CONTRACT NO. HY/2013/01
Hong Kong-Zhuhai-Macao Bridge Hong Kong Boundary Crossing Facilities – Dolphin Monthly Monitoring

Second Quarterly Progress Report (December 2017-February 2018)
submitted to Leighton – Chun Wo Joint Venture

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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 Passenger Clearance Building (PCB) requires the contractor (i.e. Leighton – Chun Wo Joint Venture) and the associated environmental team to conduct monthly line-transect vessel surveys for the Chinese White Dolphins to cover the Northwest (NWL) and Northeast Lantau (NEL) survey areas under the Environmental Monitoring and Audit (EM&A) programme.

1.2. In August 2017, Hong Kong Cetacean Research Project (HKCRP) has been commissioned by the contractor to conduct regular dolphin monitoring study in order to collect data on Chinese White Dolphins during the construction phase (i.e. impact period) of the HKBCF-PCB project, and to analyze the collected survey data to monitor distribution, encounter rate, activities and occurrence of dolphin calves. Photo-identification will also be collected from individual Chinese White Dolphins to examine their individual ranging patterns.

1.3. From the monitoring results, any changes in dolphin occurrence within the study area will be examined for possible causes, and appropriate actions and additional mitigation measures will be recommended as necessary.

1.4. This report is the second quarterly progress report under the HKBCF construction phase dolphin monitoring programme submitted to Leighton – Chun Wo Joint Venture, summarizing the results of the surveys findings during the period of December 2017 to February 2018.

1.5. Notably, throughout the present quarterly progress report, the previous monitoring data obtained under Contract No. HY/2011/03 (i.e. HKLR03) are referenced and compared to the present quarterly monitoring data collected for the HKBCF-PCB project, as both HKBCF-PCB and HKLR03 project 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 under HKLR03 and HKBCF-PCB contract). Therefore, we cannot ensure that such HKBCF monitoring data under that contract can be directly comparable to the HKBCF-PCB monitoring data, and would rather use the previous HKLR03 monitoring data instead for 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 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 20 years of marine mammal monitoring surveys in Hong Kong developed by HKCRP (see Hung 2017). 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 and porpoises continuously through 7 x 50 *Fujinon* 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}). One to two 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 (*Garmin eTrex Legend*).

2.1.5. Data including time, position and vessel speed were also automatically and continuously logged by handheld GPS throughout the entire survey for subsequent review.

2.1.6. 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.

2.1.7. 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 (*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.

2.2.4. 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).

2.2.5. 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.

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).

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.

2.3.3. 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.

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).

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:

$$SPSE = ((S / E) \times 100) / SA\%$$
$$DPSE = ((D / E) \times 100) / SA\%$$

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

2.3.4. 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.

2.3.5. 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. During the period of December 2017 to February 2018, six sets of systematic line-transect vessel surveys were conducted for the HKBCF project to cover all transect lines in NWL and NEL survey areas twice per month.

3.1.2. From these surveys, a total of 790.6 km of survey effort was collected, with 93.5% of the total survey effort being conducted under favourable weather conditions (i.e. Beaufort Sea State 3 or below with good visibility). Among the two areas, 299.5 km and 491.1 km of survey effort were conducted in NEL and NWL survey areas respectively.

3.1.3. The total survey effort conducted on primary lines was 578.6 km, while the effort on secondary lines was 212.0 km. Survey effort conducted on both primary and secondary lines were considered as on-effort survey data. A summary table of the survey effort is shown in Appendix I.

3.1.4. During the six sets of monitoring surveys in December 2017 to February 2018, 20 groups of 73 Chinese White Dolphins were sighted, with the summary table of the dolphin sightings shown in Appendix II. All except one dolphin sighting were made during

on-effort search, while 16 of the 19 on-effort dolphin sightings were made on primary lines. In addition, almost all dolphin groups were sighted in NWL, while an exceptionally rare sighting was also made in NEL (note: the last dolphin sighting made in NEL during HZMB-related surveys can be dated back to June 2016).

3.2. Distribution

3.2.1. Distribution of dolphin sightings made during monitoring surveys in December 2017 to February 2018 is shown in Figure 1. The majority of the sightings were concentrated at the northwestern end (mainly to the north of Lung Kwu Chau) and southwestern end (near HKLR09 alignment and to the west of the airport platform) of the North Lantau region (Figure 1). Other sightings were sparsely distributed near Pillar Point, Black Point, Sha Chau and to the northeast of the airport. The lone sighting made in NEL was located near Siu Ho Wan.

3.2.2. In general, the dolphins were mostly absent from the central and eastern portions of North Lantau waters, similar to the consistent findings of HKLR03 surveys in recent years (Figure 1).

3.2.3. One dolphin sighting was made in the proximity of the HKBCF reclamation site, while several groups were also sighted near the HKLR09 alignment. On the contrary, other dolphin sightings were located far away from the HKLR03 reclamation site as well as the alignment and Tuen Mun-Chek Lap Kok Link (TMCLKL) (Figure 1).

3.2.4. Sighting distribution of dolphins during the present impact phase monitoring period (December 2017 to February 2018) was very different from the one during the baseline monitoring period (Figure 1). In the present quarter, dolphins have mostly disappeared from the NEL region, which was in stark contrast to their frequent occurrence around the Brothers Islands, near Shum Shui Kok and in the vicinity of HKBCF reclamation site during the baseline period (Figure 1).

3.2.5. On the other hand, dolphin occurrence in NWL waters was also noticeably different between the baseline and impact phase periods. During the present impact monitoring period, dolphins were infrequently sighted here, and mainly at the northwestern and southwestern ends of the area, which was in stark contrast with their frequent occurrences throughout the entire survey area during the baseline period (Figure 1).

3.3. Encounter rate

3.3.1. During the present three-month study period, the encounter rates of Chinese White Dolphins 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 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).

3.3.2. To facilitate the comparison with the AFCD long-term monitoring results, the encounter rates were also calculated for the present quarter using both primary and secondary survey effort. The encounter rates of sightings (STG) and dolphins (ANI) in NWL were 3.6 sightings and 13.9 dolphins per 100 km of survey effort respectively, while the encounter rates of sightings (STG) and dolphins (ANI) in NEL were 0.3 and 1.7 respectively for this quarter.

Table 2. Dolphin encounter rates (sightings per 100 km of survey effort) during Dec 2017 - Feb 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 (1 & 7 Dec 2017)	0.0	0.0
	Set 2 (14 & 19 Dec 2017)	0.0	0.0
	Set 3 (9 & 11 Jan 2018)	0.0	0.0
	Set 4 (19 & 26 Jan 2018)	0.0	0.0
	Set 5 (1 & 6 Feb 2018)	3.1	15.7
	Set 6 (13 & 26 Feb 2018)	0.0	0.0
Northwest Lantau	Set 1 (1 & 7 Dec 2017)	1.6	14.6
	Set 2 (14 & 19 Dec 2017)	0.0	0.0
	Set 3 (9 & 11 Jan 2018)	2.0	9.8
	Set 4 (19 & 26 Jan 2018)	5.1	20.3
	Set 5 (1 & 6 Feb 2018)	4.3	6.5
	Set 6 (13 & 26 Feb 2018)	9.8	34.3

Table 3. Comparison of average dolphin encounter rates from impact monitoring period (December 2017-February 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)	
	December 2017 – February 2018	**September – November 2011**	**December 2017 – February 2018**	**September – November 2011**
Northeast Lantau	0.5 ± 1.28	6.0 ± 5.05	2.6 ± 6.40	22.2 ± 26.81
Northwest Lantau	3.8 ± 3.48	9.9 ± 5.85	14.3 ± 12.01	44.7 ± 29.85

3.3.3. In NEL, the average dolphin encounter rates (both STG and ANI) in the present three-month impact monitoring period were both very low with only one on-effort sighting of five dolphins being made, and such extremely rare occurrence of dolphins in NEL have also been consistently recorded in recent years of HZMB monitoring (Table 4). Nevertheless, after recording zero encounter rates in the previous three winter quarters during HKLR03 impact monitoring, the present quarter recorded the rare occurrence of dolphins for the first time in recent years.

3.3.4. On the other hand, the average dolphin encounter rates (STG and ANI) in NWL during the present impact phase monitoring period (reductions of 61.4% and 68.1% respectively) were only small fractions of the ones recorded during the three-month baseline period, indicating a noticeable decline in dolphin usage of this survey area during the present impact phase period (Table 5).

3.3.5. During the same winter quarters (with comparison to past HKLR03 monitoring data), dolphin encounter rates in NWL during winter 2017-18 was almost identical to the previous winter period in 2016-17, higher than the ones in 2014-15 and 2015-16, but much lower than the ones in 2012-13 and 2013-14 (Table 5). Such temporal trend should be closely monitored in the upcoming monitoring quarters whether the dolphin occurrence would continue to increase as almost all marine construction activities of HKBCF works have been completed in coming months.

Table 4. Comparison of average dolphin encounter rates in Northeast Lantau survey area from the same winter 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**
December 2012-February 2013 (HKLR03 Impact*)	3.1 ± 3.21	6.3 ± 8.64
December 2013-February 2014 (HKLR03 Impact*)	0.5 ± 1.10	1.3 ± 3.29
December 2014-February 2015 (HKLR03 Impact*)	0.0	0.0
December 2015-February 2016 (HKLR03 Impact*)	0.0	0.0
December 2016-February 2017 (HKLR03 Impact*)	0.0	0.0
December 2017-February 2018 (HKBCF Impact)	**0.5 ± 1.28**	**2.6 ± 6.40**

* As explained in Section 1.5, the previous monitoring data from Contract No. HY/2011/03 (i.e. HKLR03) were adopted for comparison with the baseline and present HKBCF impact monitoring period

Table 5. Comparison of average dolphin encounter rates in Northwest Lantau survey area from all winter 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**
December 2012-February 2013 (HKLR03 Impact*)	8.4 ± 5.03	35.9 ± 23.10
December 2013-February 2014 (HKLR03 Impact*)	8.2 ± 2.21	32.6 ± 11.21
December 2014-February 2015 (HKLR03 Impact*)	2.9 ± 2.69	11.3 ± 15.19
December 2015-February 2016 (HKLR03 Impact*)	2.6 ± 1.52	11.0 ± 3.81
December 2016-February 2017 (HKLR03 Impact*)	3.8 ± 3.79	14.5 ± 17.21
December 2017-February 2018 (HKBCF Impact)	**3.8 ± 3.48**	**14.3 ± 12.01**

* As explained in Section 1.5, the previous monitoring data from Contract No. HY/2011/03 (i.e. HKLR03) were adopted for comparison with the baseline and present HKBCF impact monitoring period

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 0.0138 and 0.0475 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. As indicated in both dolphin distribution patterns and encounter rates, dolphin usage has been significantly reduced in both NEL and NWL survey areas during the present quarterly period, and such low occurrence of dolphins has also been consistently documented in past HZMB dolphin monitoring studies.

3.3.9. The decline in dolphin usage of North Lantau region raises serious concern, as the timing of the decline in dolphin usage in North Lantau waters coincided well with the construction schedule of the HZMB-related projects (Hung 2017). Apparently there was very little sign of recovery of dolphin usage even though most of the marine works associated with the HZMB construction have been completed, and therefore continuous dolphin monitoring would remain critical in coming months.

3.4. Group size

3.4.1. Group size of Chinese White Dolphins ranged from one to nine individuals per group in North Lantau region during December 2017 to February 2018. The average dolphin group sizes from these three months 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 December 2017-February 2018) and baseline monitoring period (September-November 2011) (Note: ± denotes the standard deviation of average group size)

	Average Dolphin Group Size	
	December 2017 – February 2018	**September – November 2011**
Overall	3.7 ± 2.43 (n = 20)	3.7 ± 3.13 (n = 66)
Northeast Lantau	5.0 (n=1)	3.2 ± 2.16 (n = 17)
Northwest Lantau	3.6 ± 2.48 (n = 19)	3.9 ± 3.40 (n = 49)

3.4.2. The average dolphin group size in NWL waters during December 2017 to February 2018 was slightly lower than the one recorded during the three-month baseline period, but it should also be noted that the sample size of six dolphin groups in the present quarter was small when compared to the 66 groups sighted during the baseline period (Table 6).

3.4.3. On the other hand, even the group size of the lone dolphin sighting recorded in NEL (five animals) was higher than the average recorded during the three-month period, but it was only based on the sample size of one (Table 6).

3.4.4. Overall, it should be noted that 12 of the 20 dolphin groups sighted during the present quarter were composed of 1-3 individuals only. On the other hand, the other eight groups were medium-sized, with four groups with five animals per group, three groups with seven animals per group, and one group with nine animals (Appendix II).

3.4.5. Distribution of the larger dolphin groups with five individuals or more per group during the present quarter is shown in Figure 3, with comparison to the one in baseline period. Four of the medium-sized groups were located to the north of Lung Kwu Chau, while the other four were distributed near Sha Chau, Pillar Point, to the northeast of airport, and near Siu Ho Wan (Figure 2). Such distribution pattern was very different from the baseline period, when the larger dolphin groups were frequently sighted and evenly distributed in NWL waters, with a few also sighted in NEL waters (Figure 2).

3.5. Habitat use

3.5.1. From December 2017 to February 2018, the grids that recorded high dolphin densities were located to the north of Lung Kwu Chau, near Sha Chau and Pillar Point, to the northeast of airport platform, and near Siu Ho Wan (Figures 3a and 3b). Notably, the two grids overlapped with the HKLR09 alignment as well as the few grids to the west of the airport platform only recorded low to very low densities of dolphins in the present quarterly period (Figures 3a and 3b).

3.5.2. 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.

3.5.3. 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 4). During the baseline period, many grids between Siu Mo To and Shum Shui Kok in NEL recorded moderately high to high dolphin densities, which was in stark contrast to the near-complete absence of dolphins there during the present impact phase period (Figure 4).

3.5.4. The density patterns were also very different in NWL between the baseline and impact phase monitoring periods, with high dolphin usage throughout the area during the baseline period. In contrast, only several grids with high dolphin densities were located to the north of Lung Kwu Chau, near Sha Cha Chau and Pillar Point during the present impact phase period (Figure 4).

3.6. Mother-calf pairs

3.6.1. During the present quarterly period, only one unspotted juvenile was sighted with its mothers in the North Lantau region. This rare sighting of young calf was located near Sha Chau (Figure 5).

3.6.2. The rare occurrence of young calves in the present quarter was very different from their regular occurrence in North Lantau waters during the baseline period (Figure 5). This should be of a serious concern, and the occurrence of young calves in North Lantau waters should be closely monitored in the upcoming quarters.

3.7. Activities and associations with fishing boats

3.7.1. During the present quarterly period, two of the 20 dolphin groups were engaged in feeding activity, which were located near Sha Chau and to the northeast of the airport platform. However, the rest of the groups were not engaged in socializing, traveling or milling/resting activity during the three-month study period.

3.7.2. When compared to the baseline period, distribution of various dolphin activities during the present impact phase monitoring period was drastically different with very rare occurrence of such activities in the present quarter (Figure 6).

3.7.3. Notably, none of the 20 groups was associated with any operating fishing vessel during the present impact phase period.

3.8. Summary of photo-identification works

3.8.1. From December 2017 to February 2018, over 2,500 digital photographs of Chinese White Dolphins were taken during the impact phase monitoring surveys for the photo-identification work.

3.8.2. In total, 26 individuals sighted 52 times altogether were identified (see summary table in Appendix III and photographs of identified individuals in Appendix IV). The majority of the re-sightings were made in NWL, while there were five re-sightings of five individual dolphins (NL37, Nl120, NL123, NL136 and NL226) made in NEL from the rare sighting made in February 2018.

3.8.3. Among the 26 individuals, 15 of them were re-sighted only once, while six individuals were re-sighted 2-3 times and five individuals were re-sighted 4-7 times during the three-month period (Appendix III).

3.8.4. Notably, eight of these 26 individuals (i.e. CH34, NL123, NL136, NL182, NL226, NL261, NL272 and NL296) were also sighted in NWL during the HKLR03 monitoring surveys conducted concurrently in the same three-month period. However, none of the individual was sighted in West Lantau waters during the HKLR09 monitoring surveys from the same quarterly period.

3.9. Individual range use

3.9.1. Ranging patterns of the 26 individuals identified during the three-month study period were determined by fixed kernel method, and are shown in Appendix V.

3.9.2. The majority of identified dolphins sighted in the present quarter were utilizing NWL waters only, but five individuals have also spanned their range across to NEL waters, where many of them have utilized as their core areas in the past (Appendix V). This is still in stark contrary to the extensive movements between NEL and NWL survey areas observed in the earlier impact monitoring quarters as well as the baseline period.

3.9.3. On the other hand, none of the individuals have extended their range use to WL during the present quarter.

3.9.4. In the upcoming quarters, individual range use and movements should be continuously monitored to examine whether there has been any consistent shifts of individual home ranges from North Lantau to West or Southwest Lantau.

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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Hung, S. K. 2017. Monitoring of Marine Mammals in Hong Kong waters: final report (2016-17). An unpublished report submitted to the Agriculture, Fisheries and Conservation Department, 162 pp.

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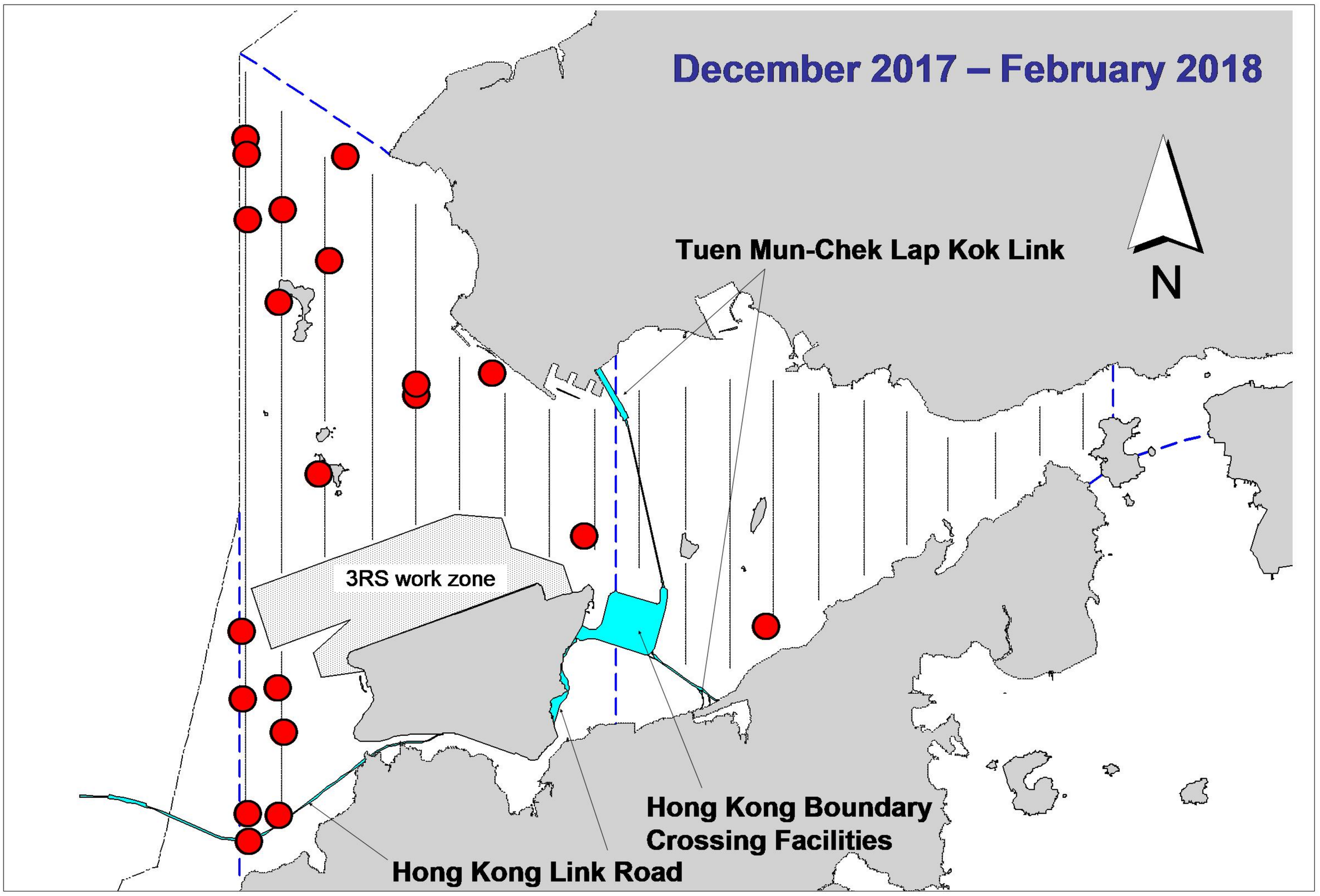


Figure 1. Distribution of Chinese white dolphin sighting in Northwest and Northeast Lantau during HKBCF impact phase (top) and baseline monitoring surveys (bottom)

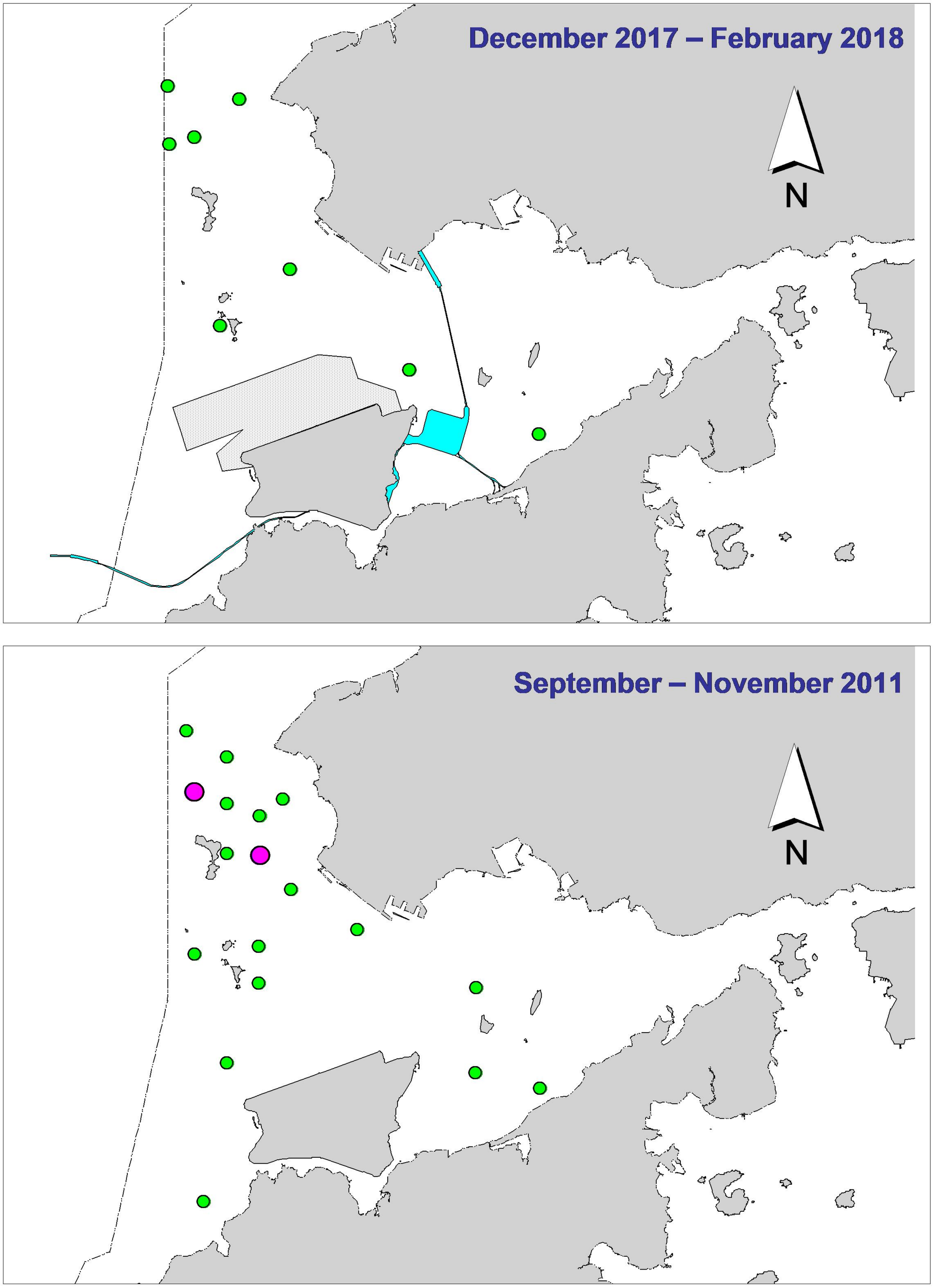


Figure 2. Distribution of Chinese white dolphins with larger group sizes during HKBCF impact phase (top) and baseline monitoring surveys (bottom) (green dots: group sizes of 5 or more; purple dots: group sizes of 10 or more)

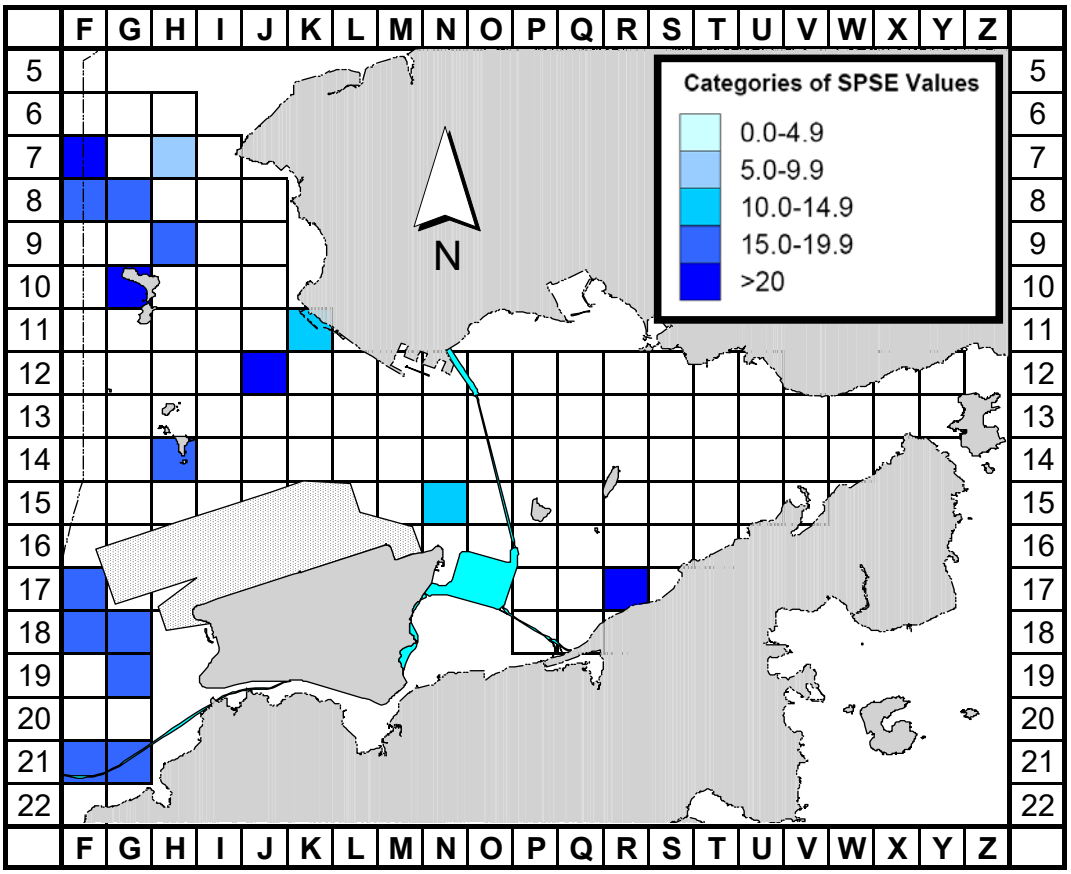


Figure 3a. Sighting density of Chinese white dolphins with corrected survey effort per km^2 in Northeast and Northwest Lantau survey areas, using data collected during HKBCF impact monitoring period monitoring period (Dec 17-Feb 18) (SPSE = no. of on-effort sightings per 100 units of survey effort)

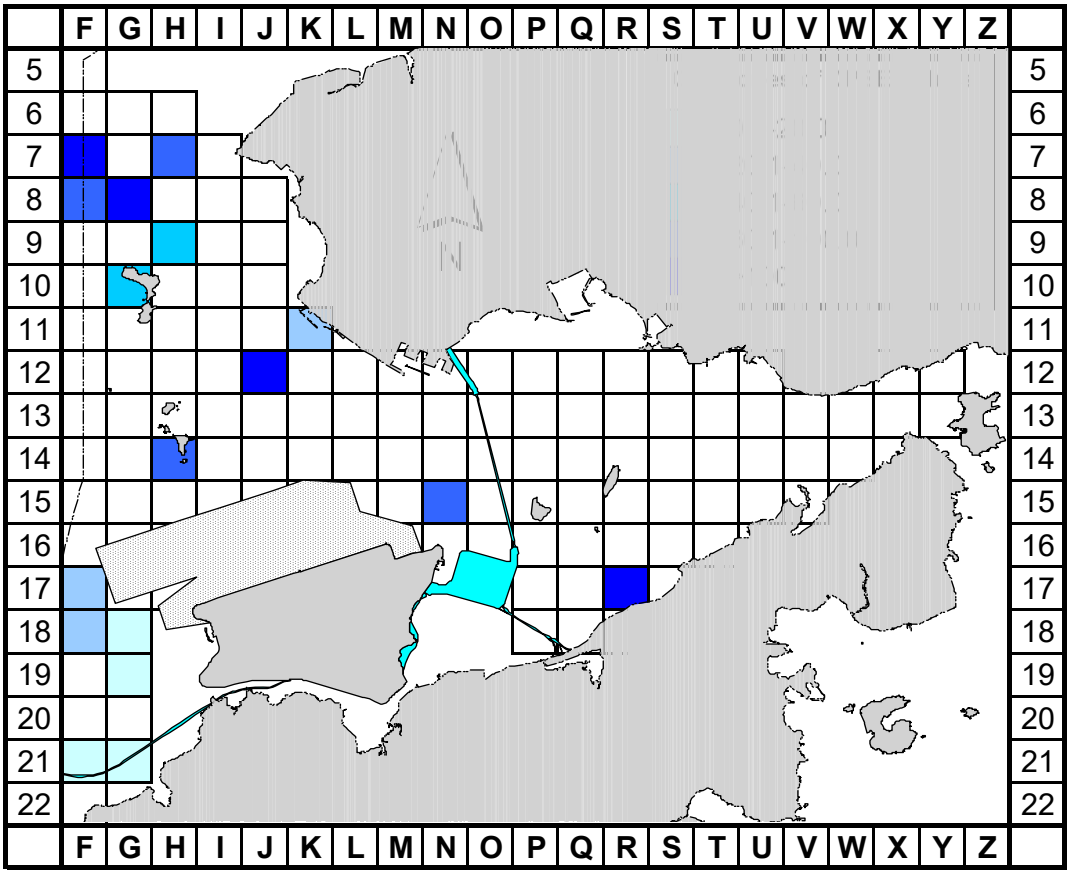


Figure 3b. Density of Chinese white dolphins with corrected survey effort per km^2 in Northeast and Northwest Lantau survey areas, using data collected during HKBCF impact monitoring period (Dec 17-Feb 18) (DPSE = no. of dolphins per 100 units of survey effort)

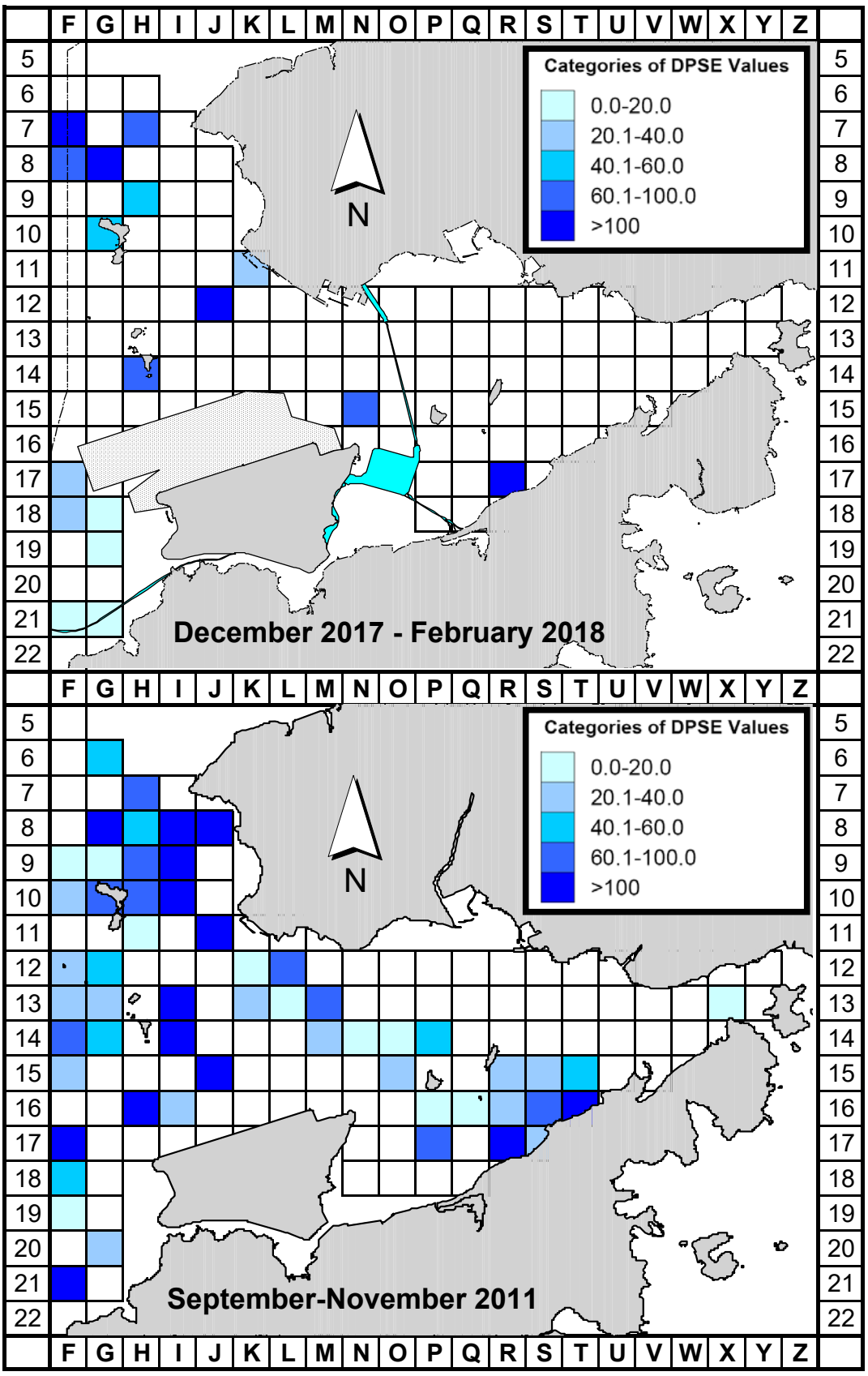


Figure 4. Comparison of density of Chinese white dolphins with corrected survey effort per km^2 in Northwest and Northeast Lantau survey area between the HKBCF impact monitoring period (December 2017 - February 2018) and baseline monitoring period (September-November 2011) (DPSE = no. of dolphins per 100 units of survey effort)

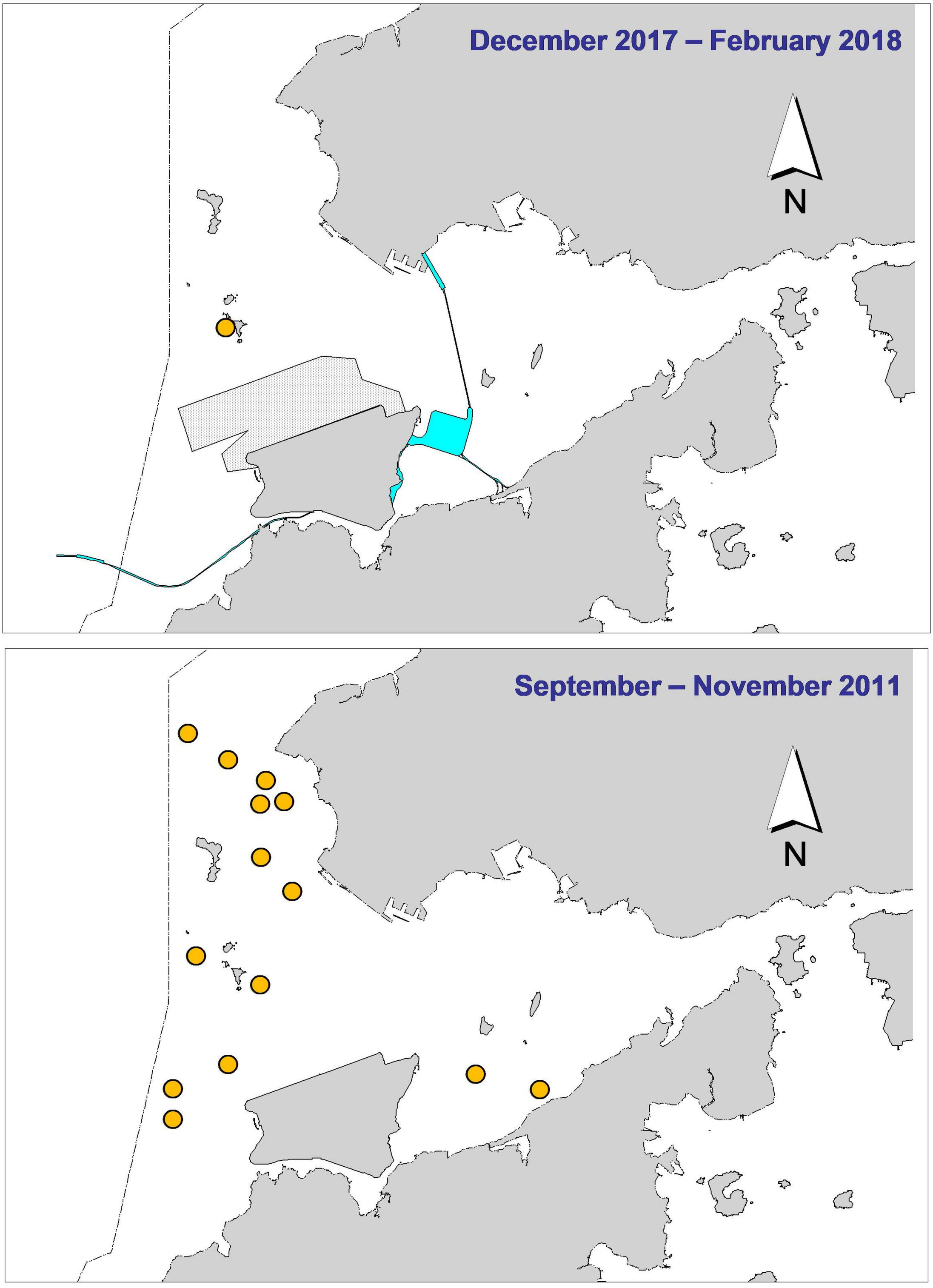


Figure 5. Distribution of young calves of Chinese white dolphins during HKBCF impact phase (top) and baseline monitoring surveys (bottom)

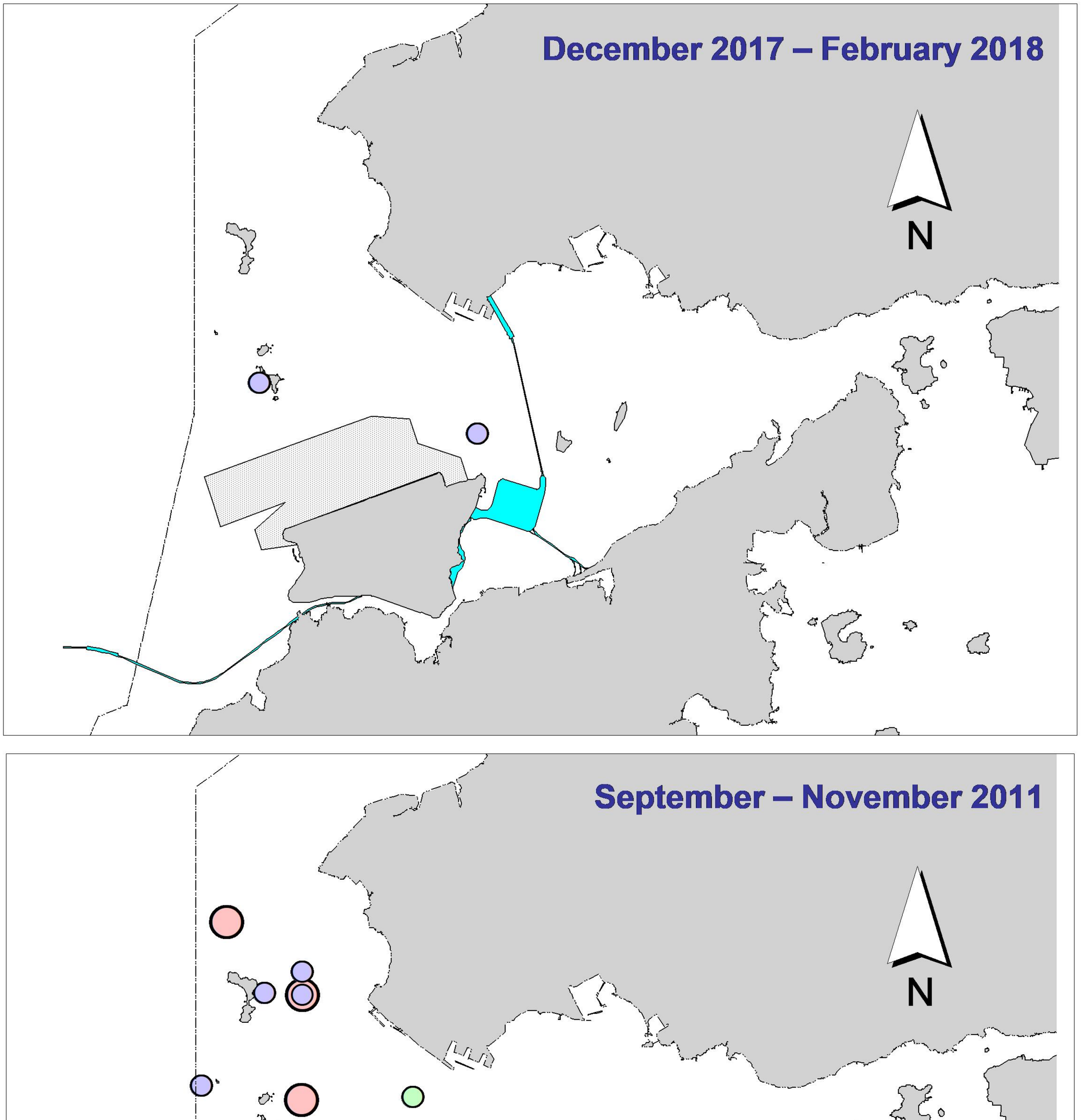


Figure 6. Distribution of Chinese white dolphins engaged in feeding (purple dots), socializing (pink dots) and traveling (green dots) activities during HKBCF impact phase (top) and baseline monitoring surveys (bottom)

Appendix I. HKBCF Survey Effort Database (December 2017-February 2018)

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

DATE	AREA	BEAU	EFFORT	SEASON	VESSEL	TYPE	P/S
1-Dec-17	NW LANTAU	2	7.28	WINTER	STANDARD36826	HKBCF	P
1-Dec-17	NW LANTAU	3	25.26	WINTER	STANDARD36826	HKBCF	P
1-Dec-17	NW LANTAU	2	3.52	WINTER	STANDARD36826	HKBCF	S
1-Dec-17	NW LANTAU	3	7.49	WINTER	STANDARD36826	HKBCF	S
1-Dec-17	NE LANTAU	1	3.60	WINTER	STANDARD36826	HKBCF	P
1-Dec-17	NE LANTAU	2	31.89	WINTER	STANDARD36826	HKBCF	P
1-Dec-17	NE LANTAU	2	11.81	WINTER	STANDARD36826	HKBCF	S
7-Dec-17	NW LANTAU	1	6.35	WINTER	STANDARD36826	HKBCF	P
7-Dec-17	NW LANTAU	2	19.51	WINTER	STANDARD36826	HKBCF	P
7-Dec-17	NW LANTAU	3	3.10	WINTER	STANDARD36826	HKBCF	P
7-Dec-17	NW LANTAU	1	5.14	WINTER	STANDARD36826	HKBCF	S
7-Dec-17	NW LANTAU	2	5.90	WINTER	STANDARD36826	HKBCF	S
14-Dec-17	NW LANTAU	1	1.60	WINTER	STANDARD36826	HKBCF	P
14-Dec-17	NW LANTAU	2	29.73	WINTER	STANDARD36826	HKBCF	P
14-Dec-17	NW LANTAU	3	1.93	WINTER	STANDARD36826	HKBCF	P
14-Dec-17	NW LANTAU	2	8.24	WINTER	STANDARD36826	HKBCF	S
19-Dec-17	NW LANTAU	3	10.00	WINTER	STANDARD36826	HKBCF	P
19-Dec-17	NW LANTAU	4	17.61	WINTER	STANDARD36826	HKBCF	P
19-Dec-17	NW LANTAU	2	2.40	WINTER	STANDARD36826	HKBCF	S
19-Dec-17	NW LANTAU	3	4.90	WINTER	STANDARD36826	HKBCF	S
19-Dec-17	NW LANTAU	4	5.09	WINTER	STANDARD36826	HKBCF	S
19-Dec-17	NE LANTAU	1	1.40	WINTER	STANDARD36826	HKBCF	P
19-Dec-17	NE LANTAU	2	20.79	WINTER	STANDARD36826	HKBCF	P
19-Dec-17	NE LANTAU	3	14.34	WINTER	STANDARD36826	HKBCF	P
19-Dec-17	NE LANTAU	2	7.82	WINTER	STANDARD36826	HKBCF	S
19-Dec-17	NE LANTAU	3	6.85	WINTER	STANDARD36826	HKBCF	S
9-Jan-18	NE LANTAU	1	1.42	WINTER	STANDARD36826	HKBCF	P
9-Jan-18	NE LANTAU	2	20.01	WINTER	STANDARD36826	HKBCF	P
9-Jan-18	NE LANTAU	3	16.10	WINTER	STANDARD36826	HKBCF	P
9-Jan-18	NE LANTAU	1	1.19	WINTER	STANDARD36826	HKBCF	S
9-Jan-18	NE LANTAU	2	8.28	WINTER	STANDARD36826	HKBCF	S
9-Jan-18	NE LANTAU	3	3.20	WINTER	STANDARD36826	HKBCF	S
9-Jan-18	NW LANTAU	2	11.32	WINTER	STANDARD36826	HKBCF	P
9-Jan-18	NW LANTAU	3	5.86	WINTER	STANDARD36826	HKBCF	P
9-Jan-18	NW LANTAU	2	4.51	WINTER	STANDARD36826	HKBCF	S
11-Jan-18	NW LANTAU	3	34.08	WINTER	STANDARD36826	HKBCF	P
11-Jan-18	NW LANTAU	4	9.19	WINTER	STANDARD36826	HKBCF	P
11-Jan-18	NW LANTAU	5	1.50	WINTER	STANDARD36826	HKBCF	P
11-Jan-18	NW LANTAU	2	1.30	WINTER	STANDARD36826	HKBCF	S
11-Jan-18	NW LANTAU	3	5.33	WINTER	STANDARD36826	HKBCF	S
11-Jan-18	NW LANTAU	4	0.80	WINTER	STANDARD36826	HKBCF	S
11-Jan-18	NW LANTAU	5	2.30	WINTER	STANDARD36826	HKBCF	S
19-Jan-18	NW LANTAU	1	1.40	WINTER	STANDARD36826	HKBCF	P
19-Jan-18	NW LANTAU	2	25.40	WINTER	STANDARD36826	HKBCF	P
19-Jan-18	NW LANTAU	1	4.29	WINTER	STANDARD36826	HKBCF	S
19-Jan-18	NW LANTAU	2	8.61	WINTER	STANDARD36826	HKBCF	S
26-Jan-18	NW LANTAU	1	8.06	WINTER	STANDARD36826	HKBCF	P
26-Jan-18	NW LANTAU	2	24.23	WINTER	STANDARD36826	HKBCF	P
26-Jan-18	NW LANTAU	2	11.24	WINTER	STANDARD36826	HKBCF	S
26-Jan-18	NE LANTAU	1	1.10	WINTER	STANDARD36826	HKBCF	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
26-Jan-18	NE LANTAU	2	35.26	WINTER	STANDARD36826	HKBCF	P
26-Jan-18	NE LANTAU	2	11.64	WINTER	STANDARD36826	HKBCF	S
1-Feb-18	NW LANTAU	2	11.07	WINTER	STANDARD36826	HKBCF	P
1-Feb-18	NW LANTAU	3	13.79	WINTER	STANDARD36826	HKBCF	P
1-Feb-18	NW LANTAU	2	5.23	WINTER	STANDARD36826	HKBCF	S
1-Feb-18	NW LANTAU	3	5.31	WINTER	STANDARD36826	HKBCF	S
1-Feb-18	NE LANTAU	2	15.10	WINTER	STANDARD36826	HKBCF	P
1-Feb-18	NE LANTAU	2	9.70	WINTER	STANDARD36826	HKBCF	S
6-Feb-18	NW LANTAU	2	6.26	WINTER	STANDARD36826	HKBCF	P
6-Feb-18	NW LANTAU	3	14.95	WINTER	STANDARD36826	HKBCF	P
6-Feb-18	NW LANTAU	4	14.58	WINTER	STANDARD36826	HKBCF	P
6-Feb-18	NW LANTAU	2	3.61	WINTER	STANDARD36826	HKBCF	S
6-Feb-18	NW LANTAU	3	9.69	WINTER	STANDARD36826	HKBCF	S
6-Feb-18	NE LANTAU	1	0.70	WINTER	STANDARD36826	HKBCF	P
6-Feb-18	NE LANTAU	2	16.08	WINTER	STANDARD36826	HKBCF	P
6-Feb-18	NE LANTAU	1	2.00	WINTER	STANDARD36826	HKBCF	S
6-Feb-18	NE LANTAU	2	12.62	WINTER	STANDARD36826	HKBCF	S
13-Feb-18	NW LANTAU	1	0.41	WINTER	STANDARD36826	HKBCF	P
13-Feb-18	NW LANTAU	2	35.45	WINTER	STANDARD36826	HKBCF	P
13-Feb-18	NW LANTAU	2	10.87	WINTER	STANDARD36826	HKBCF	S
26-Feb-18	NW LANTAU	2	23.18	WINTER	STANDARD36826	HKBCF	P
26-Feb-18	NW LANTAU	3	2.20	WINTER	STANDARD36826	HKBCF	P
26-Feb-18	NW LANTAU	2	10.02	WINTER	STANDARD36826	HKBCF	S
26-Feb-18	NE LANTAU	2	27.58	WINTER	STANDARD36826	HKBCF	P
26-Feb-18	NE LANTAU	3	7.90	WINTER	STANDARD36826	HKBCF	P
26-Feb-18	NE LANTAU	2	9.42	WINTER	STANDARD36826	HKBCF	S
26-Feb-18	NE LANTAU	3	1.70	WINTER	STANDARD36826	HKBCF	S

Appendix II. HKBCF Chinese White Dolphin Sighting Database (December 2017 - February 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)

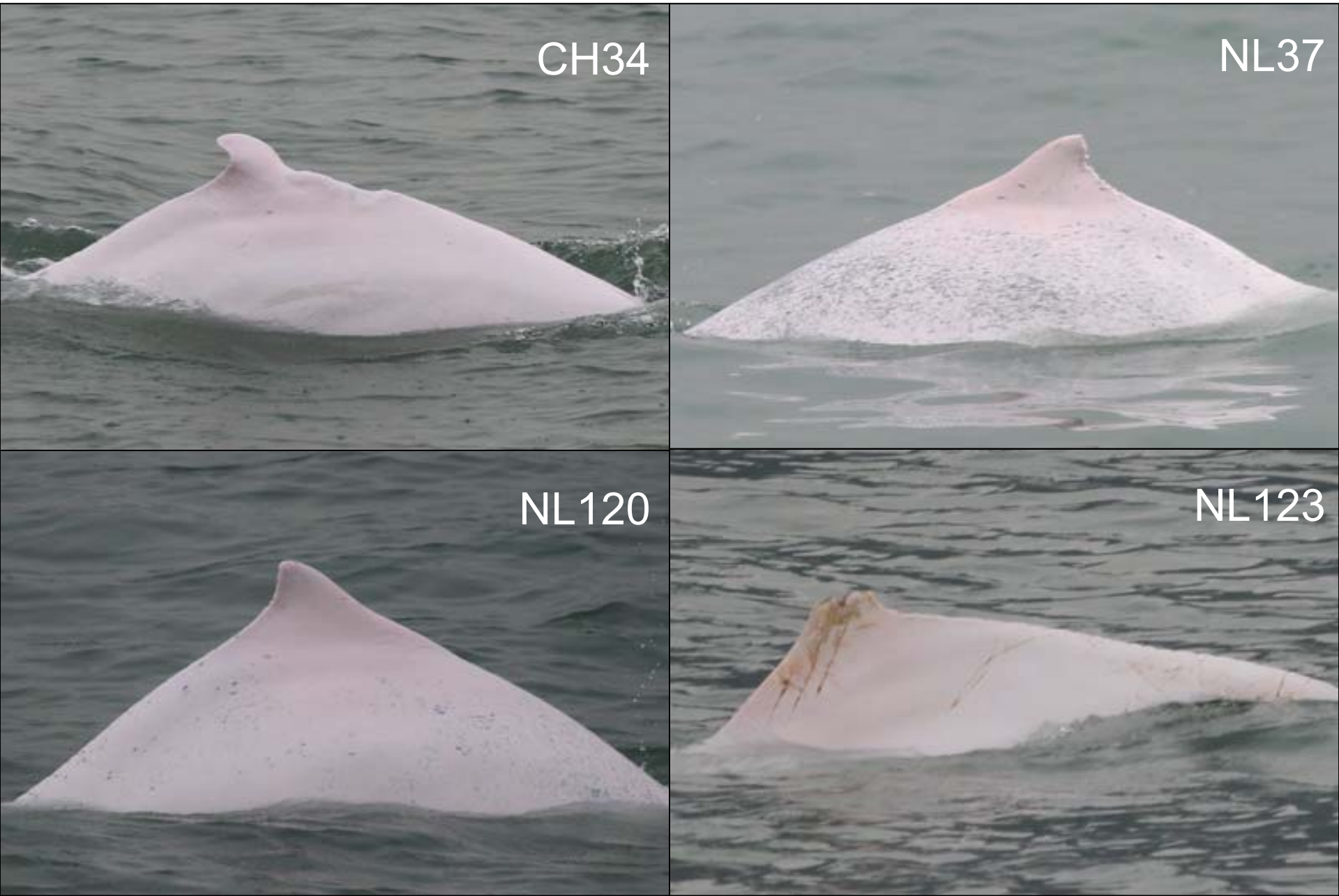
DATE	STG #	TIME	HRD SZ	AREA	BEAU	PSD	EFFORT	TYPE	NORTHING	EASTING	SEASON	BOAT ASSOC.	P/S
1-Dec-17	1	1125	9	NW LANTAU	2	1147	ON	HKBCF	829998	804640	WINTER	NONE	P
9-Jan-18	1	1401	5	NW LANTAU	3	169	ON	HKBCF	824554	808491	WINTER	NONE	P
19-Jan-18	1	1153	7	NW LANTAU	2	13	ON	HKBCF	828468	805481	WINTER	NONE	P
19-Jan-18	2	1316	2	NW LANTAU	2	ND	OFF	HKBCF	815126	804723	WINTER	NONE	
26-Jan-18	1	1023	2	NW LANTAU	2	664	ON	HKBCF	818138	804585	WINTER	NONE	P
26-Jan-18	2	1152	3	NW LANTAU	2	293	ON	HKBCF	827414	806509	WINTER	NONE	P
1-Feb-18	1	1014	1	NW LANTAU	3	48	ON	HKBCF	817428	805490	WINTER	NONE	P
1-Feb-18	2	1055	2	NW LANTAU	3	198	ON	HKBCF	826509	805385	WINTER	NONE	P
1-Feb-18	3	1244	7	NW LANTAU	2	285	ON	HKBCF	821568	812236	WINTER	NONE	S
1-Feb-18	4	1546	5	NE LANTAU	2	474	ON	HKBCF	819680	816324	WINTER	NONE	P
6-Feb-18	1	1113	3	NW LANTAU	4	785	ON	HKBCF	829655	804660	WINTER	NONE	P
6-Feb-18	2	1230	2	NW LANTAU	4	24	ON	HKBCF	824797	808482	WINTER	NONE	P
6-Feb-18	3	1310	3	NW LANTAU	2	36	ON	HKBCF	825038	810171	WINTER	NONE	S
13-Feb-18	1	1138	5	NW LANTAU	2	385	ON	HKBCF	822886	806284	WINTER	NONE	P
13-Feb-18	2	1220	7	NW LANTAU	2	467	ON	HKBCF	829595	806884	WINTER	NONE	P
13-Feb-18	3	1302	5	NW LANTAU	2	209	ON	HKBCF	828282	804688	WINTER	NONE	P
13-Feb-18	4	1342	2	NW LANTAU	2	398	ON	HKBCF	819567	804567	WINTER	NONE	P
13-Feb-18	5	1404	1	NW LANTAU	2	799	ON	HKBCF	815702	804693	WINTER	NONE	S
26-Feb-18	1	1015	1	NW LANTAU	2	92	ON	HKBCF	815667	805394	WINTER	NONE	P
26-Feb-18	2	1030	1	NW LANTAU	2	15	ON	HKBCF	818369	805378	WINTER	NONE	P

Appendix III. Individual dolphins identified during HKBCF monitoring surveys in December 2017 - February 2018

ID#	DATE	STG#	AREA
CH34	01/12/17	1	NW LANTAU
	19/01/18	1	NW LANTAU
	26/01/18	2	NW LANTAU
	13/02/18	2	NW LANTAU
	13/02/18	3	NW LANTAU
NL37	01/02/18	3	NW LANTAU
	01/02/18	4	NE LANTAU
NL120	09/01/18	1	NW LANTAU
	19/01/18	1	NW LANTAU
	01/02/18	3	NW LANTAU
	01/02/18	4	NE LANTAU
NL123	01/02/18	3	NW LANTAU
	01/02/18	4	NE LANTAU
NL136	19/01/18	1	NW LANTAU
	01/02/18	3	NW LANTAU
	01/02/18	4	NE LANTAU
	06/02/18	2	NW LANTAU
	06/02/18	3	NW LANTAU
	13/02/18	2	NW LANTAU
	13/02/18	3	NW LANTAU
NL182	19/01/18	1	NW LANTAU
	06/02/18	2	NW LANTAU
	13/02/18	2	NW LANTAU
	13/02/18	3	NW LANTAU
NL210	01/12/17	1	NW LANTAU
	26/01/18	2	NW LANTAU

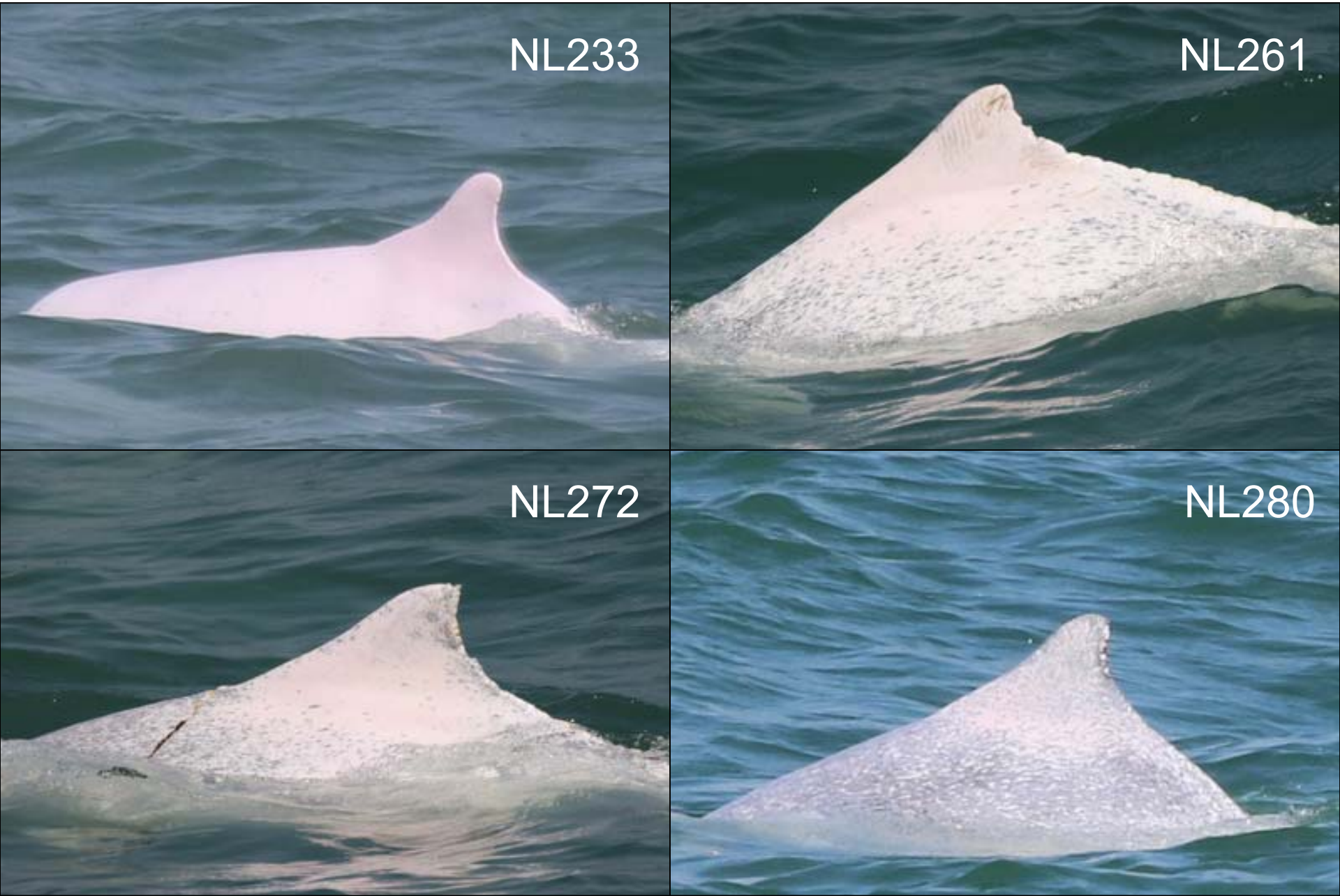
ID#	DATE	STG#	AREA
NL226	09/01/18	1	NW LANTAU
	01/02/18	3	NW LANTAU
	01/02/18	4	NE LANTAU
NL233	01/12/17	1	NW LANTAU
NL261	19/01/18	1	NW LANTAU
	13/02/18	2	NW LANTAU
	13/02/18	3	NW LANTAU
NL272	19/01/18	1	NW LANTAU
	13/02/18	2	NW LANTAU
NL280	01/12/17	1	NW LANTAU
NL295	09/01/18	1	NW LANTAU
NL296	09/01/18	1	NW LANTAU
NL317	01/12/17	1	NW LANTAU
NL320	19/01/18	1	NW LANTAU
NL328	26/01/18	2	NW LANTAU
NL329	01/12/17	1	NW LANTAU
WL145	26/01/18	1	NW LANTAU
WL167	13/02/18	1	NW LANTAU
WL179	13/02/18	1	NW LANTAU
WL241	19/01/18	2	NW LANTAU
WL243	19/01/18	2	NW LANTAU
	13/02/18	1	NW LANTAU
	26/02/18	1	NW LANTAU
WL281	01/02/18	2	NW LANTAU
WL283	01/02/18	2	NW LANTAU
WL291	13/02/18	1	NW LANTAU

Appendix IV. Twenty-six individual dolphins that were identified during December 2017 to February 2018 under HKBCF impact phase monitoring surveys



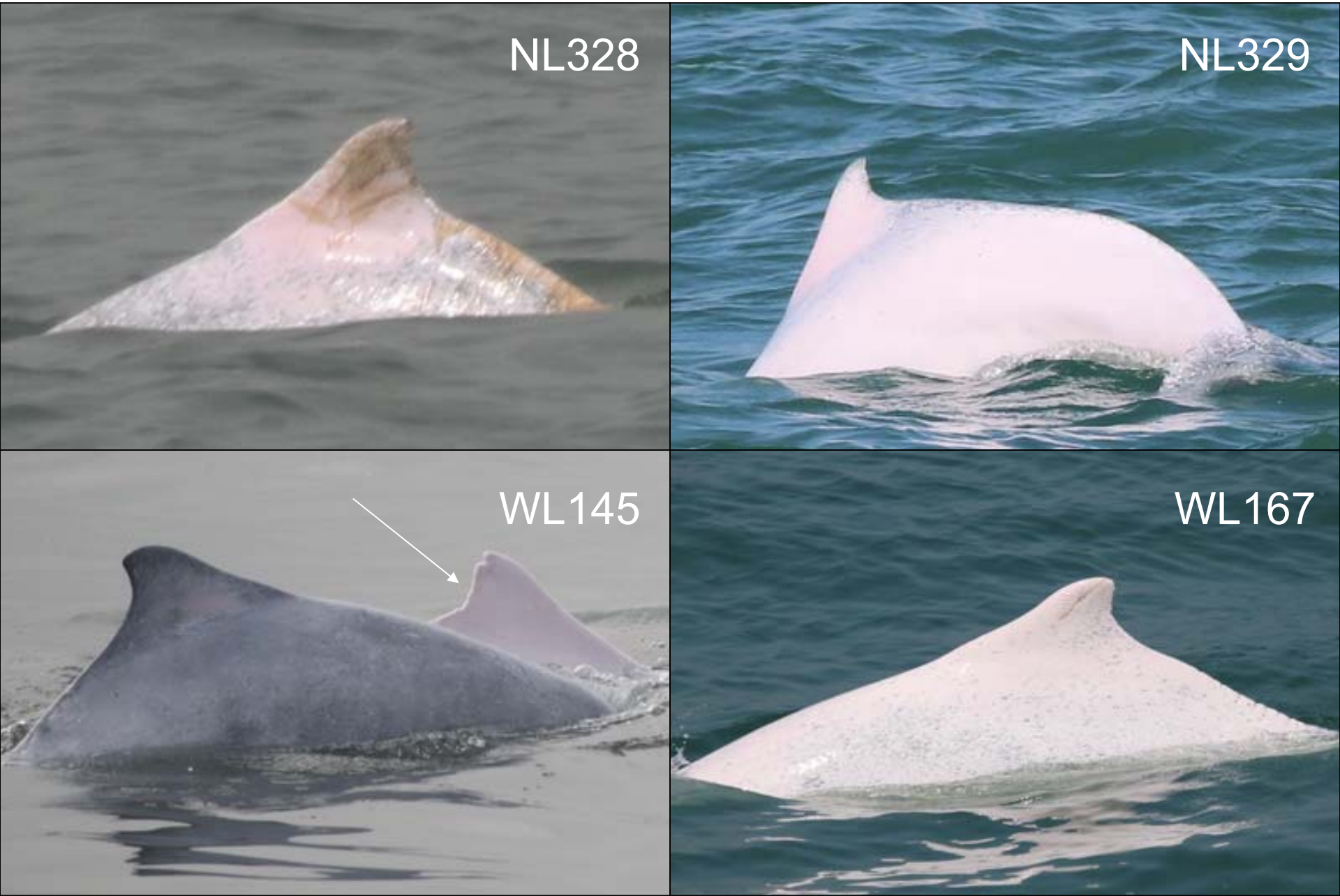
Appendix IV. (cont'd)

Appendix IV. (cont'd)



Appendix IV. (cont'd)

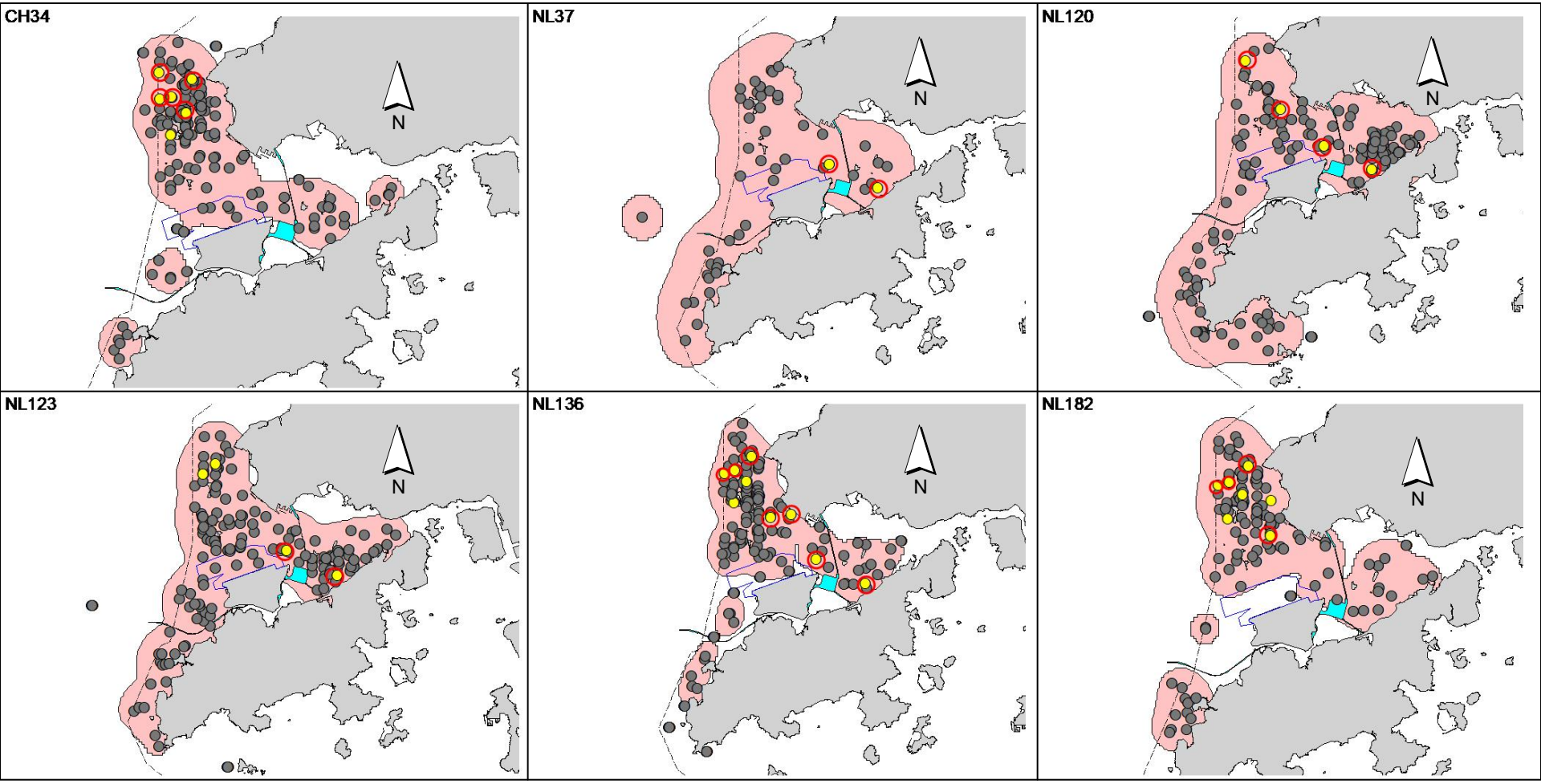
Appendix IV. (cont'd)




WL179
WL241
WL243
WL281

Appendix IV. (cont'd)

Appendix V. Ranging patterns (95% kernel ranges) of 26 individual dolphins that were sighted during HKBCF impact phase monitoring period (note: yellow dots with red circles indicate sightings made in December 2017-February 2018 during HKBCF monitoring surveys; other yellow dots indicate the ones made during HKLR03 & HKLR09 monitoring surveys)



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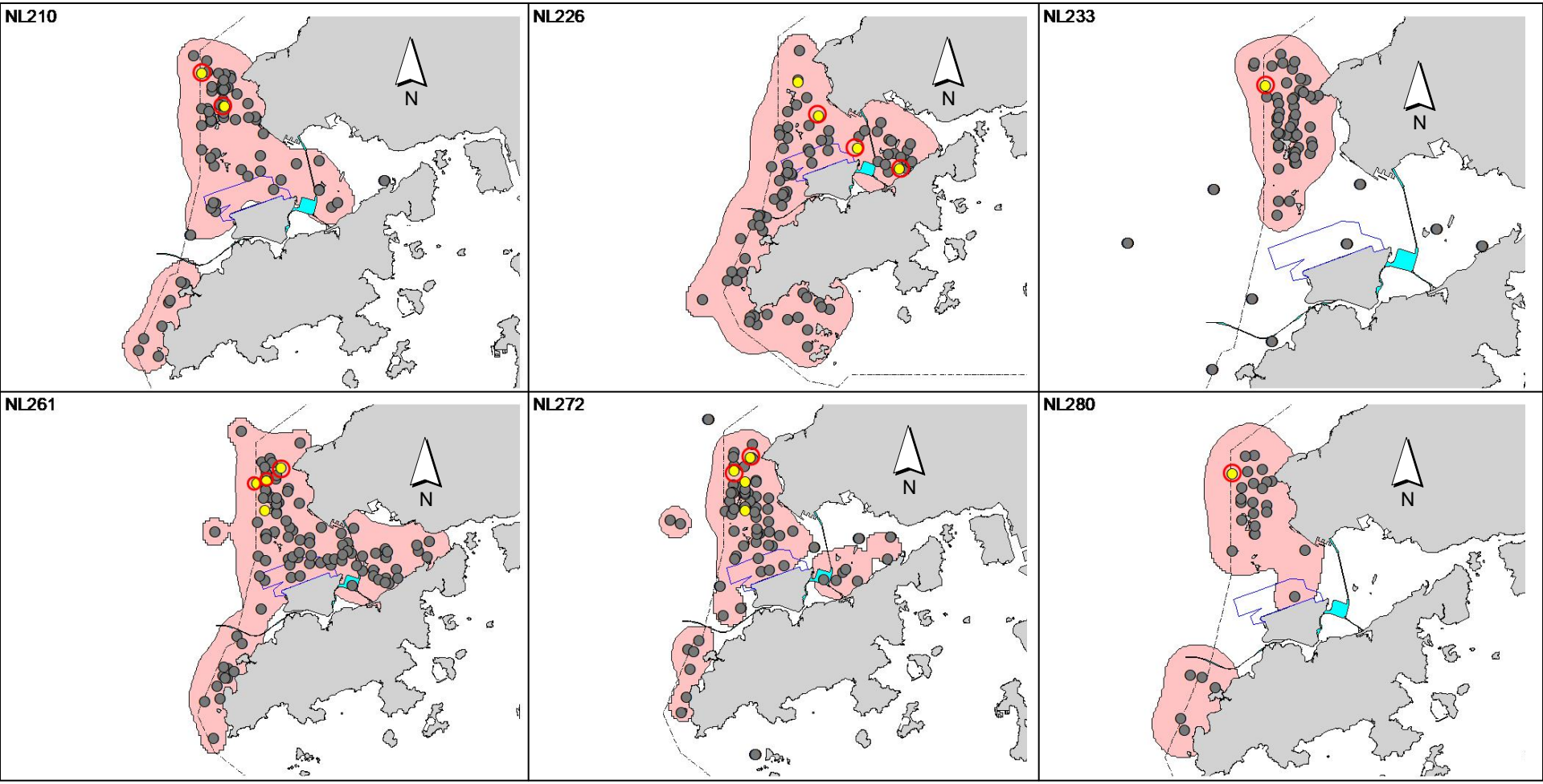
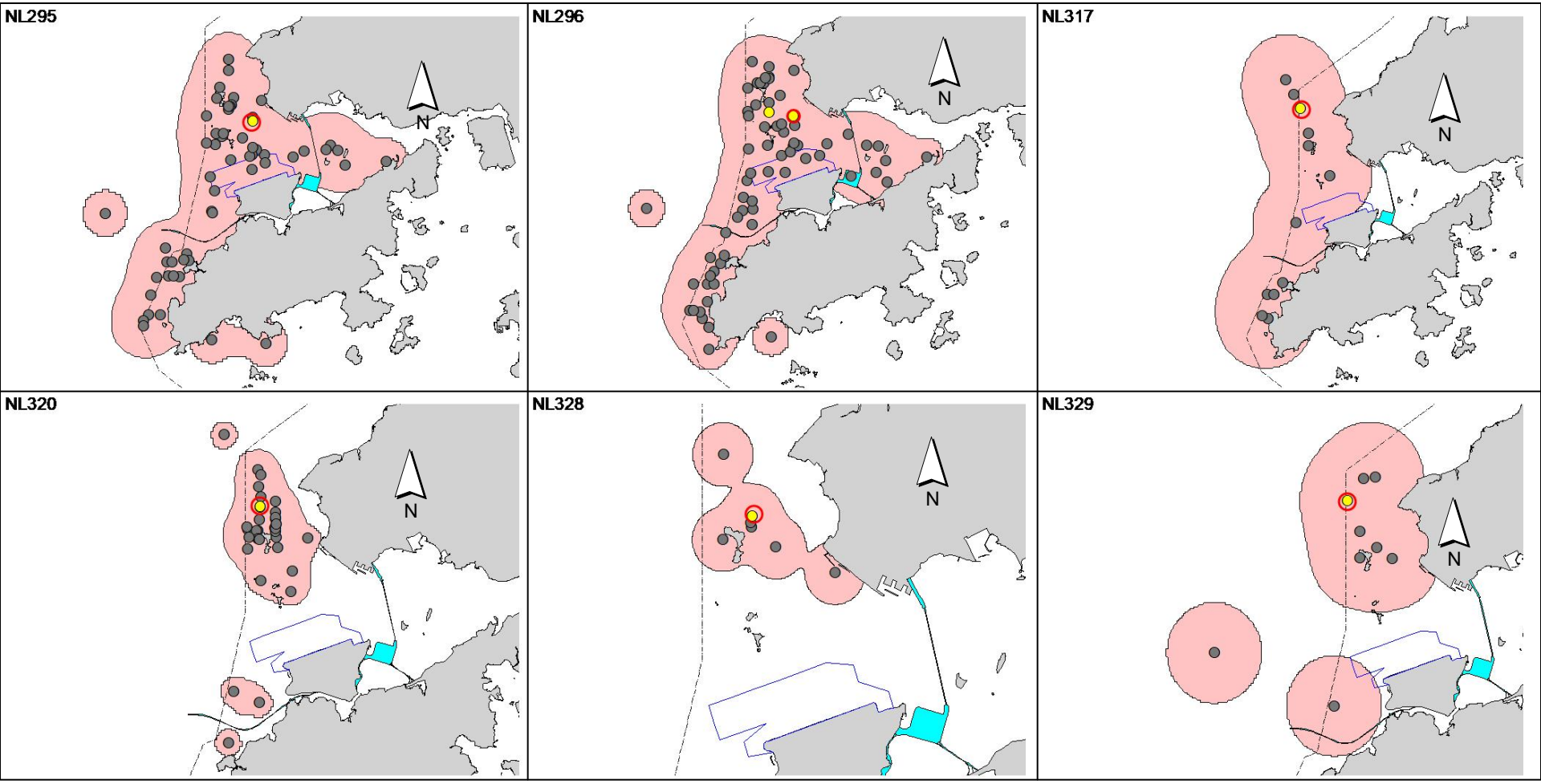
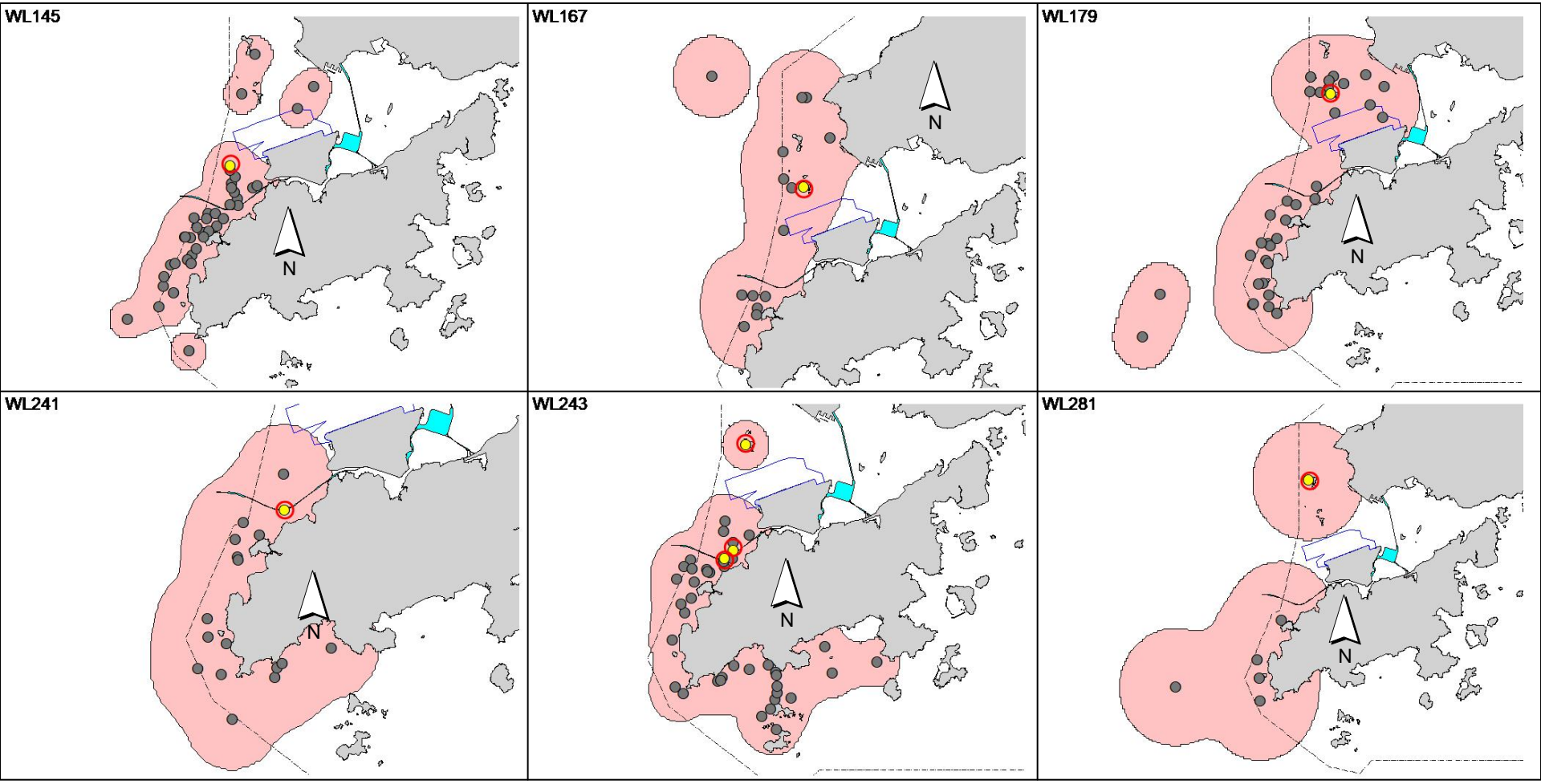


Appendix V. (cont'd)



Appendix V. (cont'd)



Appendix V. (cont'd)