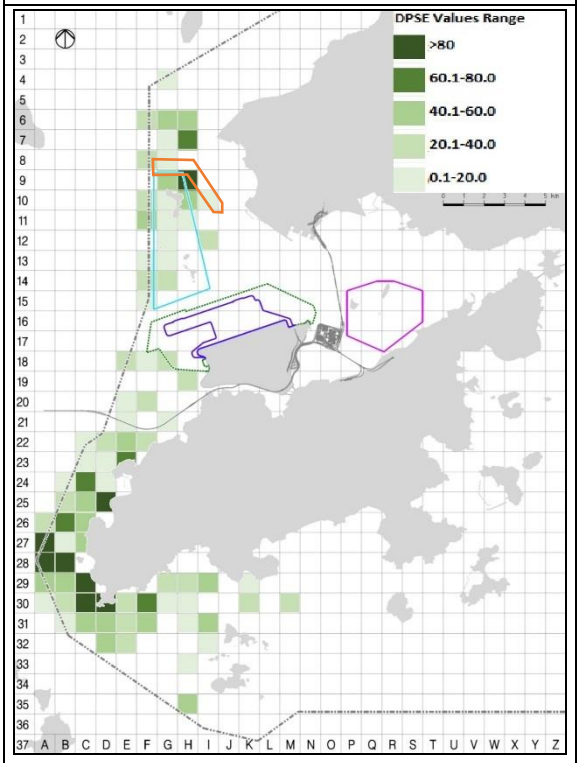
Figure 2: SPSE and DPSE of CWDs with Corrected Survey Effort per km^2 (Upper Left: SPSE from 3RS monitoring in 2016, Lower Left: DPSE from 3RS monitoring in 2016, Upper Right: SPSE from 3RS monitoring in 2017, Lower Right: DPSE from 3RS monitoring in 2017)



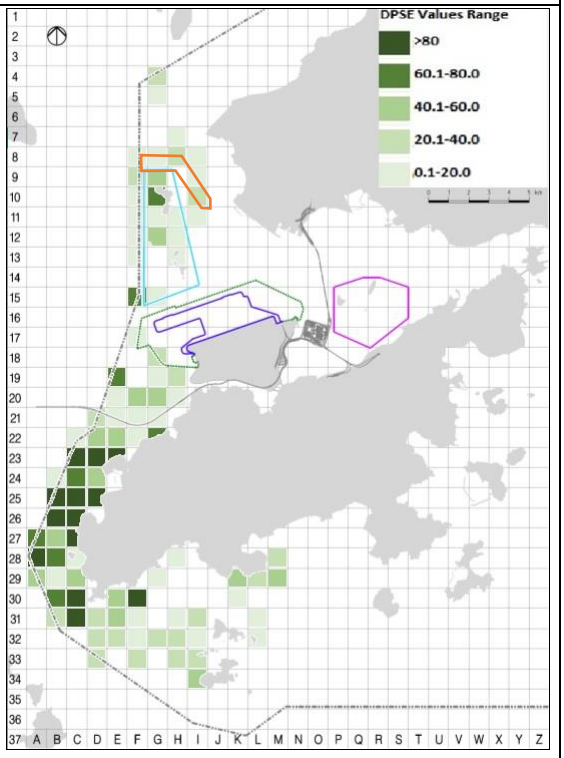
SPSE of Dec 2015 to Dec 2016



SPSE of 2017

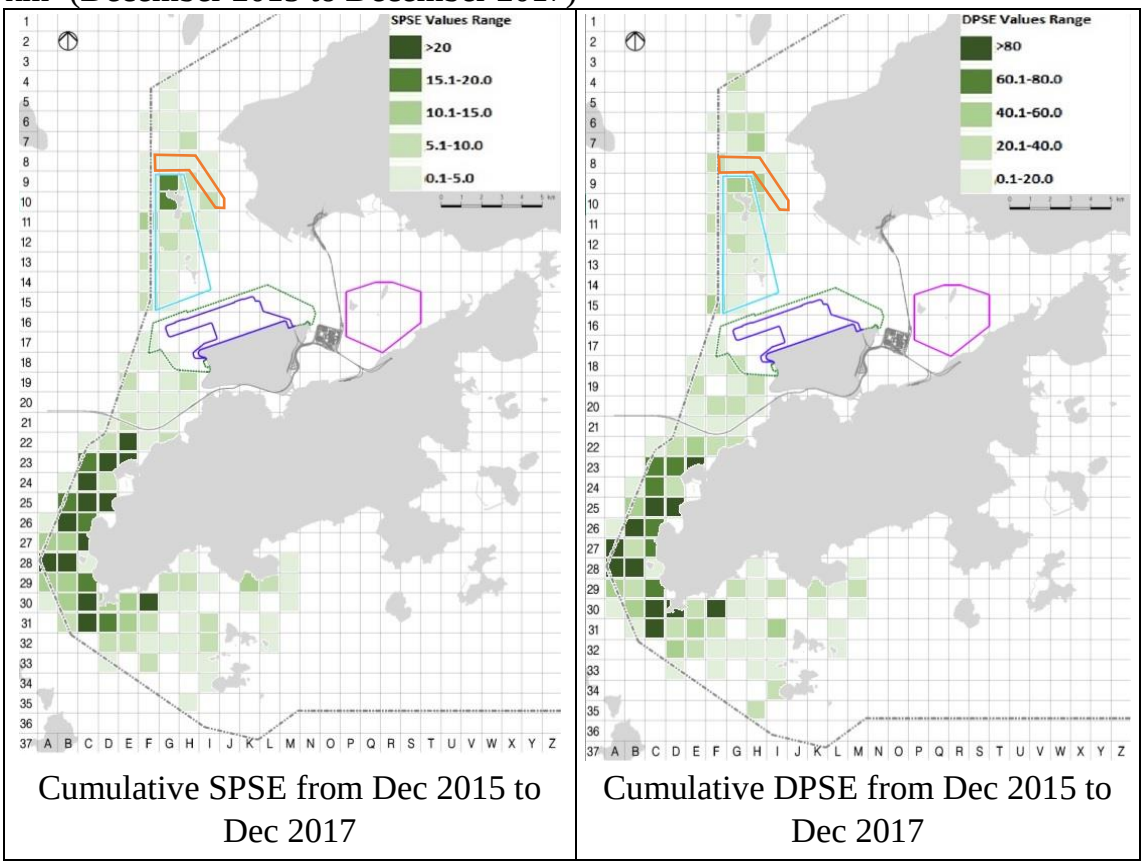


DPSE of Dec 2015 to Dec 2016



DPSE of 2017

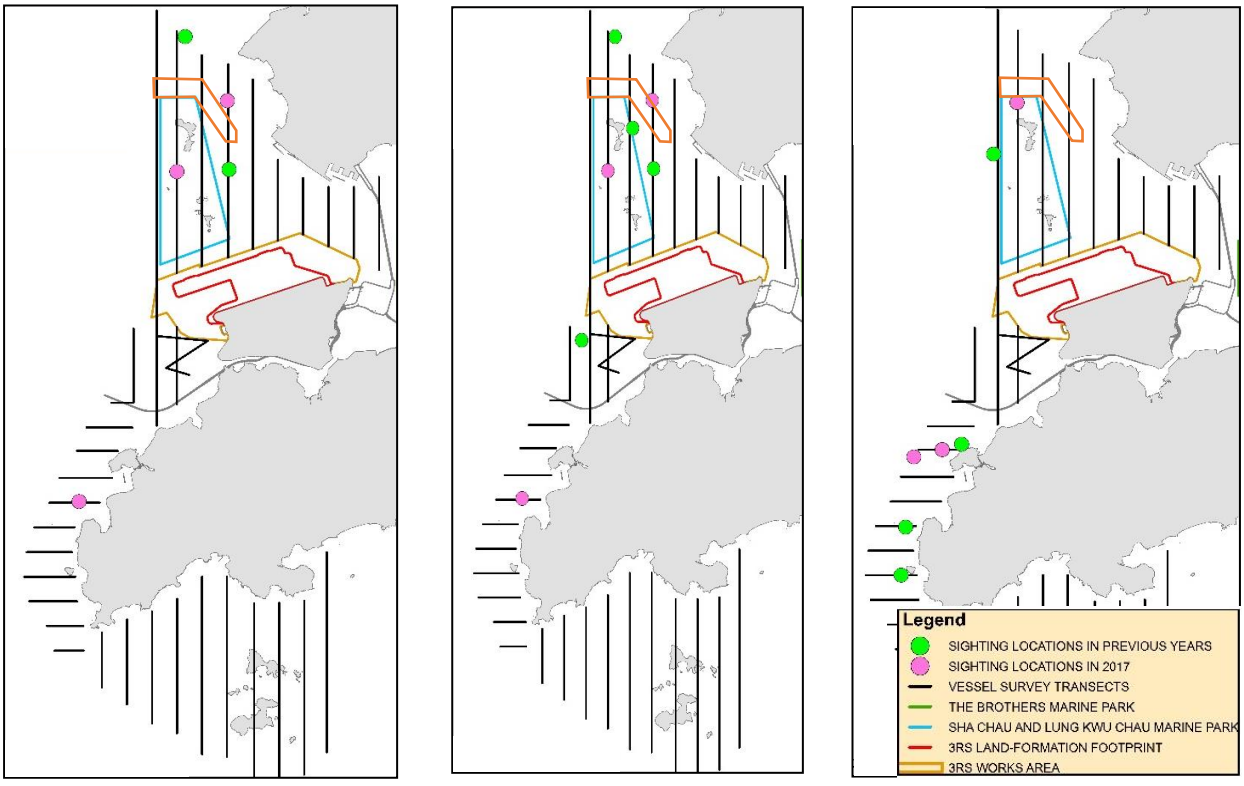
Figure 3: Cumulative SPSE and DPSE of CWDs with Corrected Survey Effort per km^2 (December 2015 to December 2017)



Cumulative SPSE from Dec 2015 to Dec 2017

Cumulative DPSE from Dec 2015 to Dec 2017

Figure 4: Sighting Locations of NLMM027 (left), NLMM028 (middle) and WLMM030 (right) from January to December 2017



9. From the 3RS CWD monitoring data, the estimate of overall abundance for 2017 was 71 individuals, which is somewhat higher than the year before (63 individuals in December 2015 to December 2016), with the associated precision (CV) (the lower the CV the higher the precision) of 19.9%, which indicates a reasonable level of precision (**Table 1**). Within NWL waters, dolphins are mostly found around the Castle Peak and LKC areas. The seasonal analysis showed that within summer, dolphin numbers are still quite high in Hong Kong waters. The 2017 seasonal range is 40-112 dolphins. The spring estimate was the lowest (40 dolphins), while the summer estimate was the highest (112 dolphins), and this indicates that, despite the overall reduction in the average number of dolphins using Hong Kong waters in recent years, there are quite a number of dolphins still present in the summer months.

10. Concerns had been expressed by some stakeholders that dolphin numbers in NWL may have decreased, specifically due to potential negative impacts from the re-routing of the SkyPier HSF to the SCZ north of LKC. Therefore, the 3RS CWD monitoring has been paying specific attention to this issue. The analysis covering the entire first year post-SCZ (December 2015 to December 2016) provided an estimated abundance of 15 dolphins for NWL (see **Table 1**). The estimate for 2017 for the same area was of 14 dolphins (the relatively higher CV by area would reduce the sample sizes and result in a lower precision); this is considered a non-significant difference. Therefore, these 2-year analyses have not supported the hypothesis of a decline, and in fact suggested that dolphin numbers in NWL may have remained quite stable since the SCZ has been implemented.

Table 1: CWD Line Transects Parameters and Estimates of Density and Abundance for Western Hong Kong based on 3RS data (December 2015 to December 2017)

Time Period	Stratum	No. of Sightings	Average Group Size	Trackline Detection Prob. - g(0)#	Individual Density (no./100km^2)	Abundance	95% CI (Abund.)	%CV
2016								
Dec 2015-Dec 2016	AW	3	2.0	1.0	14.00	1	0-2	64.6
Dec 2015-Dec 2016	DB	2	7.0	1.0	8.42	3	1-12	75.1
Dec 2015-Dec 2016	NEL	0	n/a	1.0	0.00	0	n/a	n/a
Dec 2015-Dec 2016	NWL	40	3.3	1.0	17.60	15	10-25	24.3
Dec 2015-Dec 2016	SWL	44	2.7	1.0	21.80	14	8-26	30.7
Dec 2015-Dec 2016	WL	77	3.8	1.0	109.20	30	19-48	23.3
Dec 2015-Dec 2016	**Pooled^**	**166**	**3.3**	**1.0**	**23.40**	**63**	**45-89**	**17.6**

Time Period	Stratum	No. of Sightings	Average Group Size	Trackline Detection Prob. - g(0)#	Individual Density (no./100km^2)	Abundance	95% CI (Abund.)	%CV
2017								
Jan-Dec 2017	AW	5	2.6*	1.0	40.55	2	1-4	43.9
Jan-Dec 2017	DB	1	2.6*	1.0	2.31	1	0-4	97.5
Jan-Dec 2017	NEL	0	n/a	1.0	0.00	0	n/a	n/a
Jan-Dec 2017	NWL	37	2.6*	1.0	16.59	14	9-23	23.6
Jan-Dec 2017	SWL	65	2.6*	1.0	33.57	22	14-35	23.0
Jan-Dec 2017	WL	113	2.6*	1.0	132.22	36	23-58	23.8
Jan-Dec 2017	**Pooled^**	**221**	**2.6***	**1.0**	**27.33**	**71**	**48-102**	**19.9**

^ Pooled abundance not including Airport West (AW). Note that the pooled estimates do not necessarily add up to the sum of the individual stratum estimates, as these are computed separately.

From Jefferson (2000)

* Group size samples for some areas was very small in 2017, so the line transect analysis used a pooled group size for all survey areas

SUMMARY OF CWD LAND-BASED THEODOLITE TRACKING FINDINGS

11. The result of land-based theodolite tracking surveys with plots of first sightings of all the tracked CWD groups in the two full years (December 2015 to December 2017) at LKC are summarized in **Figure 5**. A total of 194 CWD groups were sighted in 2017 from LKC during essentially the same survey effort as in 2016 or December 2015 to December 2016 (total of 126 CWDs sighted). Based on theodolite data, the waters off LKC remain an important foraging area for CWDs throughout the year. Foraging and travelling were observed most frequently (51.0% and 36.4%, respectively) off LKC during the two full years (**Figure 6**). Within the SCZ, 75 groups were tracked and travelling was the most frequently observed behaviour (61.9%) followed by foraging (31.6%) in the two years (**Figure 7**).

Figure 5: Plots of First Sightings of All CWD Groups recorded from Lung Kwu Chau (December 2015 to December 2017)

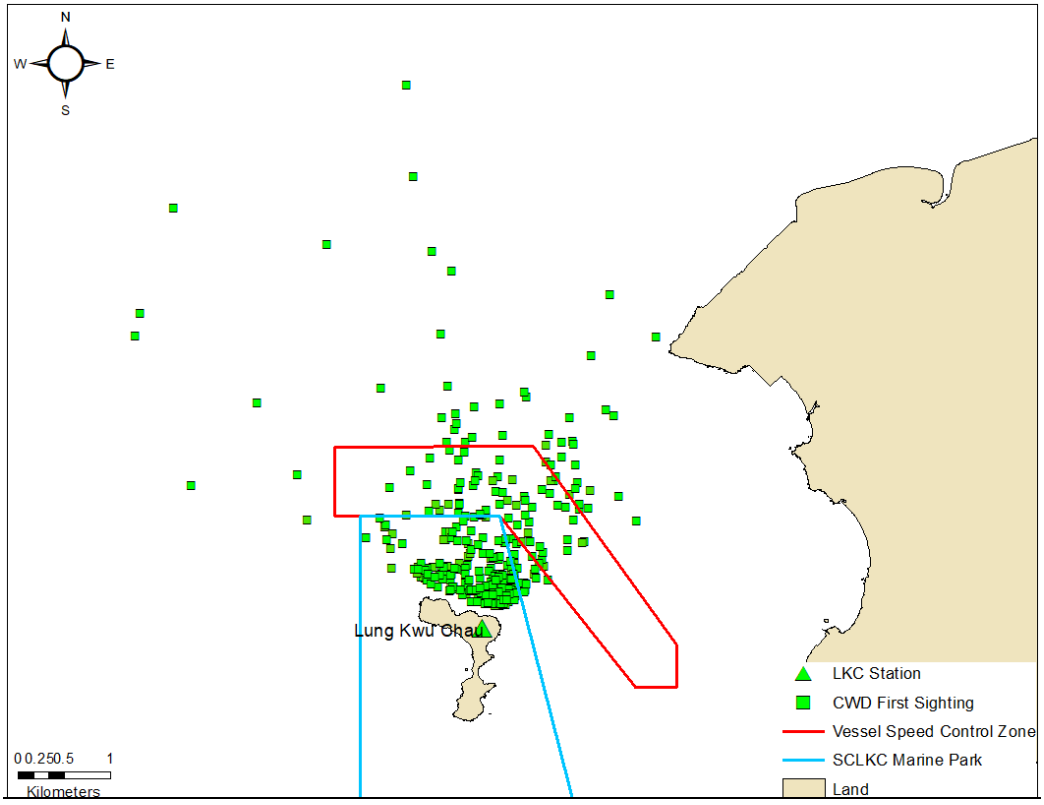
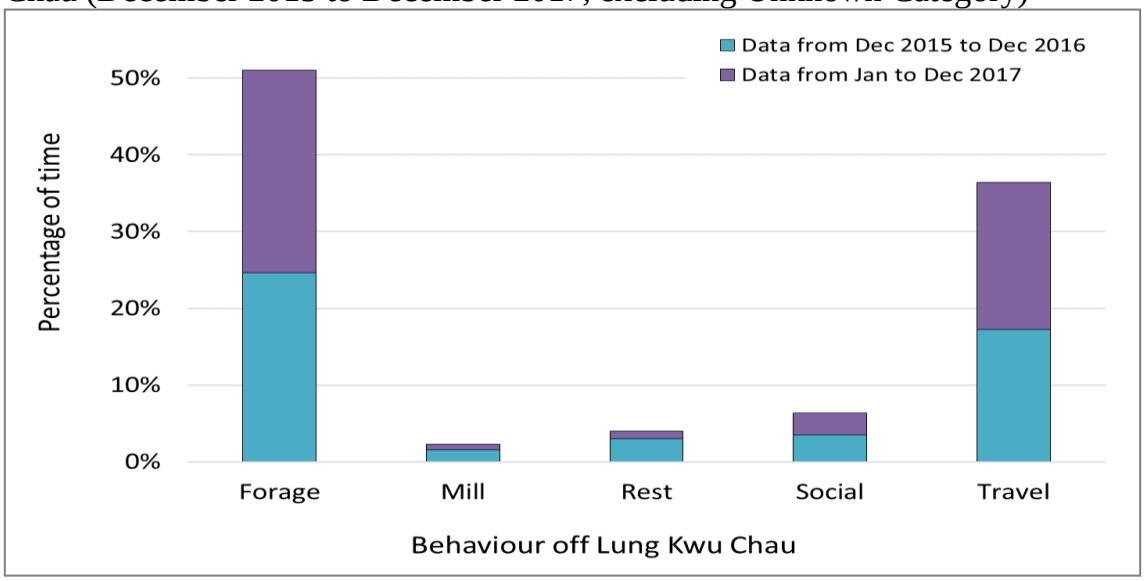
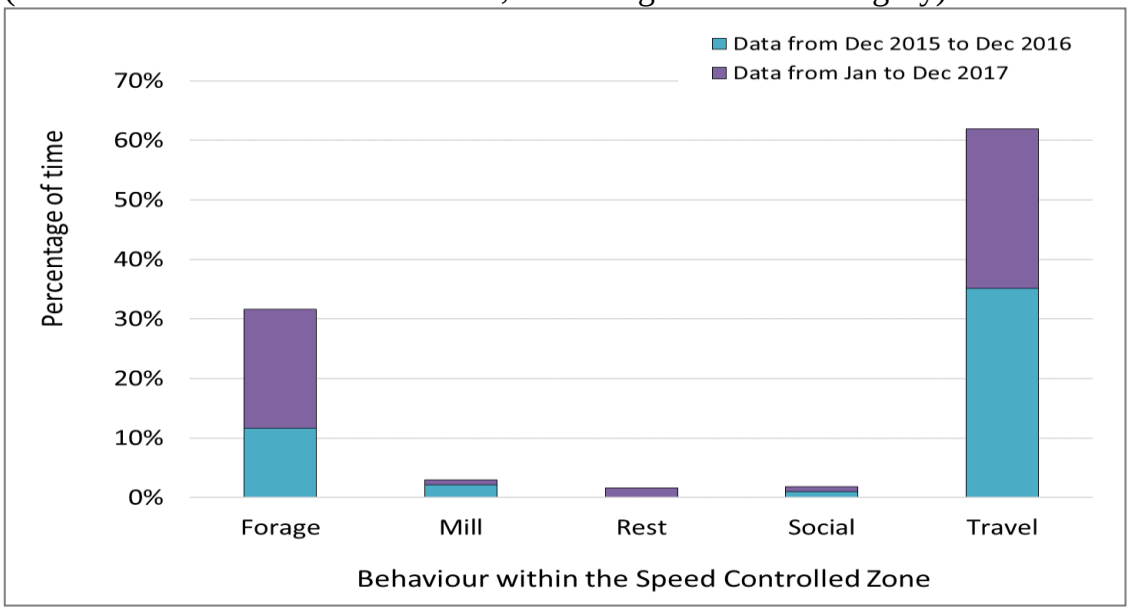


Figure 6: Bar chart showing percentages of CWD Behavioural States off Lung Kwu Chau (December 2015 to December 2017, excluding Unknown Category)



Note: Percentages calculated from 898 positional fixes with associated behavioural data

Figure 7: Bar chart showing percentages of CWD Behavioural States within SCZ (December 2015 to December 2017, excluding Unknown Category)



Note: Percentages calculated from 217 positional fixes with associated behavioural data

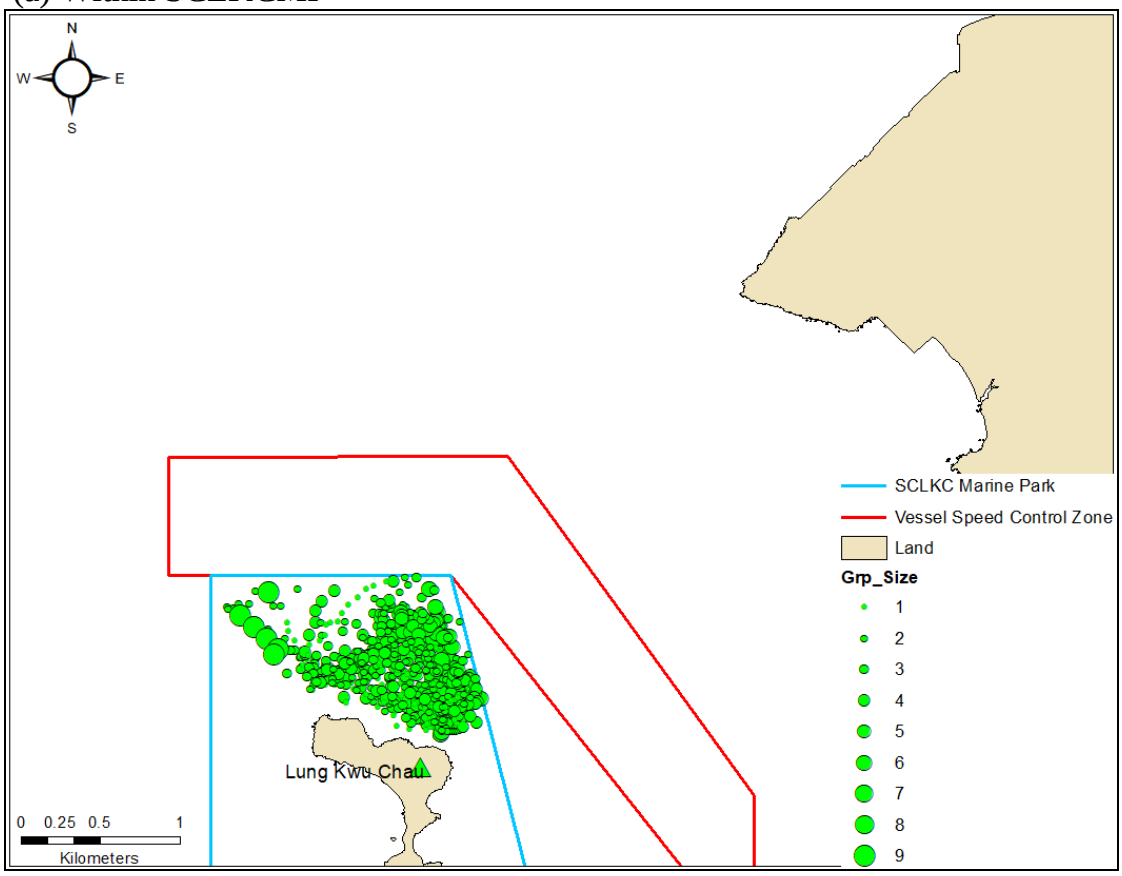
Vessel-Dolphin Co-occurrence

12. Regarding CWD group size and vessel activity, data from the two full years (December 2015 to December 2017) has been combined for study with a larger sample size. The mean group size of CWD off LKC was 3.04 (**Table 2**). The Kruskal-Wallis and Dunn post hoc tests showed that group size was significantly larger outside the SCLKCMP than inside it (see **Figure 8 (a) to (c)** for the plots of CWD positions relative to group sizes within; crossing and outside the boundary of

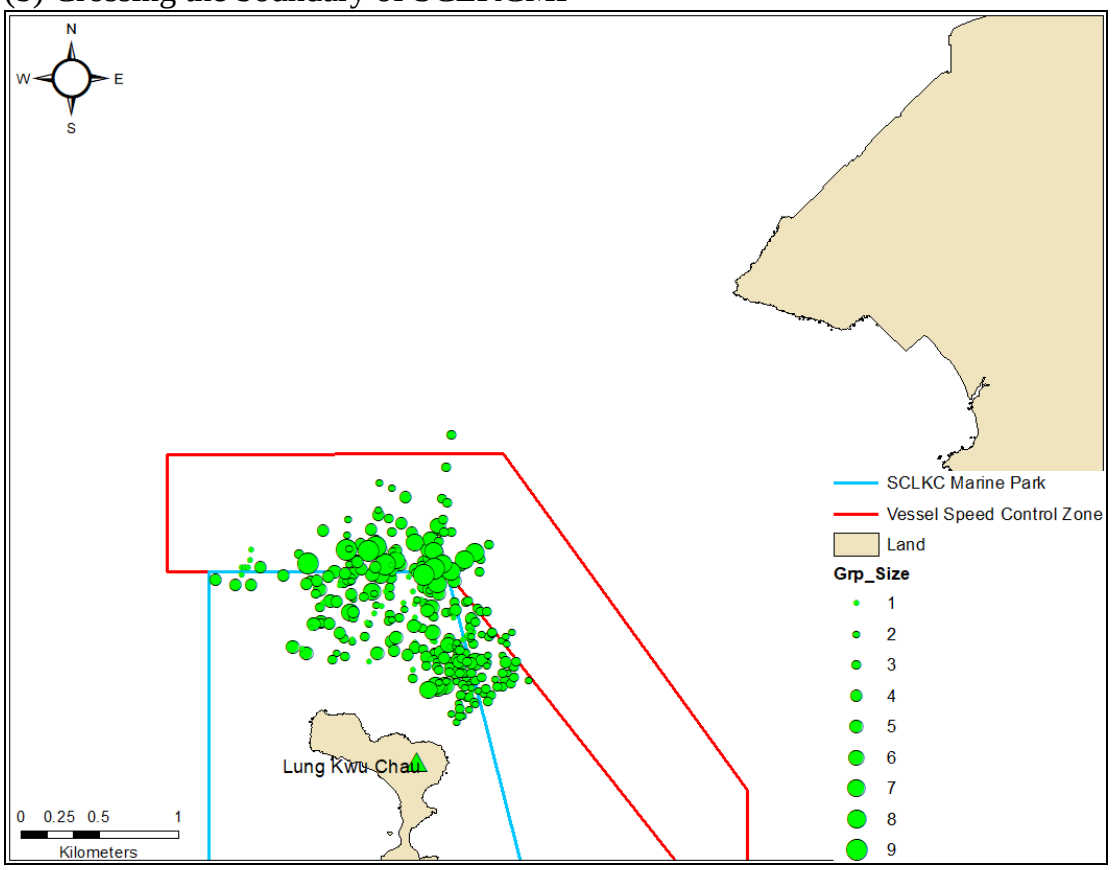
SCLKCMP). Vessels were recorded within 500 meters of focal CWD groups off LKC on 47 occasions, including HSF travelling at restricted speeds (≤ 15 knots) on 16 occasions, HSF travelling at normal speeds (>15 knots) on 10 occasions, and other vessels (e.g., fishing and government vessels) on 21 occasions (**Table 2**). The group size of CWDs within 500 m of HSF under restricted speeds (≤15 knots) was 3.54, HSF under normal speeds (>15 knots) was 4.07, and other vessel type was 3.43. CWD group size with no vessels within 500 m was 2.90 (**Table 2**). The Kruskal-Wallis and Dunn post hoc tests showed that CWD group size was significantly higher in the presence of HSF under normal or restricted speeds and other vessels. Mean speed, reorientation rate and linearity for CWDs in the absence of vessels and in the presence of each vessel category are detailed in **Table 3**. A basic one-way ANOVA showed no significant difference in CWD speed, reorientation rate, or linearity relative to vessel type present.

Figure 8: Plots of CWD Short-track Positions (Standardized Segments) relative to Group Size tracked from LKC in December 2015 to December 2017

(a) Within SCLKCMP



(b) Crossing the boundary of SCLKCMP



(c) Outside SCLKCMP

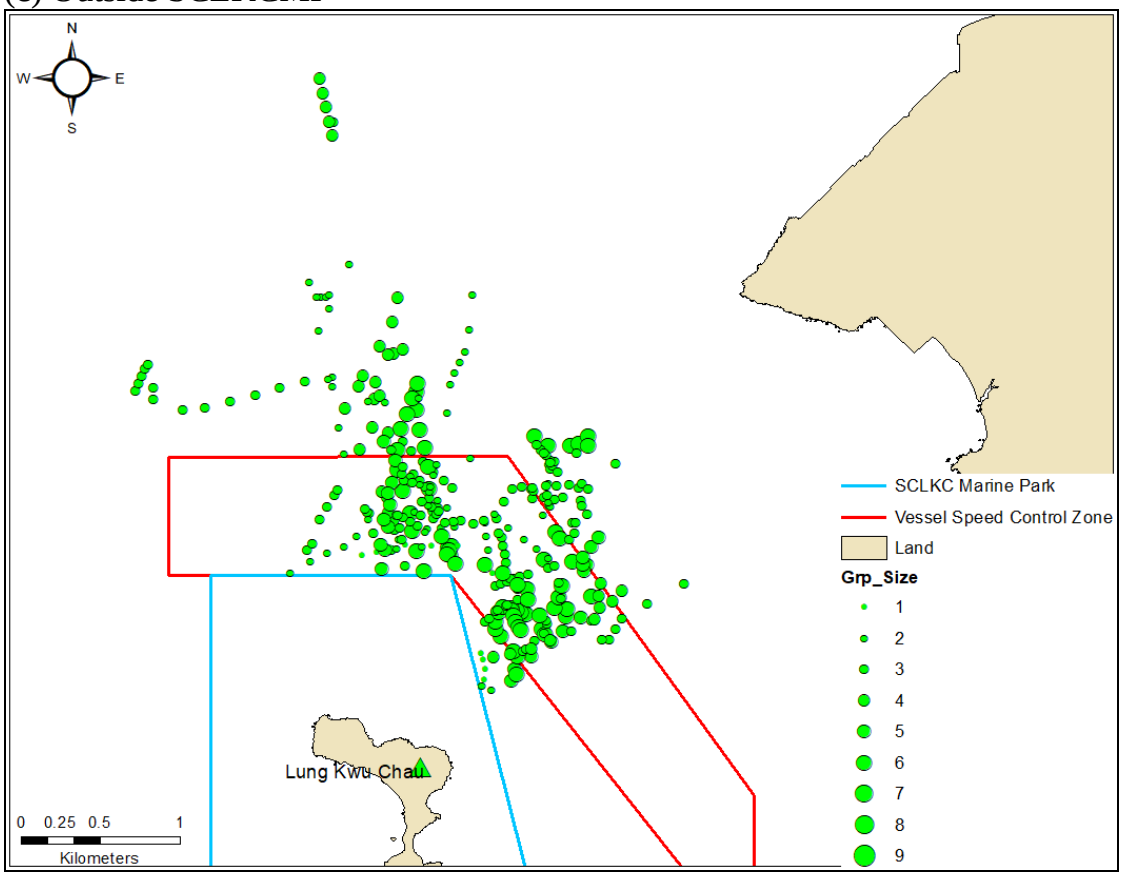


Table 2: CWD Focal Group Size Summary off LKC from December 2015 to December 2017 (Standardized Segments)

Station	Sample Size	Minimum No. of Individuals	Maximum No. of Individuals	Mean Group Size	Standard Deviation
Lung Kwu Chau Total	**234**	**1**	**9**	**3.04**	**1.66**
Inside SCLKCMP boundary	125	1	9	2.69	1.54
Crossing SCLKCMP boundary	55	1	9	3.21	1.81
Outside SCLKCMP boundary	54	1	7	3.69	1.55
No boats present	187	1	9	2.90	1.54
HSF travelling at normal speed (>15 knots) within 500 m	10	1	9	4.07	2.36
HSF travelling at restricted speed (≤15 knots) within 500 m	16	1	7	3.54	1.79
Other boats within 500 m	21	1	7	3.43	1.90

Table 3: CWD Mean Swimming Speed, Reorientation Rate, and Linearity off LKC based on Vessel Presence from December 2015 to December 2017

Vessel Type	Sample Size	Mean Speed, km/hr (SD)	Mean Reorientation Rate, deg/min (SD)	Mean Linearity, index 0 to 1 (SD)
No Vessel	187	2.82 (1.21)	27.73 (21.10)	0.79 (0.23)
HSF travelling at normal speed (>15 knots) within 500 m	10	3.36 (1.87)	28.93 (27.58)	0.80 (0.26)
HSF travelling at restricted speed (≤15 knots) within 500 m	16	3.24 (1.39)	29.19 (24.24)	0.79 (0.24)
Other boats within 500 m	21	2.37 (1.56)	41.46 (24.85)	0.64 (0.30)

SD: Standard Deviation

13. In order to review the effect of the implementation of SkyPier Plan on the behaviour of the dolphin, several analyses that are additional to the standard data analyses as specified in the Updated EM&A Manual were conducted. These include:

i) Extract vessel data at different distances (500 m, 300 m and 100 m) from the tracked CWD groups from the land-based monitoring data collected at the Lung Kwu Chau (LKC) station, in order to review any co-occurrence pattern. The 500 m distance is well-established in the literature as a distance at which: a)

vessels can potentially begin to affect dolphin behaviours, and b) the distance is not so far that we cannot both see and track the dolphin group and the vessel. The 100 m distance is quite close, and more extreme and consistent behaviours are expected (depending on type and movement of vessel and behavioural states of dolphins). This close-up distance is also highlighted in the literature. The intermediate 300 m is suggested as a halfway point, to ascertain whether and behaviourally how -- in general and in what situations -- dolphins are being affected relative to the "farther" and extreme "closer" situations.

ii) Two levels of land-based theodolite tracking data of dolphins and vessels from the Lung Kwu Chau station for co-occurrence data analysis were performed – a) First level: Using data for statistical analysis only when the data meet predetermined speed /orientation /distance criteria. b) Second level: Determination of behavioural state for all instances of before, during, and after HSF (and other) traffic.

First-level Results: Vessel Distances

14. Boat presence was categorized based on three different distance thresholds: 1) within 100 m, 2) between 101-300 m, and 3) between 301-500 m of focal CWDs. Sample size and mean speed, reorientation rate and linearity for CWDs in the absence of boats and in the presence of each boat type and distance threshold are detailed in **Table 4**. While not likely to be significant (due to low sample sizes), it is clear from **Table 4** that greatest variation of swimming speeds, reorientation rates, and linearity may have occurred with high speed vessels at high speed vs. at low speed vs. "other" vessels in the 0-100 m distance category. As an example, the one available sample of dolphin speed with a high speed vessel at 0-100 m distance was over 5 km/hr, compared to 3 km/hr of high speed vessel at close range at restricted speed (but faster than the 1.75 km/hr. of other vessels). More in-depth statistical analyses are given below.

Table 4: CWD Mean Swimming Speed, Reorientation Rate, and Linearity based on Boat Type and Distance from CWD off Lung Kwu Chau in 2015-2017. NA = Not applicable (due to 1 sample each).

Distance Threshold	Vessel Type	Sample Size	Mean Speed km/hr (SD)	Mean Reorientation Rate deg/30 sec (SD)	Mean Linearity 0 to 1 (SD)
>500 m	**No Vessel**	**187**	**2.82 (1.21)**	**27.73 (21.10)**	**0.79 (0.23)**
0-100 m	**Boat Types Combined**	**13**	**2.41 (1.48)**	**44.52 (22.59)**	**0.62 (0.27)**
	High Speed Ferry (>15 kn)	1	5.31 (NA)	17.24 (NA)	0.97 (NA)
	High Speed Ferry (≤15 kn)	4	3.01 (1.74)	31.51 (17.53)	0.70 (0.18)
	Other	8	1.75 (0.75)	54.44 (20.68)	0.55 (0.29)
101-300 m	**Boat Types Combined**	**18**	**3.46 (1.69)**	**30.32 (28.58)**	**0.76 (0.29)**
	High Speed Ferry (>15 kn)	4	3.64 (2.21)	37.14 (41.04)	0.64 (0.38)
	High Speed Ferry (≤15 kn)	7	3.84 (1.14)	27.54 (27.12)	0.84 (0.21)
	Other	7	2.98 (1.98)	29.20 (26.36)	0.74 (0.32)
301-500 m	**Boat Types Combined**	**16**	**2.61 (1.50)**	**31.39 (23.11)**	**0.76 (0.27)**
	High Speed Ferry (>15 kn)	5	2.75 (1.66)	24.70 (18.02)	0.89 (0.08)
	High Speed Ferry (≤15 kn)	5	2.59 (1.33)	29.63 (29.30)	0.77 (0.32)
	Other	6	2.50 (1.77)	38.45 (23.40)	0.65 (0.30)

Swimming Speed

15. The swimming speed was significantly slower when boats were between 301-500 m of CWD groups than when boats were not present. Group size had a significant effect on swimming speed, with speed generally increasing as group size increased from 1 to 5 individuals, and plateauing thereafter with larger group sizes. Socialising behaviour was associated with significantly slower swimming speed than travelling. Swimming speed was significantly faster during the wet season, and among CWDs crossing the marine park boundary than within the marine park. Time of day did not have a significant effect on swimming speed.

Reorientation Rate

16. The reorientation rate was significantly higher in the presence of boats within 100 m, but not those greater than 100 m away. Group size had a significant effect on reorientation rate, with bearing change generally increasing as group size increased. Foraging behaviour was associated with significantly higher reorientation rate than travelling. Reorientation rate was significantly lower among CWDs crossing the marine park boundary. Time of day did not have a significant effect on reorientation rate.

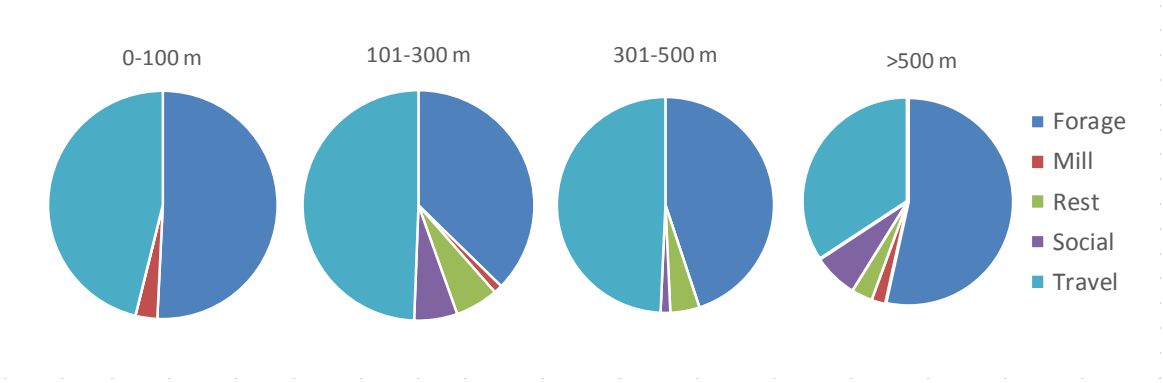
Linearity

17. The linearity decreased in the presence of boats within 100 m, but not those greater than 100 m away. Foraging behaviour was associated with significantly reduced linearity than travelling behaviour. Linearity was significantly higher among CWDs crossing the marine park boundary than those inside the marine park. Time of day and group size did not have a significant effect on linearity rate.

Behavioural States

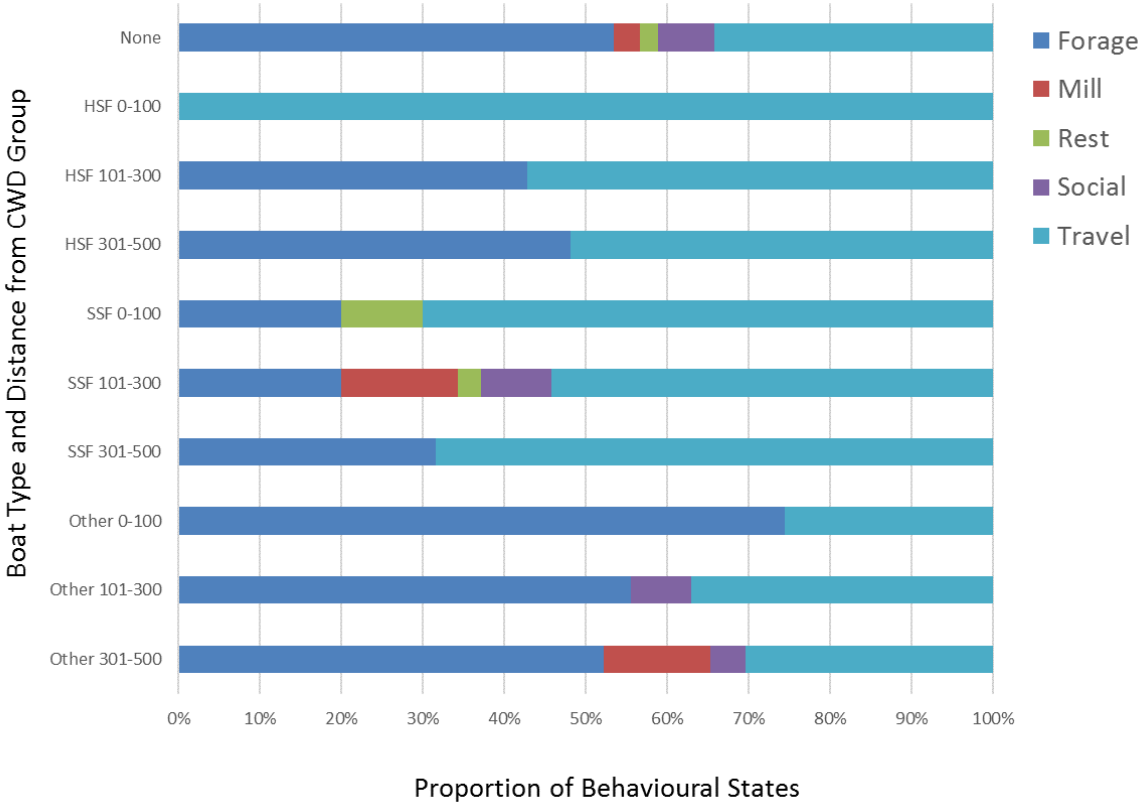
18. Dolphin behaviour varied significantly in response to vessel presence/distance (**Figure 9**). Post hoc tests showed that if a CWD sample occurred when boats were within 100 m, CWDs were less likely to be engaged in milling, resting, or socialising. If a CWD sample occurred when boats were between 101-300 m, CWDs were less likely to be foraging and more likely to be travelling. If a CWD sample occurred when boats were between 301-500 m, CWDs were more likely to be travelling.

Figure 9: Pie charts showing behavioural activity states (excluding the "unknown" category) off Lung Kwu Chau in 2015 – 2017 based on distance of boats present.



19. While behavioural states pooled based on boat type and boat distance did not meet assumptions, a general trend of increased travelling and decreased foraging were expressed for HSFs at speed (>15kn), especially when ferries were within 100 m, and HSFs under speed restriction (≤15kn), especially when ferries were within 300 m of CWDs (**Figure 10**).

Figure 10: Stacked bar graph showing behavioural activity states (excluding the "unknown" category) off Lung Kwu Chau in 2015-2017 based on type and distance of boats present. "HSF" = high speed ferry (>15kn), "SSF" = high speed ferry under speed restriction (≤15kn), and "Other" = all other boat types.



Second-level Results: Dolphin Behaviour Before-During-After

20. Behavioural activity states were not significantly different based on vessel before-during-after exposure categories. However, CWDs shifted between behavioural states significantly more "during" (n=107) vessel exposure than "after" (n=57) vessel exposure. No other behavioural state proportion comparisons were significant.

SUMMARY

21. In 2017, CWD use of Hong Kong waters was similar to in 2016, though with an apparent increase in use of the western waters, especially WL and SWL. It is estimated that 71 dolphins (on average) were found within Hong Kong waters in 2017, which is up slightly from last year (63 dolphins in 2016).

22. For land-based theodolite tracking monitoring, 194 CWD groups were tracked from LKC. Group sizes of CWDs were generally smaller closer to shore, with larger groups in closer proximity to the marine park boundary. While shore-based observations and theodolite tracking do not present overall estimates of numbers of dolphins, the 2017 data from LKC showed about 1.5 as many groups sighted and tracked as in 2016 (an increase of about 0.3 sightings per survey hour), with overall very similar observation effort between the two years. This indicates a higher use of this area in 2017 than 2016, indicative of more dolphins using the habitat at north of LKC.

23. The behavioural states of foraging and travelling were by far the most frequent off LKC. CWDs had slower swimming speeds and changed direction more frequently when foraging than when travelling. As expected, swim speed decreased with increase in socialising. Swim speed increased while dolphins crossed the marine park boundary, but boat presence showed no significant effect. Reorientation rate increased in the presence of non-ferry vessels, and there was a potential, but non-significant, trend for reorientation rate in the presence of ferries travelling ≤15 knots. Linearity decreased in the presence of non-ferries, and there was a potential, but non-significant, variation in linearity in the presence of ferries travelling ≤15 knots.

24. Overall, there is still no evidence that the implementation of the speed control zone is having any negative impacts on dolphin use of the NWL area.

-End-