CONTRACT NO. HY/2013/04
Hong Kong-Zhuhai-Macao Bridge Hong Kong Boundary Crossing Facilities – Infrastructure Works Stage II (Southern Portion) Dolphin Monitoring

Quarterly Progress Report (September-November 2018)

Submitted to Mott MacDonald Hong Kong Limited &
China State Construction Engineering (Hong Kong) Limited

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1. Introduction

1.1. For the Hong Kong-Zhuhai-Macao Bridge (HZMB) Hong Kong Boundary Crossing Facilities (HKBCF), the construction of the Infrastructure Works Stage II (Southern Portion) requires the contractor (i.e. China State Construction Engineering (Hong Kong) Limited) and the associated Environmental Team, Mott MacDonald Hong Kong Limited to implement the Environmental Monitoring and Audit (EM&A) programme.

1.2. According to the HKBCF EM&A Manual, monthly line-transect vessel surveys for Chinese White Dolphins should be conducted to cover the Northwest (NWL) and Northeast Lantau (NEL) survey areas, which should be the same as in AFCD annual marine mammal monitoring programme. However, as such construction-phase monitoring surveys have been undertaken by the HKLR03 project in the same areas (i.e. NWL and NEL), a combined monitoring approach is recommended by the Highways Department, that the HKBCF EM&A project should utilize the monitoring data collected by HKLR03 project to avoid any redundancy in monitoring effort.

1.3. In October 2018, the Director of Hong Kong Cetacean Research Project (HKCRP), Dr. Samuel Hung, has been appointed by the ET as the dolphin specialist for the HKBCF EM&A project. He is responsible for the dolphin monitoring study, including the

collection and collation of dolphin monitoring data from the HKLR03 project to examine any potential impacts of HKBCF constructions works on the dolphins. From the monitoring results, any changes in dolphin occurrence within the study area will be reviewed for possible causes, and appropriate actions and additional mitigation measures will be recommended as necessary.

1.4. The present quarterly progress report of this HKBCF construction-phase dolphin monitoring programme is submitted to the ET and the contractor, summarizing the result of the survey findings during the quarterly period of September to November 2018. Notably, for the present quarter, monitoring data collected in September 2018 through another HKBCF-Passenger Clearance Building (or HKBCF-PCB) Contract No. HY/2013/01 as well as in October-November 2018 through HKLR03 Contract No. HY/2011/03 were reviewed and utilized for various analyses. Moreover, the monitoring data from previous years obtained under the HKLR03 Contract are also referenced and compared to the present quarterly monitoring data from the HKBCF-PCB/HKLR03 combined dataset. All these previous monitoring data was collected by the same HKCRP survey team, to ensure 100% consistency in monitoring methodology including vessel survey method as well as various analyses. On the contrary, the previous monitoring data collected under HZMB HKBCF-Reclamation Works contract (Contract No. HY/2010/02) was from a different survey team that have adopted different survey methodology (e.g. two observers and one data recorder under HKBCF-Reclamation Works contract, as compared to one primary observer and one data recorder adopted by HKCRP team in the past 20+ years). Therefore, we cannot ensure that such monitoring data from that contract can be directly comparable to the HKBCF-PCB/HKLR03 monitoring data, and would rather use the previous HZMB monitoring data collected by HKCRP team instead for direct comparison with the present quarterly findings.

2. Monitoring Methodology

2.1. Vessel-based Line-transect Survey

2.1.1. According to the requirement of the updated EM&A manual, dolphin monitoring programme should cover all transect lines in NEL and NWL survey areas (see Figure 1) twice per month throughout the entire construction period. The co-ordinates of all transect lines are shown in Table 1.

Table 1 Co-ordinates of transect lines

Line No.	Easting	Northing		Line No.	Easting	Northing

1	Start Point	804671	815456		13	Start Point	816506	819480
1	End Point	804671	831404		13	End Point	816506	824859
2	Start Point	805476	820800		14	Start Point	817537	820220
2	End Point	805476	826654		14	End Point	817537	824613
3	Start Point	806464	821150		15	Start Point	818568	820735
3	End Point	806464	822911		15	End Point	818568	824433
4	Start Point	807518	821500		16	Start Point	819532	821420
4	End Point	807518	829230		16	End Point	819532	824209
5	Start Point	808504	821850		17	Start Point	820451	822125
5	End Point	808504	828602		17	End Point	820451	823671
6	Start Point	809490	822150		18	Start Point	821504	822371
6	End Point	809490	825352		18	End Point	821504	823761
7	Start Point	810499	822000		19	Start Point	822513	823268
7	End Point	810499	824613		19	End Point	822513	824321
8	Start Point	811508	821123		20	Start Point	823477	823402
8	End Point	811508	824254		20	End Point	823477	824613
9	Start Point	812516	821303		21	Start Point	805476	827081
9	End Point	812516	824254		21	End Point	805476	830562
10	Start Point	813525	821176		22	Start Point	806464	824033
10	End Point	813525	824657		22	End Point	806464	829598
11	Start Point	814556	818853		23	Start Point	814559	821739
11	End Point	814556	820992		23	End Point	814559	824768
12	Start Point	815542	818807		24	Start Point	805476	815900
12	End Point	815542	824882		24	End Point	805476	819100

2.1.2. The HKCRP survey team used standard line-transect methods (Buckland et al. 2001) to conduct the systematic vessel surveys, and followed the same technique of data collection that has been adopted over the last 22 years of marine mammal monitoring surveys in Hong Kong (see Hung 2018). For each monitoring vessel survey, a 15-m inboard vessel with an open upper deck (about 4.5 m above water surface) was used to make

observations from the flying bridge area.

2.1.3. Two experienced observers (a data recorder and a primary observer) made up the on-effort survey team, and the survey vessel transited different transect lines at a constant speed of 13-15 km per hour. The data recorder searched with unaided eyes and filled out the datasheets, while the primary observer searched for dolphins continuously through 7 x 50 marine binoculars. Both observers searched the sea ahead of the vessel, between 270^{o} and 90^{o} (in relation to the bow, which is defined as 0^{o}). At least one additional experienced observers were available on the boat to work in shift (i.e. rotate every 30 minutes) in order to minimize fatigue of the survey team members. All observers were experienced in small cetacean survey techniques and identifying local cetacean species.

2.1.4. During on-effort survey periods, the survey team recorded effort data including time, position (latitude and longitude), weather conditions (Beaufort sea state and visibility), and distance traveled in each series (a continuous period of search effort) with the assistance of a handheld GPS (e.g. *Garmin eTrex Legend*). Data including time, position and vessel speed were also automatically and continuously logged by handheld GPS throughout the entire survey for subsequent review.

2.1.5. When dolphins were sighted, the survey team would end the survey effort, and immediately record the initial sighting distance and angle of the dolphin group from the survey vessel, as well as the sighting time and position. Then the research vessel was diverted from its course to approach the animals for species identification, group size estimation, assessment of group composition, and behavioural observations. The perpendicular distance (PSD) of the dolphin group to the transect line was later calculated from the initial sighting distance and angle.

2.1.6. Survey effort being conducted along the parallel transect lines that were perpendicular to the coastlines (as indicated in Figure 1) was labeled as “primary” survey effort, while the survey effort conducted along the connecting lines between parallel lines was labeled as “secondary” survey effort. According to HKCRP long-term dolphin monitoring data, encounter rates of Chinese white dolphins deduced from effort and sighting data collected along primary and secondary lines were similar in NEL and NWL survey areas. Therefore, both primary and secondary survey effort were presented as on-effort survey effort in this report.

2.2. Photo-identification Work

2.2.1. When a group of Chinese White Dolphins were sighted during the line-transect survey, the survey team would end effort and approach the group slowly from the side and behind

to take photographs of them. Every attempt was made to photograph every dolphin in the group, and even photograph both sides of the dolphins, since the colouration and markings on both sides may not be symmetrical.

2.2.2. One to two professional digital cameras (e.g. *Canon* EOS 7D model), each equipped with long telephoto lenses (100-400 mm zoom), were available on board for researchers to take sharp, close-up photographs of dolphins as they surfaced. The images were shot at the highest available resolution and stored on Compact Flash memory cards for downloading onto a computer.

2.2.3. All digital images taken in the field were first examined, and those containing potentially identifiable individuals were sorted out. These photographs would then be examined in greater detail, and were carefully compared to the existing Chinese White Dolphin photo-identification catalogue maintained by HKCRP since 1995. Chinese White Dolphins can be identified by their natural markings, such as nicks, cuts, scars and deformities on their dorsal fin and body, and their unique spotting patterns were also used as secondary identifying features (Jefferson 2000).

2.2.4. All photographs of each individual were then compiled and arranged in chronological order, with data including the date and location first identified (initial sighting), re-sightings, associated dolphins, distinctive features, and age classes entered into a computer database.

2.3. Data analysis

2.3.1. Distribution Analysis – The line-transect survey data was integrated with the Geographic Information System (GIS) in order to visualize and interpret different spatial and temporal patterns of dolphin distribution using sighting positions. Location data of dolphin groups were plotted on map layers of Hong Kong using a desktop GIS (ArcView© 3.1) to examine their distribution patterns in details. The dataset was also stratified into different subsets to examine distribution patterns of dolphin groups with different categories of group sizes, young calves and activities.

2.3.2. Encounter rate analysis – Encounter rates of Chinese White Dolphins (number of on-effort sightings per 100 km of survey effort, and total number of dolphins sighted on-effort per 100 km of survey effort) were calculated in NEL and NWL survey areas in relation to the amount of survey effort conducted during each month of monitoring survey. Dolphin encounter rates were calculated in two ways for comparisons with the HZMB baseline monitoring results as well as to AFCD long-term marine mammal monitoring results.

2.3.3. Firstly, for the comparison with the HZMB baseline monitoring results, the encounter rates were calculated using primary survey effort alone, and only data collected under Beaufort 3 or below condition would be used for encounter rate analysis. The average encounter rate of sightings (STG) and average encounter rate of dolphins (ANI) were deduced based on the encounter rates from six events during the present quarter (i.e. six sets of line-transect surveys in North Lantau), which was also compared with the one deduced from the six events during the baseline period (i.e. six sets of line-transect surveys in North Lantau).

2.3.4. Secondly, the encounter rates were calculated using both primary and secondary survey effort collected under Beaufort 3 or below condition as in AFCD long-term monitoring study. The encounter rate of sightings and dolphins were deduced by dividing the total number of on-effort sightings (STG) and total number of dolphins (ANI) by the amount of survey effort for the present quarterly period.

2.3.5. Quantitative grid analysis on habitat use – To conduct quantitative grid analysis of habitat use, positions of on-effort sightings of Chinese White Dolphins collected during the quarterly impact phase monitoring period were plotted onto 1-km^2 grids among NWL and NEL survey areas on GIS. Sighting densities (number of on-effort sightings per km^2) and dolphin densities (total number of dolphins from on-effort sightings per km^2) were then calculated for each 1 km by 1 km grid with the aid of GIS.

2.3.6. Sighting density grids and dolphin density grids were then further normalized with the amount of survey effort conducted within each grid. The total amount of survey effort spent on each grid was calculated by examining the survey coverage on each line-transect survey to determine how many times the grid was surveyed during the study period. For example, when the survey boat traversed through a specific grid 50 times, 50 units of survey effort were counted for that grid. With the amount of survey effort calculated for each grid, the sighting density and dolphin density of each grid were then normalized (i.e. divided by the unit of survey effort).

2.3.7. The newly-derived unit for sighting density was termed SPSE, representing the number of on-effort **s**ightings **p**er 100 units of **s**urvey **e**ffort. In addition, the derived unit for actual dolphin density was termed DPSE, representing the number of **d**olphins **p**er 100 units of **s**urvey **e**ffort. Among the 1-km^2 grids that were partially covered by land, the percentage of sea area was calculated using GIS tools, and their SPSE and DPSE values were adjusted accordingly. The following formulae were used to estimate SPSE and DPSE in each 1-km^2 grid within the study area:

SPSE = ((S / E) x 100) / SA%

DPSE = ((D / E) x 100) / SA%

where S = total number of on-effort sightings
D = total number of dolphins from on-effort sightings
E = total number of units of survey effort
SA% = percentage of sea area

2.3.8. Behavioural analysis – When dolphins were sighted during vessel surveys, their behaviour was observed. Different activities were categorized (i.e. feeding, milling/resting, traveling, socializing) and recorded on sighting datasheets. This data was then input into a separate database with sighting information, which can be used to determine the distribution of behavioural data with a desktop GIS. Distribution of sightings of dolphins engaged in different activities and behaviours would then be plotted on GIS and carefully examined to identify important areas for different activities of the dolphins.

2.3.9. Ranging pattern analysis – Location data of individual dolphins that occurred during the 3-month impact phase monitoring period were obtained from the dolphin sighting database and photo-identification catalogue. To deduce home ranges for individual dolphins using the fixed kernel methods, the program Animal Movement Analyst Extension, was loaded as an extension with ArcView© 3.1 along with another extension Spatial Analyst 2.0. Using the fixed kernel method, the program calculated kernel density estimates based on all sighting positions, and provided an active interface to display kernel density plots. The kernel estimator then calculated and displayed the overall ranging area at 95% UD level.

3. Monitoring Results

3.1. Summary of survey effort and dolphin sightings

3.1.1. A total of six sets of systematic line-transect vessel surveys were conducted for the HKBCF-PCB and HKLR03 contracts during the period of September to November 2018, to cover all transect lines in NWL and NEL survey areas twice per month. From these surveys, 795.4 km of total survey effort was collected, and 94.4% of such effort was conducted under favourable weather conditions (i.e. Beaufort Sea State 3 or below with good visibility). Among the NEL and NWL survey areas, 293.3 km and 502.1 km of survey effort were collected respectively.

3.1.2. Moreover, 574.9 km of survey effort was conducted on primary lines, while another 220.5 km of survey effort was conducted on secondary lines. As mentioned in the methodology section, survey effort conducted on primary and secondary lines were all considered as on-effort survey data. A summary table of the survey effort for the three-month period is shown in Appendix I.

3.1.3. From September to November 2018, only six groups of 14 Chinese White Dolphins were sighted from the combined dataset of HKBCF-PCB/HKLR03, and the summary table of dolphin sightings is shown in Appendix II. All six groups were sighted during on-effort search, and five of the six on-effort sightings were made on primary lines. All dolphin groups were only sighted in NWL, with none being sighted in NEL at all during the three-month monitoring period.

3.2. Distribution

3.2.1. Distribution of the six dolphin groups being sighted during the September-November 2018 monitoring surveys is shown in Figure 1. These six sightings were all concentrated at the northwestern portion of the North Lantau region, mostly in waters around Lung Kwu Chau. On the contrary, no dolphin was sighted at all in the central, eastern and southwestern portions of the North Lantau region (Figure 1). All six groups were also sighted very far away from the HKBCF and HKLR03 reclamation sites, as well as the bridge alignments of HKLR09 and Tuen Mun-Chek Lap Kok Link (TMCLKL).

3.2.2. A comparison of dolphin distribution between the present impact phase period (September-November 2018) and the baseline monitoring period (September-November 2011) revealed considerable differences. For example, in NEL dolphin was not found during the survey in the present quarter but in the baseline survey they were frequently found in the same study area, including the waters near Shum Shui Kok and in the vicinity of the HKBCF reclamation site (Figure 1). Furthermore, dolphins were infrequently sighted in NWL waters and mainly at the northwestern end of the survey area during the present three-month period. This was in stark contrast with their frequent occurrences throughout the entire NWL survey area during the baseline period (Figure 1).

3.3. Encounter rate

3.3.1. The encounter rates of Chinese White Dolphins were deduced from the survey effort and on-effort sighting data from the primary transect lines under favourable conditions (Beaufort 3 or below) for each set of the surveys in NEL and NWL during the present three-month impact monitoring period, and are shown in Table 2. The average encounter rates deduced from the six sets of surveys were also compared with the ones

deduced from the baseline monitoring period (September-November 2011) (Table 3).

Table 2. Dolphin encounter rates (sightings per 100 km of survey effort) during September-November 2018

SURVEY AREA	DOLPHIN MONITORING DATES	Encounter rate (STG) (no. of on-effort dolphin sightings per 100 km of survey effort)	Encounter rate (ANI) (no. of dolphins from all on-effort sightings per 100 km of survey effort)
		Primary Lines Only	Primary Lines Only
Northeast Lantau	Set 1 (10 & 14 Sep 2018)	0.0	0.0
	Set 2 (19 & 24 Sep 2018)	0.0	0.0
	Set 3 (4 & 11 Oct 2018)	0.0	0.0
	Set 4 (16 & 18 Oct 2018)	0.0	0.0
	Set 5 (1 & 6 Nov 2018)	0.0	0.0
	Set 6 (8 & 13 Nov 2018)	0.0	0.0
Northwest Lantau	Set 1 (10 & 14 Sep 2018)	1.7	5.0
	Set 2 (19 & 24 Sep 2018)	0.0	0.0
	Set 3 (4 & 11 Oct 2018)	0.0	0.0
	Set 4 (16 & 18 Oct 2018)	1.6	3.3
	Set 5 (1 & 6 Nov 2018)	5.8	9.7
	Set 6 (8 & 13 Nov 2018)	0.0	0.0

3.3.2. To facilitate another comparison with the AFCD long-term monitoring data, the encounter rates were also calculated for the present quarter using both primary and secondary survey effort. Such encounter rates of sightings (STG) and dolphins (ANI) in NEL were both nil, while the ones the in NWL were 1.3 sightings and 3.0 dolphins per 100 km of survey effort respectively for this quarter.

Table 3. Comparison of average dolphin encounter rates from impact monitoring period (September-November 2018) and baseline monitoring period (September-November 2011) (Note: encounter rates deduced from the baseline monitoring period have been recalculated based only on survey effort and on-effort sighting data made along the primary transect lines under favourable conditions; ± denotes the standard deviation of the average encounter rates)

	Encounter rate (STG) (no. of on-effort dolphin sightings per 100 km of survey effort)		**Encounter rate (ANI)** (no. of dolphins from all on-effort sightings per 100 km of survey effort)	
	September – November 2018	**September – November 2011**	**September – November 2018**	**September – November 2011**
Northeast Lantau	0.00	6.0 ± 5.05	0.0	22.2 ± 26.81
Northwest Lantau	1.5 ± 2.25	9.9 ± 5.85	3.0 ± 3.89	44.7 ± 29.85

3.3.3. For the present three-month impact monitoring period, the average dolphin encounter rates (both STG and ANI) in NEL were both zero with no on-effort sighting being made. Such extremely low occurrence of dolphins in NEL has also been consistently recorded during the same autumn quarters throughout the HZMB monitoring period (Table 4).

Table 4. Comparison of average dolphin encounter rates in Northeast Lantau survey area from the same autumn quarters of HKLR03 and HKBCF impact monitoring periods and baseline monitoring period (September-November 2011) (Note: encounter rates deduced from the baseline monitoring period have been recalculated based only on survey effort and on-effort sighting data made along the primary transect lines under favourable conditions; ± denotes the standard deviation of the average encounter rates)

	Encounter rate (STG) (no. of on-effort dolphin sightings per 100 km of survey effort)	**Encounter rate (ANI)** (no. of dolphins from all on-effort sightings per 100 km of survey effort)
September-November 2011 (Baseline)	**6.0 ± 5.05**	**22.2 ± 26.81**
September-November 2013 (HKLR03 Impact*)	1.0 ± 1.59	3.8 ± 6.49
September-November 2014 (HKLR03 Impact*)	0.0	0.0
September-November 2015 (HKLR03 Impact*)	0.0	0.0
September-November 2016 (HKLR03 Impact*)	0.0	0.0
September-November 2017 (HKLR03 Impact*)	0.0	0.0
September-November 2018 (HKBCF Impact)	0.0	0.0

* As explained in Section 1.4, the previous monitoring data from Contract No. HY/2011/03 (i.e. HKLR03) were adopted for comparison with the baseline and present impact monitoring period

3.3.4. On the other hand, the average dolphin encounter rates (STG and ANI) in NWL during the present impact phase monitoring period were only small fractions of the ones recorded during the three-month baseline period (with reductions of 84.8% and 93.3% respectively), indicating a dramatic decline in dolphin usage of this survey area during the present impact phase period (Table 5).

Table 5. Comparison of average dolphin encounter rates in Northwest Lantau survey area from all autumn quarters of HKLR03 and HKBCF impact monitoring periods and baseline monitoring period (September-November 2011) (Note: encounter rates deduced from the baseline monitoring period have been recalculated based only on survey effort and on-effort sighting data made along the primary transect lines under favourable conditions; ± denotes the standard deviation of the average encounter rates)

	Encounter rate (STG) (no. of on-effort dolphin sightings per 100 km of survey effort)	**Encounter rate (ANI)** (no. of dolphins from all on-effort sightings per 100 km of survey effort)
September-November 2011 (Baseline)	**9.9 ± 5.85**	**44.7 ± 29.85**
September-November 2013 (HKLR03 Impact*)	8.0 ± 1.10	32.5 ± 26.51
September-November 2014 (HKLR03 Impact*)	5.1 ± 4.40	20.5 ± 15.10
September-November 2015 (HKLR03 Impact*)	3.9 ± 1.57	21.1 ± 17.19
September-November 2016 (HKLR03 Impact*)	2.9 ± 1.98	10.9 ± 10.98
September-November 2017 (HKLR03 Impact*)	3.1 ± 1.91	10.4 ± 9.66
September-November 2018 (HKBCF Impact)	1.5 ± 2.25	3.0 ± 3.89

* As explained in Section 1.4, the previous monitoring data from Contract No. HY/2011/03 (i.e. HKLR03) were adopted for comparison with the baseline and present impact monitoring period

3.3.5. Both dolphin encounter rates in NWL in autumn 2018 were the lowest among all autumn quarters during the HZMB monitoring period, and apparently there has been a steady decline in dolphin occurrence in the past several years to reach to the lowest point in 2018 (Table 5). This is a very worrying trend as the dolphin occurrence should have recovered somewhat since the HKBCF reclamation works, which incurred permanent habitat loss, have been completed a few years ago and the remaining marine construction activities for the HKBCF are also nearly completed.

3.3.6. A two-way ANOVA with repeated measures and unequal sample size was conducted to examine whether there were any significant differences in the average encounter rates between the baseline and impact monitoring periods. The two variables that were examined included the two periods (baseline and impact phases) and two locations (NEL and NWL).

3.3.7. For the comparison between the baseline period and the present quarter, the p-values for the differences in average dolphin encounter rates of STG and ANI were 0.0029 and 0.0146 respectively. If the alpha value is set at 0.05, significant differences were detected between the baseline and present quarter in both the average dolphin encounter rates of STG and ANI.

3.3.8. Both distribution patterns and encounter rates of Chinese White Dolphins indicated that their usage have been dramatically reduced in both NEL and NWL survey areas during the present quarterly period, and such low occurrence of dolphins has been consistently documented in recent years of HZMB dolphin monitoring. Such significant decline in dolphin occurrence should raise serious concern, as the timing of the decline coincided well with the construction schedule of the HZMB related project as suggested by Hung (2018). Moreover, it is apparent that there has been no sign of recovery in dolphin usage, even with most of the marine works associated with the HZMB construction being completed. Continuous dolphin monitoring would be critical to examine whether the downward trend would continue, stabilize or revert in upcoming quarters.

3.4. Group size

3.4.1. From September to November 2018, the group sizes of Chinese White Dolphins ranged from one to four individuals per group in North Lantau region. The average dolphin group sizes from the present three-month period were compared with the ones deduced from the baseline period in September to November 2011, as shown in Table 6.

Table 6. Comparison of average dolphin group sizes from impact monitoring period (September-November 2018) and baseline monitoring period (September-November 2011) (Note: ± denotes the standard deviation of average group size)

	Average Dolphin Group Size	
	September – November 2018	**September – November 2011**
Overall	2.3 ± 1.03 (n = 6)	3.7 ± 3.13 (n = 66)
Northeast Lantau	---	3.2 ± 2.16 (n = 17)
Northwest Lantau	2.3 ± 1.03 (n = 6)	3.9 ± 3.40 (n = 49)

3.4.2. During the present quarter, the average dolphin group size in NWL was much lower than the one recorded during the baseline period. However, it should also be noted that the sample size in the present quarter (six groups) was much smaller than the 66 groups sighted during the baseline period (Table 6).

3.4.3. All six dolphin groups were composed of small groups with 1-4 animals only (Appendix

II). This is in contrary to the baseline period when the larger groups (at least with five animals) were frequently sighted and evenly distributed in NWL, with a few also sighted in NEL waters.

3.5. Habitat use

3.5.1. During the present quarter, the quantitative grid analysis revealed that only six grids recorded dolphin occurrence, with just one grid adjacent to Lung Kwu Chau recorded higher dolphin density (Figures 2a and 2b). However, it should be emphasized that the amount of survey effort collected in each grid during the three-month period was fairly low (6-12 units of survey effort for most grids), and therefore the habitat use pattern derived from the three-month dataset should be treated with caution. A more complete picture of dolphin habitat use pattern should be examined when more survey effort for each grid will be collected throughout the impact phase monitoring programme.

3.5.2. When compared with the habitat use patterns during the baseline period, dolphin usage in NEL and NWL has drastically diminished in both areas during the present impact monitoring period (Figure 3). During the baseline period, many grids between Siu Mo To and Shum Shui Kok in NEL recorded moderately high to high dolphin densities, but the dolphins have completely disappeared from this area during the present impact phase period (Figure 3).

3.5.3. Moreover, the dolphin density patterns were also very different in NWL between the baseline and impact phase monitoring periods, with high usage throughout the area during the baseline period, while only two grids located adjacent to Lung Kwu Chau recoded moderate to high dolphin densities during the present impact phase period (Figure 3).

3.6. Mother-calf pairs

3.6.1. No mother-calf pair was sighted at all among the six dolphin groups during the present quarterly period. This was in stark contrast to the regular occurrence of young calves with their mothers in North Lantau waters during the baseline period, which should be of a serious concern.

3.7. Activities and associations with fishing boats

3.7.1. Only one of the six groups was engaged in both feeding and socializing activities during the present quarterly period, which was located to the north of Lung Kwu Chau (Figure 4). On the other hand, none of the groups was engaged in traveling or milling/resting activity.

3.7.2. When compared to the baseline period, distribution of various dolphin activities during the present quarterly period was drastically different with very rare occurrence of such

activities (Figure 4).

3.7.3. It should also be noted that none of the dolphin groups sighted during the present quarter was associated with any operating fishing vessels.

3.8. Summary of photo-identification works

3.8.1. Over 800 digital photographs of Chinese White Dolphins were taken from September to November 2018 for the photo-identification work during the HKBCF/HKLR03 surveys. A total of eight individuals were identified and sighted 12 times altogether (see summary table in Appendix III and photographs of identified individuals in Appendix IV). Re-sightings of individual dolphins were only made in NWL, while none was re-sighted in NEL during the quarterly period.

3.8.2. Five of the eight individuals were re-sighted only once, while the other three individuals (NL136, NL261 and NL328) were re-sighted twice or thrice during the quarterly period (Appendix III). Notably, none of these individuals sighted in NWL survey area during the HKBCF/HKLR03 monitoring surveys were also sighted in West Lantau waters during the HKLR09 monitoring surveys during the same quarterly period.

3.9. Individual range use

3.9.1. Ranging patterns of the eight individuals identified during the three-month study period were determined by fixed kernel method, and are shown in Appendix V.

3.9.2. While all eight individuals were sighted only in NWL waters in the present quarter, none of them occurred in NEL waters (Appendix V), which is in stark contrast to the extensive movements of many individual dolphins between NEL and NWL survey areas during the baseline period as well as in the earlier impact monitoring quarters. Moreover, none of the individuals has extended their range use to WL waters, even though such movements between North and West Lantau waters were quite common in the past several years.

3.9.4. Individual range use and movements should be continuously examined in the upcoming quarters, to determine whether there has been any consistent shifts of individual home ranges from North Lantau to West or Southwest Lantau, or vice versa.

4. Conclusion

4.1. During the present quarter of dolphin monitoring, no adverse impact from the activities of this construction project on Chinese White Dolphins was noticeable from general

observations.

4.2. Although dolphins seldom occurred in the area of HKBCF construction in the past and during the baseline monitoring period, it is apparent that dolphin usage has been dramatically reduced in North Lantau waters in recent years, and many individuals have shifted away from this once-important habitat for the dolphins.

4.3. It is critical to continuously monitor the dolphin usage in North Lantau region in the upcoming quarters, to determine whether the dolphins are continuously affected by the various construction activities in relation to the HZMB-related works, and whether there is any sign of recovery when the construction works have been completed.

5. References

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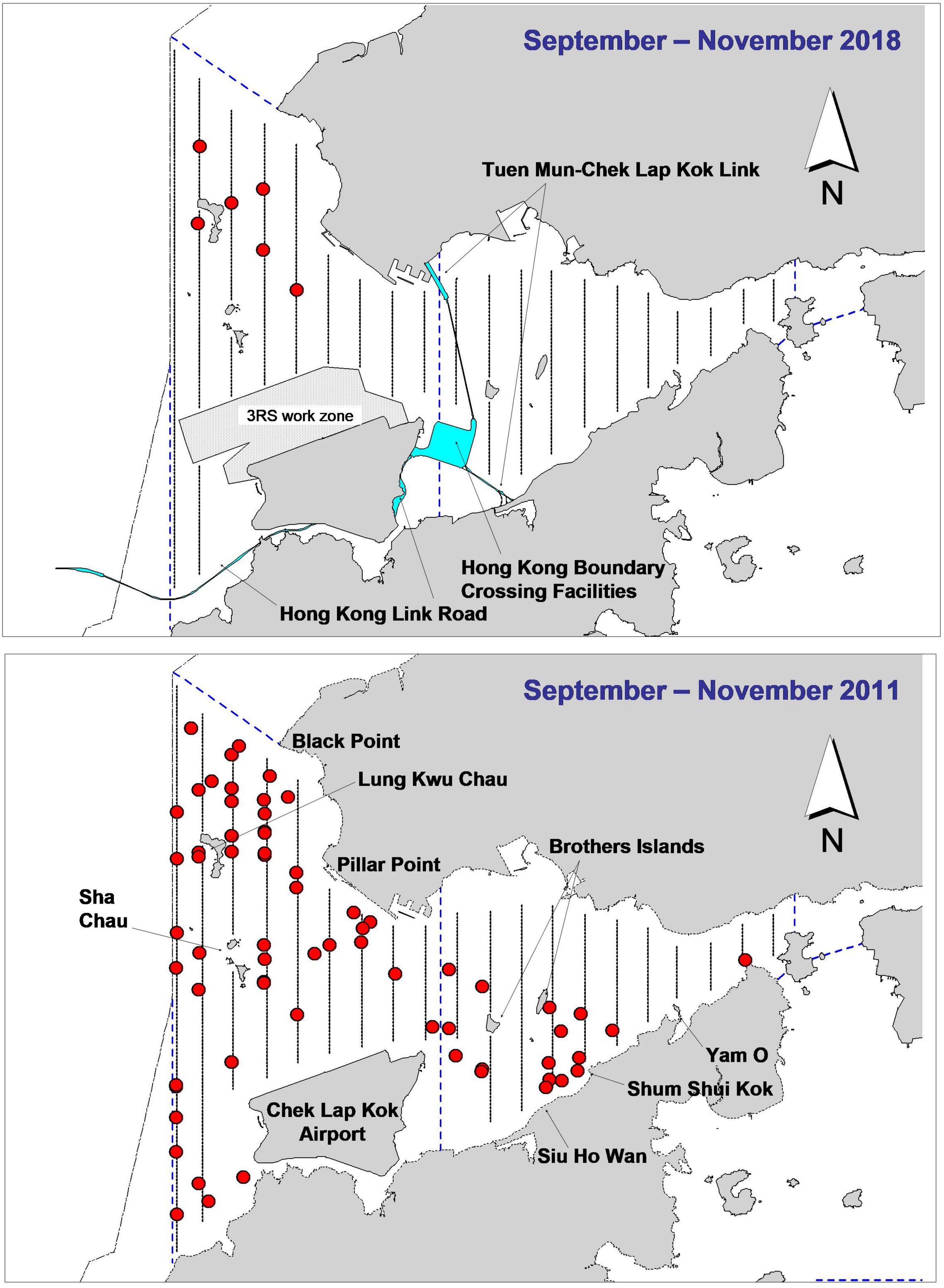


Figure 1. Distribution of Chinese white dolphin sighting in Northwest and Northeast Lantau during the present impact phase (top) and baseline monitoring surveys (bottom)

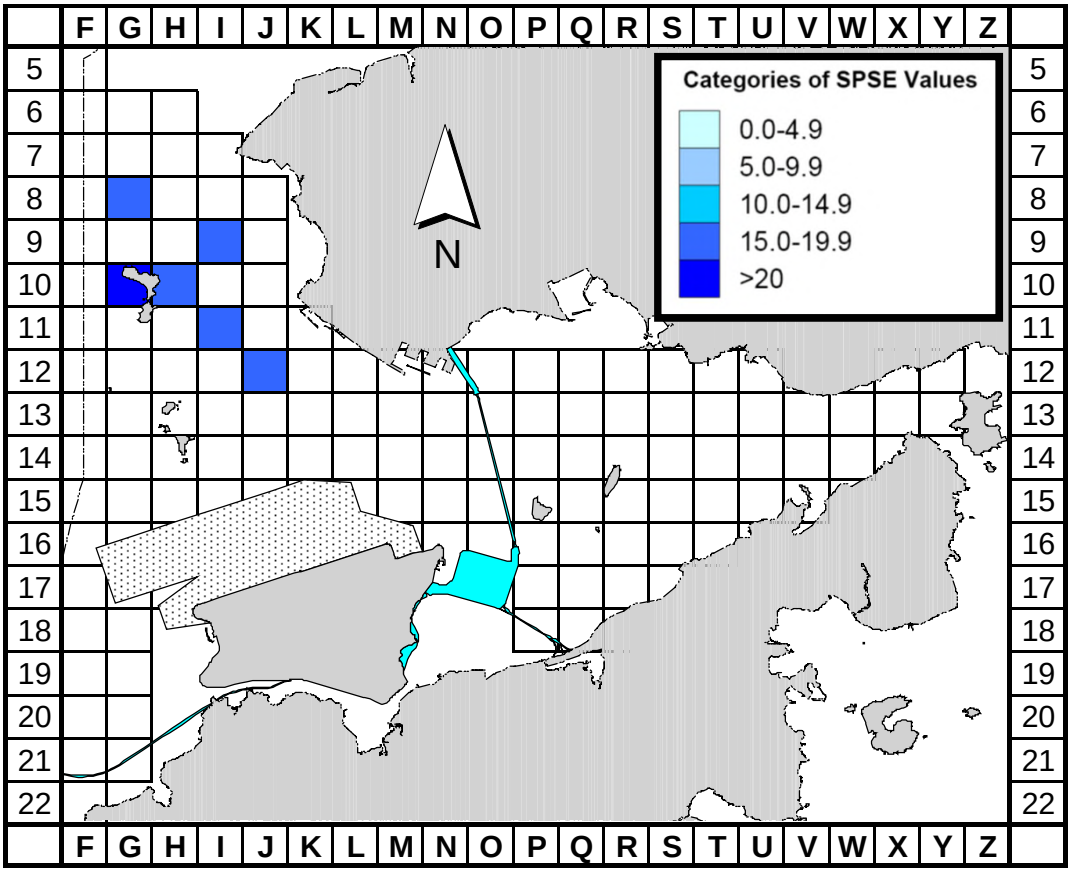


Figure 2a. Sighting density of Chinese white dolphins with corrected survey effort per km^2 in Northeast and Northwest Lantau survey areas, using data collected during the present impact monitoring period monitoring period (Sep-Nov 18) (SPSE = no. of on-effort sightings per 100 units of survey effort)

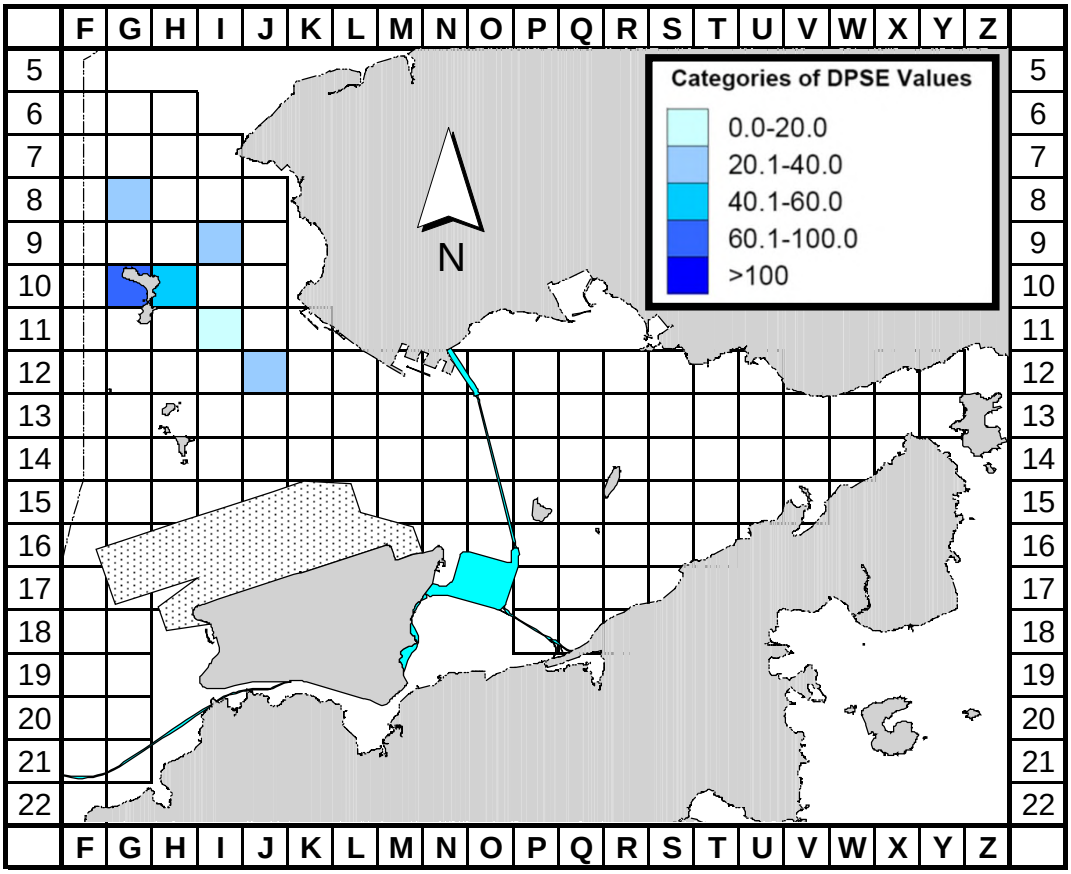


Figure 2b. Density of Chinese white dolphins with corrected survey effort per km^2 in Northeast and Northwest Lantau survey areas, using data collected during the present impact monitoring period (Sep-Nov 18) (DPSE = no. of dolphins per 100 units of survey effort)

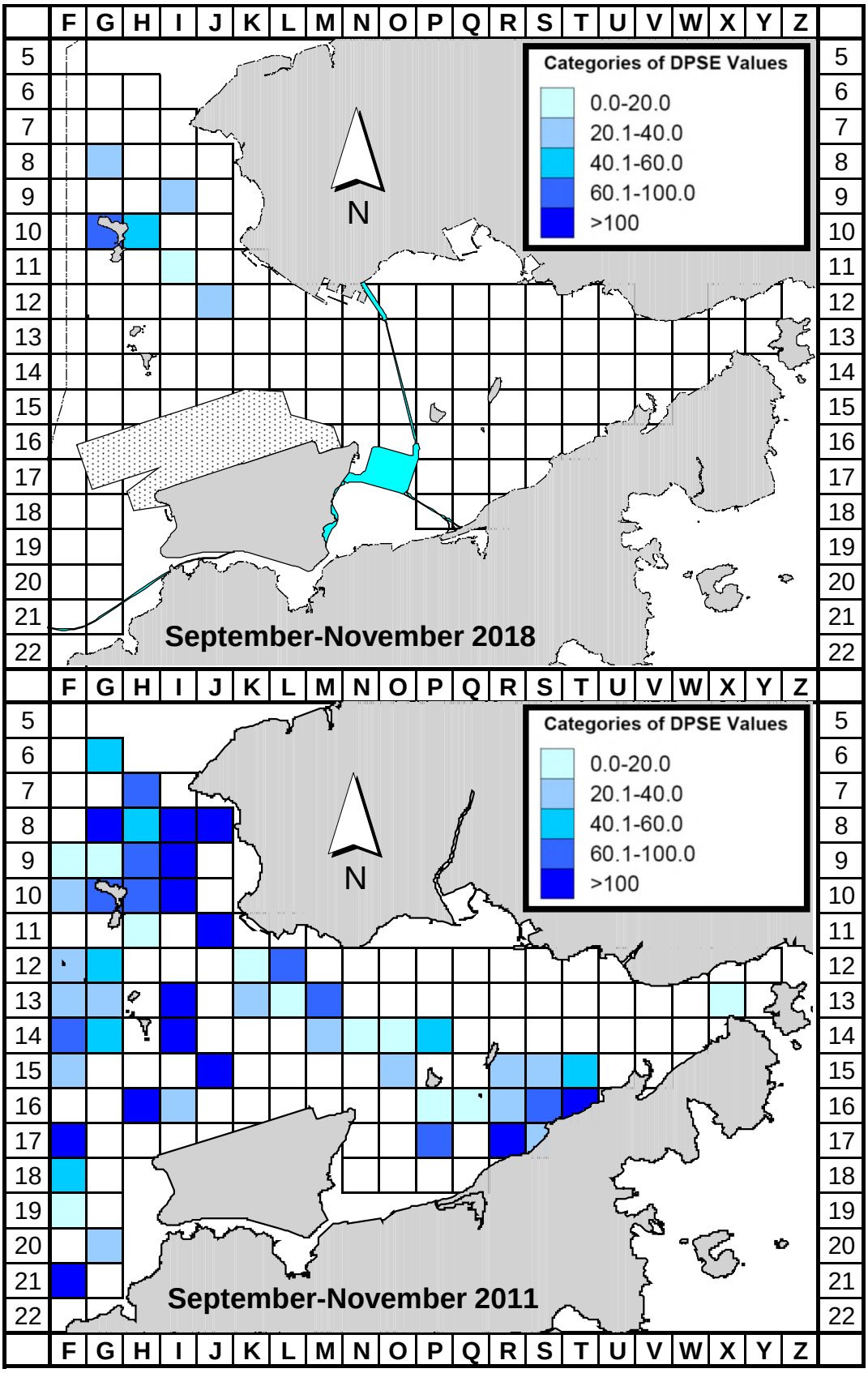


Figure 3. Comparison of density of Chinese white dolphins with corrected survey effort per km^2 in Northwest and Northeast Lantau survey area between the present impact monitoring period (September-November 2018) and baseline monitoring period (September-November 2011) (DPSE = no. of dolphins per 100 units of survey effort)

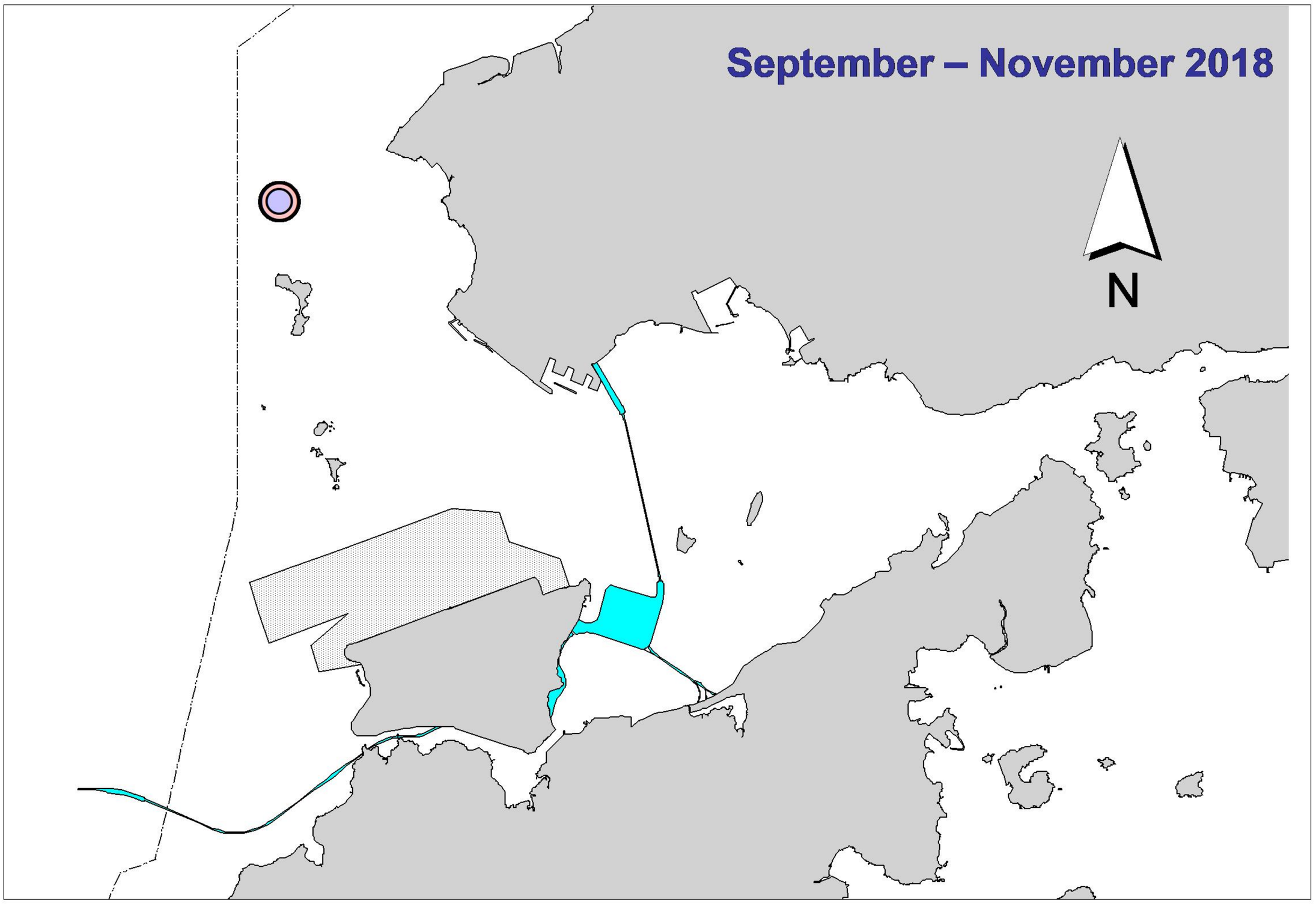


Figure 4. Distribution of Chinese white dolphins engaged in feeding (purple dots), socializing (pink dots) and traveling (green dots) activities during the present impact phase (top) and baseline monitoring surveys (bottom)

Appendix I. HKBCF/HKLR03 Survey Effort Database in Sep-Nov 2018

(Abbreviations: BEAU = Beaufort Sea State; P = Primary Line Effort; S = Secondary Line Effort)

DATE	AREA	BEAU	EFFORT	SEASON	VESSEL	TYPE	P/S
10-Sep-18	NW LANTAU	1	7.01	AUTUMN	STANDARD36826	HKBCF	P
10-Sep-18	NW LANTAU	2	28.97	AUTUMN	STANDARD36826	HKBCF	P
10-Sep-18	NW LANTAU	1	3.50	AUTUMN	STANDARD36826	HKBCF	S
10-Sep-18	NW LANTAU	2	9.92	AUTUMN	STANDARD36826	HKBCF	S
10-Sep-18	NE LANTAU	1	5.90	AUTUMN	STANDARD36826	HKBCF	P
10-Sep-18	NE LANTAU	2	30.19	AUTUMN	STANDARD36826	HKBCF	P
10-Sep-18	NE LANTAU	1	1.59	AUTUMN	STANDARD36826	HKBCF	S
10-Sep-18	NE LANTAU	2	12.32	AUTUMN	STANDARD36826	HKBCF	S
14-Sep-18	NW LANTAU	1	2.60	AUTUMN	STANDARD138716	HKBCF	P
14-Sep-18	NW LANTAU	2	21.43	AUTUMN	STANDARD138716	HKBCF	P
14-Sep-18	NW LANTAU	2	11.97	AUTUMN	STANDARD138716	HKBCF	S
19-Sep-18	NW LANTAU	2	31.78	AUTUMN	STANDARD36826	HKBCF	P
19-Sep-18	NW LANTAU	2	9.82	AUTUMN	STANDARD36826	HKBCF	S
19-Sep-18	NW LANTAU	3	1.20	AUTUMN	STANDARD36826	HKBCF	S
24-Sep-18	NW LANTAU	1	3.00	AUTUMN	STANDARD36826	HKBCF	P
24-Sep-18	NW LANTAU	2	19.49	AUTUMN	STANDARD36826	HKBCF	P
24-Sep-18	NW LANTAU	3	2.90	AUTUMN	STANDARD36826	HKBCF	P
24-Sep-18	NW LANTAU	2	10.71	AUTUMN	STANDARD36826	HKBCF	S
24-Sep-18	NE LANTAU	2	24.22	AUTUMN	STANDARD36826	HKBCF	P
24-Sep-18	NE LANTAU	3	12.02	AUTUMN	STANDARD36826	HKBCF	P
24-Sep-18	NE LANTAU	2	10.06	AUTUMN	STANDARD36826	HKBCF	S
24-Sep-18	NE LANTAU	3	1.20	AUTUMN	STANDARD36826	HKBCF	S
4-Oct-18	*NW LANTAU*	*2*	*19.20*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
4-Oct-18	*NW LANTAU*	*3*	*12.68*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
4-Oct-18	*NW LANTAU*	*4*	*0.62*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
4-Oct-18	*NW LANTAU*	*2*	*6.10*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
4-Oct-18	*NW LANTAU*	*3*	*5.60*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
4-Oct-18	*NE LANTAU*	*2*	*19.33*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
4-Oct-18	*NE LANTAU*	*3*	*15.44*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
4-Oct-18	*NE LANTAU*	*2*	*8.06*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
4-Oct-18	*NE LANTAU*	*3*	*5.07*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
11-Oct-18	*NW LANTAU*	*2*	*15.31*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
11-Oct-18	*NW LANTAU*	*3*	*12.41*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
11-Oct-18	*NW LANTAU*	*2*	*4.07*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
11-Oct-18	*NW LANTAU*	*3*	*9.41*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
16-Oct-18	*NW LANTAU*	*2*	*23.58*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
16-Oct-18	*NW LANTAU*	*3*	*5.15*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
16-Oct-18	*NW LANTAU*	*2*	*10.36*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
16-Oct-18	*NW LANTAU*	*3*	*2.11*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
18-Oct-18	*NW LANTAU*	*2*	*32.45*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
18-Oct-18	*NW LANTAU*	*2*	*11.05*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
18-Oct-18	*NE LANTAU*	*2*	*34.26*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
18-Oct-18	*NE LANTAU*	*3*	*2.27*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
18-Oct-18	*NE LANTAU*	*2*	*11.07*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
1-Nov-18	*NE LANTAU*	*2*	*10.78*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
1-Nov-18	*NE LANTAU*	*3*	*19.78*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
1-Nov-18	*NE LANTAU*	*4*	*6.85*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
1-Nov-18	*NE LANTAU*	*2*	*4.88*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
1-Nov-18	*NE LANTAU*	*3*	*7.41*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
6-Nov-18	*NW LANTAU*	*2*	*32.12*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
6-Nov-18	*NW LANTAU*	*3*	*19.50*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*

Appendix I. (cont'd)

(Abbreviations: BEAU = Beaufort Sea State; P = Primary Line Effort; S = Secondary Line Effort)

DATE	AREA	BEAU	EFFORT	SEASON	VESSEL	TYPE	P/S
6-Nov-18	*NW LANTAU*	*4*	*6.80*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
6-Nov-18	*NW LANTAU*	*2*	*17.37*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
6-Nov-18	*NW LANTAU*	*3*	*7.91*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
6-Nov-18	*NW LANTAU*	*4*	*2.70*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
8-Nov-18	*NW LANTAU*	*3*	*9.12*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
8-Nov-18	*NW LANTAU*	*4*	*16.42*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
8-Nov-18	*NW LANTAU*	*5*	*1.50*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
8-Nov-18	*NW LANTAU*	*3*	*5.80*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
8-Nov-18	*NW LANTAU*	*4*	*5.75*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
8-Nov-18	*NW LANTAU*	*5*	*1.40*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
8-Nov-18	*NE LANTAU*	*2*	*21.83*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
8-Nov-18	*NE LANTAU*	*3*	*13.92*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
8-Nov-18	*NE LANTAU*	*4*	*1.30*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
8-Nov-18	*NE LANTAU*	*2*	*7.10*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
8-Nov-18	*NE LANTAU*	*3*	*5.64*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
8-Nov-18	*NE LANTAU*	*4*	*0.81*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
13-Nov-18	*NW LANTAU*	*2*	*18.07*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
13-Nov-18	*NW LANTAU*	*3*	*14.72*	*AUTUMN*	*STANDARD36826*	*HKLR*	*P*
13-Nov-18	*NW LANTAU*	*2*	*6.80*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*
13-Nov-18	*NW LANTAU*	*3*	*1.71*	*AUTUMN*	*STANDARD36826*	*HKLR*	*S*

Appendix II. HKBCF/HKLR03 Chinese White Dolphin Sighting Database in September-November 2018

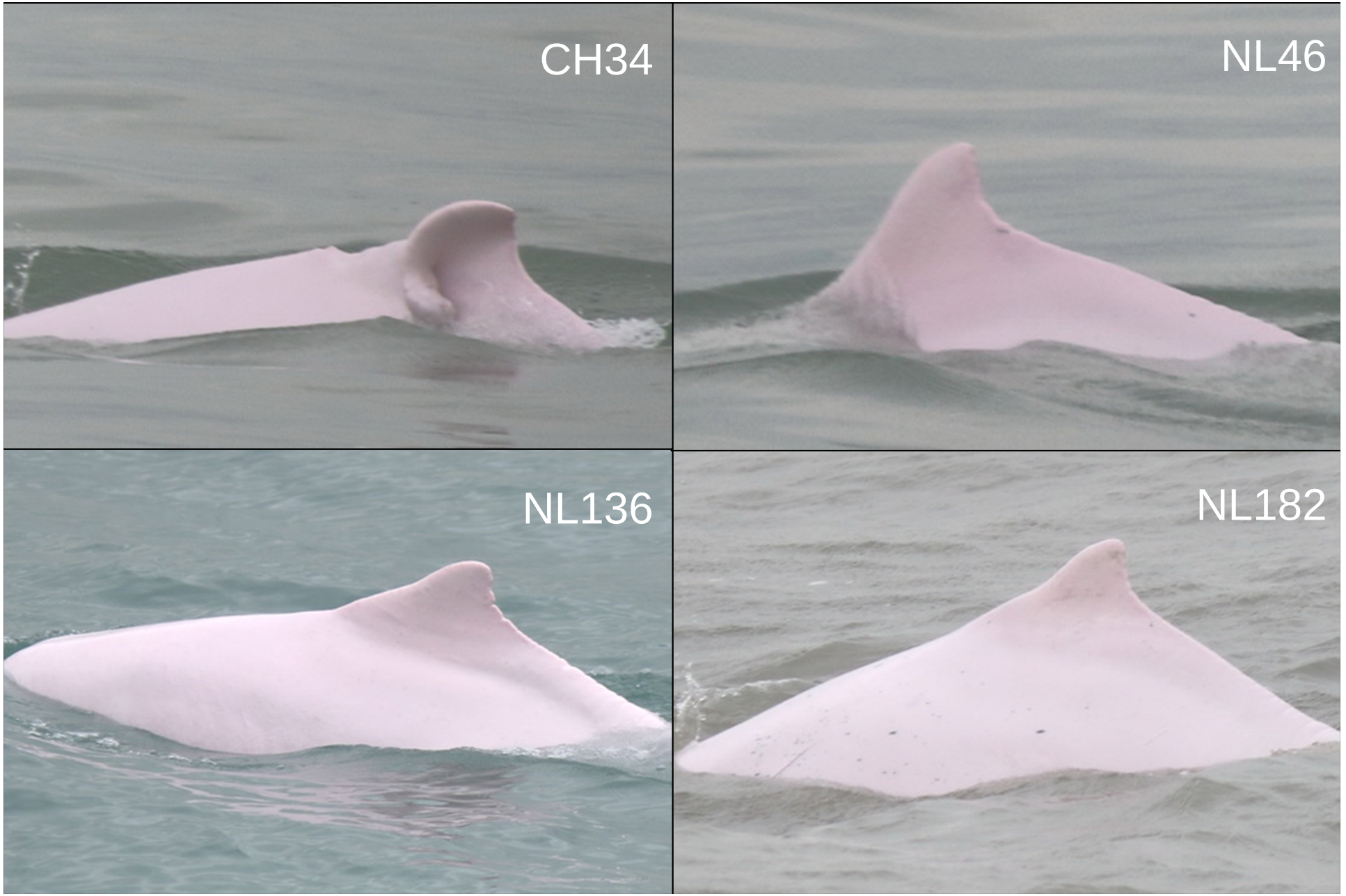
(Abberviations: STG# = Sighting Number; HRD SZ = Dolphin Herd Size; BEAU = Beaufort Sea State; PSD = Perpendicular Distance; BOAT ASSOC. = Fishing Boat Association; P/S: Sighting Made on Primary/Secondary Lines)

DATE	STG #	TIME	HRD SZ	AREA	BEAU	PSD	EFFORT	TYPE	NORTHING	EASTING	SEASON	BOAT ASSOC.	P/S
10-Sep-18	1	1143	3	NW LANTAU	1	195	ON	HKBCF	826872	806456	AUTUMN	NONE	P
11-Oct-18	*1*	*1222*	*4*	*NW LANTAU*	*3*	*362*	*ON*	*HKLR*	*826265*	*805415*	*AUTUMN*	*NONE*	*S*
18-Oct-18	*1*	*1232*	*2*	*NW LANTAU*	*2*	*145*	*ON*	*HKLR*	*824310*	*808501*	*AUTUMN*	*NONE*	*P*
6-Nov-18	*1*	*1107*	*1*	*NW LANTAU*	*2*	*364*	*ON*	*HKLR*	*825486*	*807443*	*AUTUMN*	*NONE*	*P*
6-Nov-18	*2*	*1119*	*2*	*NW LANTAU*	*2*	*221*	*ON*	*HKLR*	*827280*	*807456*	*AUTUMN*	*NONE*	*P*
6-Nov-18	*3*	*1202*	*2*	*NW LANTAU*	*2*	*84*	*ON*	*HKLR*	*828546*	*805451*	*AUTUMN*	*NONE*	*P*

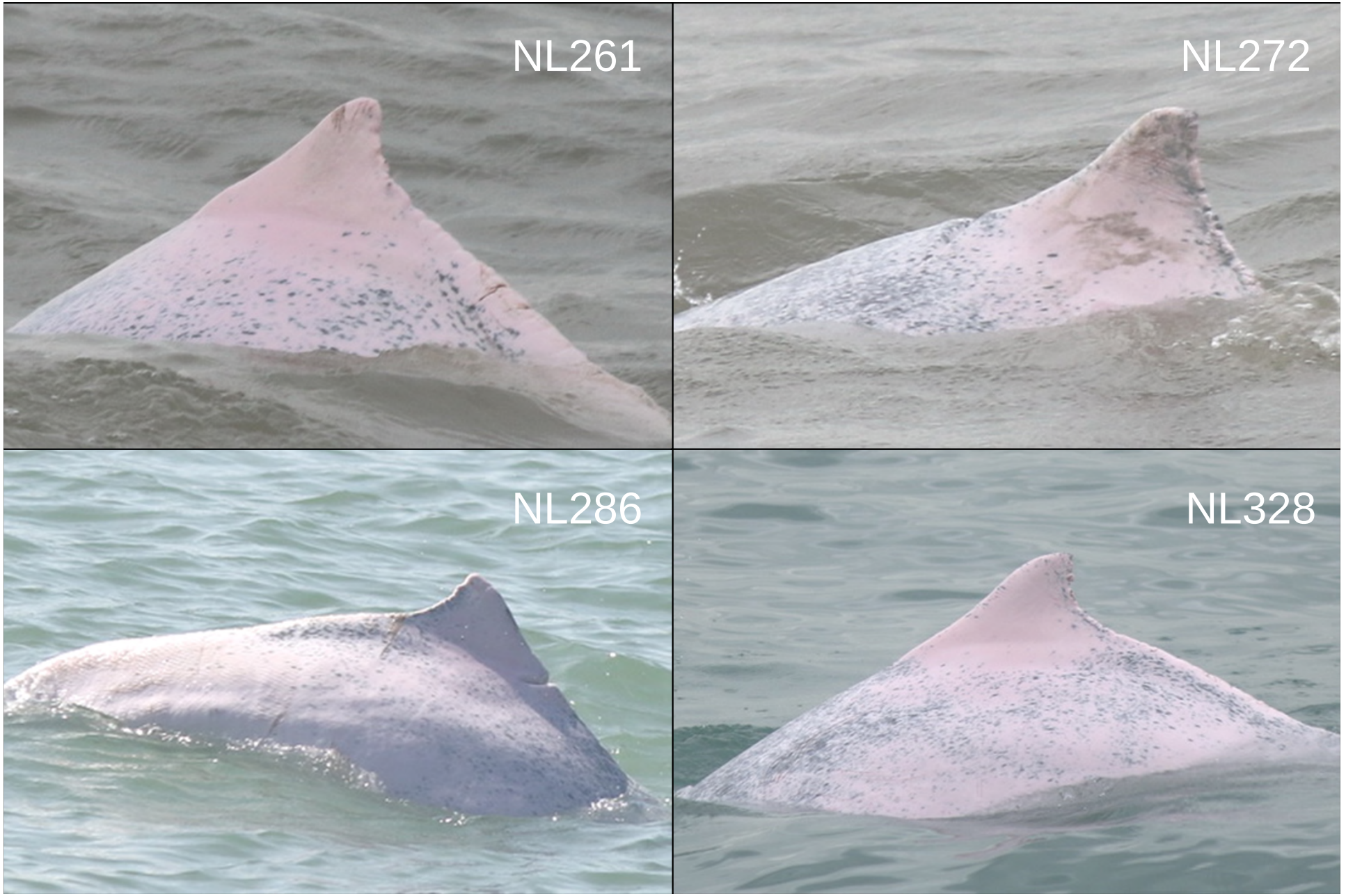
Appendix III. Individual dolphins identified during HKBCF/HKLR03 monitoring surveys in September-November 2018

ID#	DATE	STG#	TYPE	AREA
CH34	10/09/18	1	HKBCF	NW LANTAU
NL46	10/09/18	1	HKBCF	NW LANTAU
NL136	10/09/18	1	HKBCF	NW LANTAU
	11/10/18	*1*	*HKLR*	*NW LANTAU*
	18/10/18	*1*	*HKLR*	*NW LANTAU*
NL182	*11/10/18*	*1*	*HKLR*	*NW LANTAU*
NL261	*11/10/18*	*1*	*HKLR*	*NW LANTAU*
	06/11/18	*3*	*HKLR*	*NW LANTAU*
NL272	*11/10/18*	*1*	*HKLR*	*NW LANTAU*
NL286	*06/11/18*	*2*	*HKLR*	*NW LANTAU*
NL328	*18/10/18*	*1*	*HKLR*	*NW LANTAU*
	06/11/18	*3*	*HKLR*	*NW LANTAU*

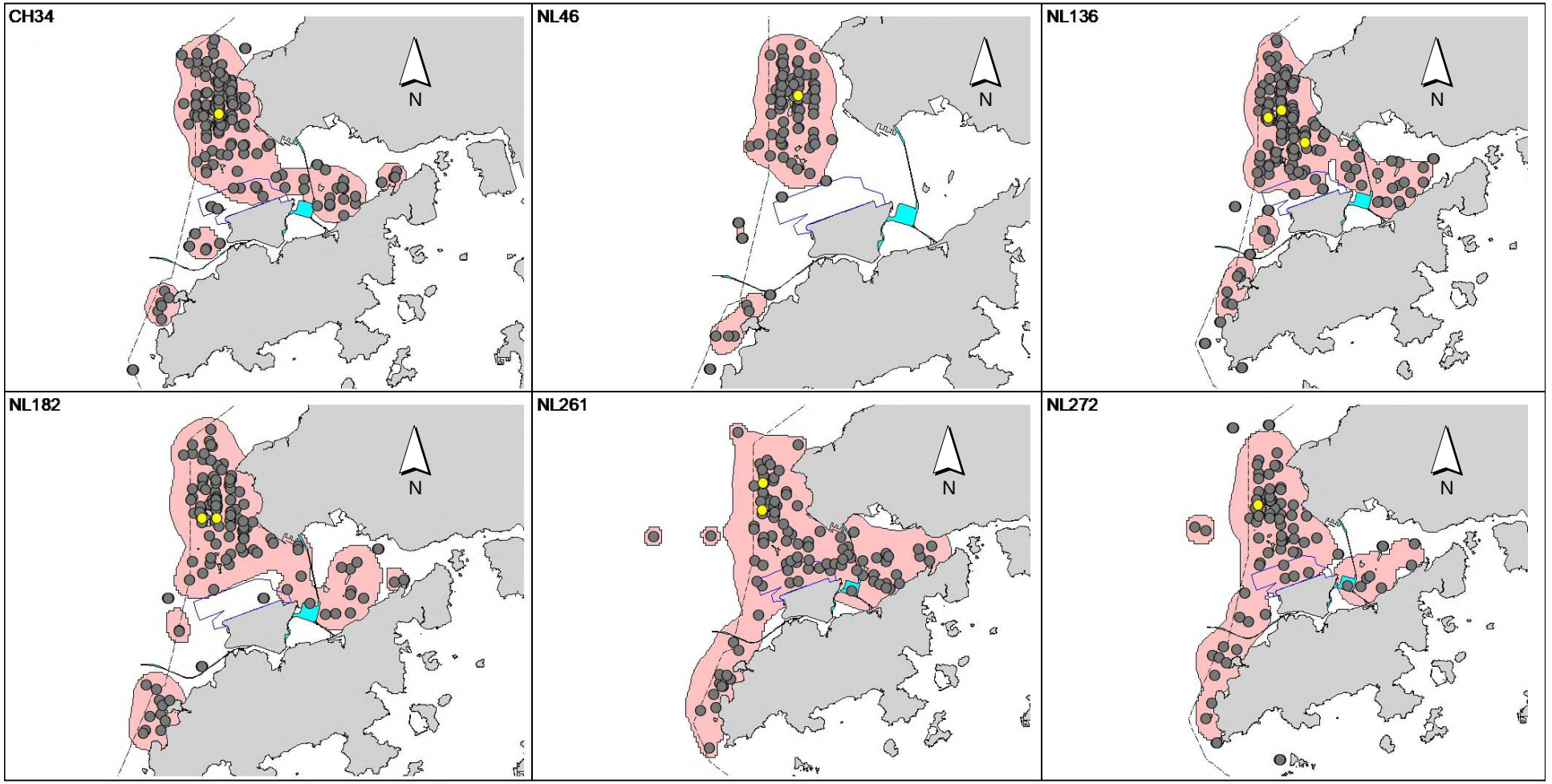
Appendix IV. Eight individual dolphins that were identified during September to November 2018 under the present impact phase monitoring surveys



Appendix IV. (cont'd)



Appendix V. Ranging patterns (95% kernel ranges) of eight individual dolphins that were sighted during the present impact phase monitoring period from September to November 2018



Appendix V. (cont'd)