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

First Quarterly Progress Report (September-November 2017)
submitted to Leighton – Chun Wo Joint Venture

Submitted by
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January 18, 2018

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 first 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 September to November 2017.

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 19 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 and/or 60D models), 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 September to November 2017, 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 790.3 km of survey effort was collected, with 97.9% 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, 289.9 km and 500.4 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 574.2 km, while the effort on secondary lines was 216.1 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 September to November 2017, six groups of 25 Chinese White Dolphins were sighted, with the summary table of the dolphin sightings

shown in Appendix II. All dolphin sightings were made during on-effort search, while five of the six on-effort dolphin sightings were made on primary lines. In addition, all dolphin groups were sighted in NWL, and no dolphin was sighted at all in NEL.

3.2. Distribution

3.2.1. Distribution of dolphin sightings made during monitoring surveys in September to November 2017 is shown in Figure 1. Five of the four sightings were made at the northwest portion of the North Lantau region, mainly within the Sha Chau and Lung Kwu Chau Marine Park (Figure 1). One dolphin group was also sighted at the southwestern end of NWL survey area, or near the HKLR09 alignment. On the contrary, the dolphins were completely absent from the central and eastern portions of North Lantau waters, similar to the consistent findings of HKLR03 surveys in recent years (Figure 1).

3.2.2. All dolphin sightings were located far away from the HKBCF and HKLR03 reclamation sites as well as along the alignment and Tuen Mun-Chek Lap Kok Link (TMCLKL) (Figure 1). However, one sighting was made near the alignment of HKLR09 as mentioned above.

3.2.3. Sighting distribution of dolphins during the present impact phase monitoring period (September to November 2017) was drastically different from the one during the baseline monitoring period (Figure 1). In the present quarter, dolphins have 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).

3.2.4. 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 seldom sighted here, and mainly at the northwestern end 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 1.2 sightings and 5.2 dolphins per 100 km of survey effort respectively, while the encounter rates of sightings (STG) and dolphins (ANI) in NEL were both nil for this quarter.

Table 2. Dolphin encounter rates (sightings per 100 km of survey effort) during September-November 2017

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 (5 & 14 Sep 2017)	0.0	0.0
	Set 2 (21 & 25 Sep 2017)	0.0	0.0
	Set 3 (6 & 12 Oct 2017)	0.0	0.0
	Set 4 (17 & 19 Oct 2017)	0.0	0.0
	Set 5 (6 & 14 Nov 2017)	0.0	0.0
	Set 6 (23 & 28 Nov 2017)	0.0	0.0
Northwest Lantau	Set 1 (5 & 14 Sep 2017)	3.4	11.9
	Set 2 (21 & 25 Sep 2017)	3.3	8.3
	Set 3 (6 & 12 Oct 2017)	0.0	0.0
	Set 4 (17 & 19 Oct 2017)	0.0	0.0
	Set 5 (6 & 14 Nov 2017)	1.7	1.7
	Set 6 (23 & 28 Nov 2017)	0.0	0.0

3.3.3. In NEL, the average dolphin encounter rates (both STG and ANI) in the present three-month impact monitoring period were both zero with no on-effort sighting being made, and such extremely low occurrence of dolphins in NEL have also been consistently recorded in recent years of HZMB monitoring (Table 4).

Table 3. Comparison of average dolphin encounter rates from impact monitoring period (September – November 2017) 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 2017	**September – November 2011**	**September – November 2017**	**September – November 2011**
Northeast Lantau	0.0	6.0 ± 5.05	0.0	22.2 ± 26.81
Northwest Lantau	1.4 ± 1.65	9.9 ± 5.85	3.7 ± 5.17	44.7 ± 29.85

Table 4. Comparison of average dolphin encounter rates in Northeast Lantau survey area from the same autumn quarters of HKLR03 and HKBCF impact monitoring period 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*)	0.00	0.00
September-November 2015 (HKLR03 Impact*)	0.00	0.00
September-November 2016 (HKLR03 Impact*)	0.00	0.00
September-November 2017 (HKBCF Impact)	**0.00**	**0.00**

* 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

3.3.4. On the other hand, the average dolphin encounter rates (STG and ANI) in NWL during the present impact phase monitoring period (reductions of 85.7% and 91.8% respectively) were only very small fractions of the ones recorded during the three-month baseline period, indicating a dramatic decline in dolphin usage of this survey area as well during the present impact phase period (Table 5).

3.3.5. During the same autumn quarters (with comparison to past HKLR03 monitoring data), dolphin encounter rates in NWL during autumn 2017 was similar to the previous autumn period in and 2016, but was much lower than the ones in the summer periods of 2013, 2014 and 2015 (Table 5). Such temporal trend should be closely monitored in the upcoming monitoring quarters whether the dolphin occurrence would continue to increase as the construction activities of HZMB works have been mostly completed in coming months.

Table 5. Comparison of average dolphin encounter rates in Northwest Lantau survey area from all quarters of HKLR03 and HKBCF impact monitoring period 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 (HKBCF Impact)	**3.1 ± 1.91**	**10.4 ± 9.66**

* 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 0.0025 and 0.0156 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 dramatic 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 no sign of recovery of dolphin usage even though most of the marine works associated with the HZMB construction have been completed.

3.4. Group size

3.4.1. Group size of Chinese White Dolphins ranged from one to 12 individuals per group in North Lantau region during September to November 2017. 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 (September-November 2017) and baseline monitoring period (September-November 2011) (Note: ± denotes the standard deviation of average group size)

	Average Dolphin Group Size	
	September – November 2017	**September – November 2011**
Overall	4.2 ± 4.17 (n = 6)	3.7 ± 3.13 (n = 66)
Northeast Lantau	---	3.2 ± 2.16 (n = 17)
Northwest Lantau	4.2 ± 4.17 (n = 6)	3.9 ± 3.40 (n = 49)

3.4.2. The average dolphin group size in NWL waters during September to November 2017 was slightly higher 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 very small when compared to the 66 groups sighted during the baseline period (Table 6).

3.4.3. Notably, four of the six dolphin groups were composed of 1-4 individuals only, while there was one medium-sized group with five dolphins, and another large group with 12 dolphins (Appendix II).

3.4.4. 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. The medium-sized group with 5 dolphins was located to the west of the airport near the HKLR09 alignment, while the large group of 12 dolphins was sighted adjacent to the west

of Lung Kwu Chau (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 September to November 2017, the three of the six grids with high dolphin densities were located to the west of Lung Kwu Chau, north of Sha Chau and near the HKLR09 alignment (Figures 3a and 3b). Notably, all grids near HKBCF/HKLR03 reclamation sites as well as TMCLKL alignment did not record any presence of dolphins at all during on-effort search 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 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 near Lung Kwu Chau and Sha Chau during the present impact phase period (Figure 4).

3.6. Mother-calf pairs

3.6.1. During the present quarterly period, no young calf was sighted at all among the six groups of dolphins.

3.7. Activities and associations with fishing boats

3.7.1. One of the six dolphin groups (i.e. the large group located just to the west of Lung Kwu Chau; Figure 5) were engaged in socializing activity, while the rest of the groups were not engaged in feeding, 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 5).

3.7.3. Notably, none of the six 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 September to November 2017, over 1,000 digital photographs of Chinese White Dolphins were taken during the impact phase monitoring surveys for the photo-identification work.

3.8.2. In total, 18 individuals sighted 19 times altogether were identified (see summary table in Appendix III and photographs of identified individuals in Appendix IV). All of these re-sightings were made in NWL.

3.8.3. Among the 18 individuals, only one individual (i.e. CH34) was re-sighted twice, while the rest were only re-sighted once during the three-month period (Appendix III).

3.8.4. Notably, ten of these 18 individuals (i.e. CH34, NL12, NL49, NL104, NL136, NL182, NL202, NL320, NL321 and WL05) were also sighted in Northwest Lantau during the HKLR03 monitoring surveys conducted concurrently in the same three-month period. Moreover, six individuals (i.e. CH34, NL12, NL49, NL182, NL317, and WL05) were also sighted in West Lantau waters during the HKLR09 monitoring surveys from September to November 2017, showing their extensive individual movements across different survey areas.

3.9. Individual range use

3.9.1. Ranging patterns of the 18 individuals identified during the three-month study period were determined by fixed kernel method, and are shown in Appendix V.

3.9.2. All identified dolphins sighted in the present quarter were utilizing NWL waters only, but have completely avoided NEL waters where many of them have utilized as their core areas in the past (Appendix V). This is 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, some individuals (NL12, NL182 and WL05) consistently utilized North Lantau waters in the past 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, as such shift could possibly be related to the HZMB-related construction works (see Hung 2017).

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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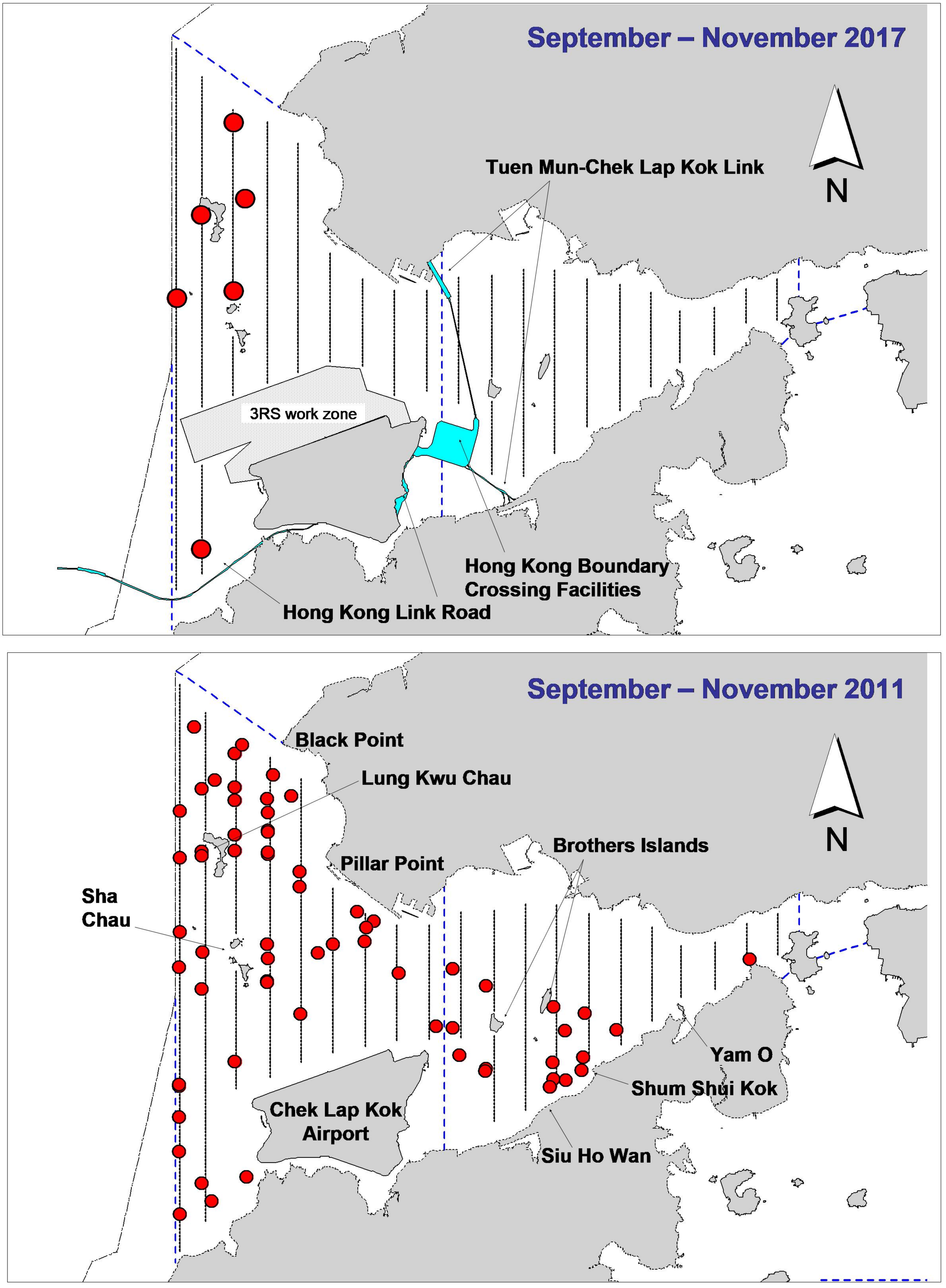


Figure 1. Distribution of Chinese white dolphin sighting in Northwest and Northeast Lantau during HKBCF impact phase (top) and baseline monitoring surveys (bottom)

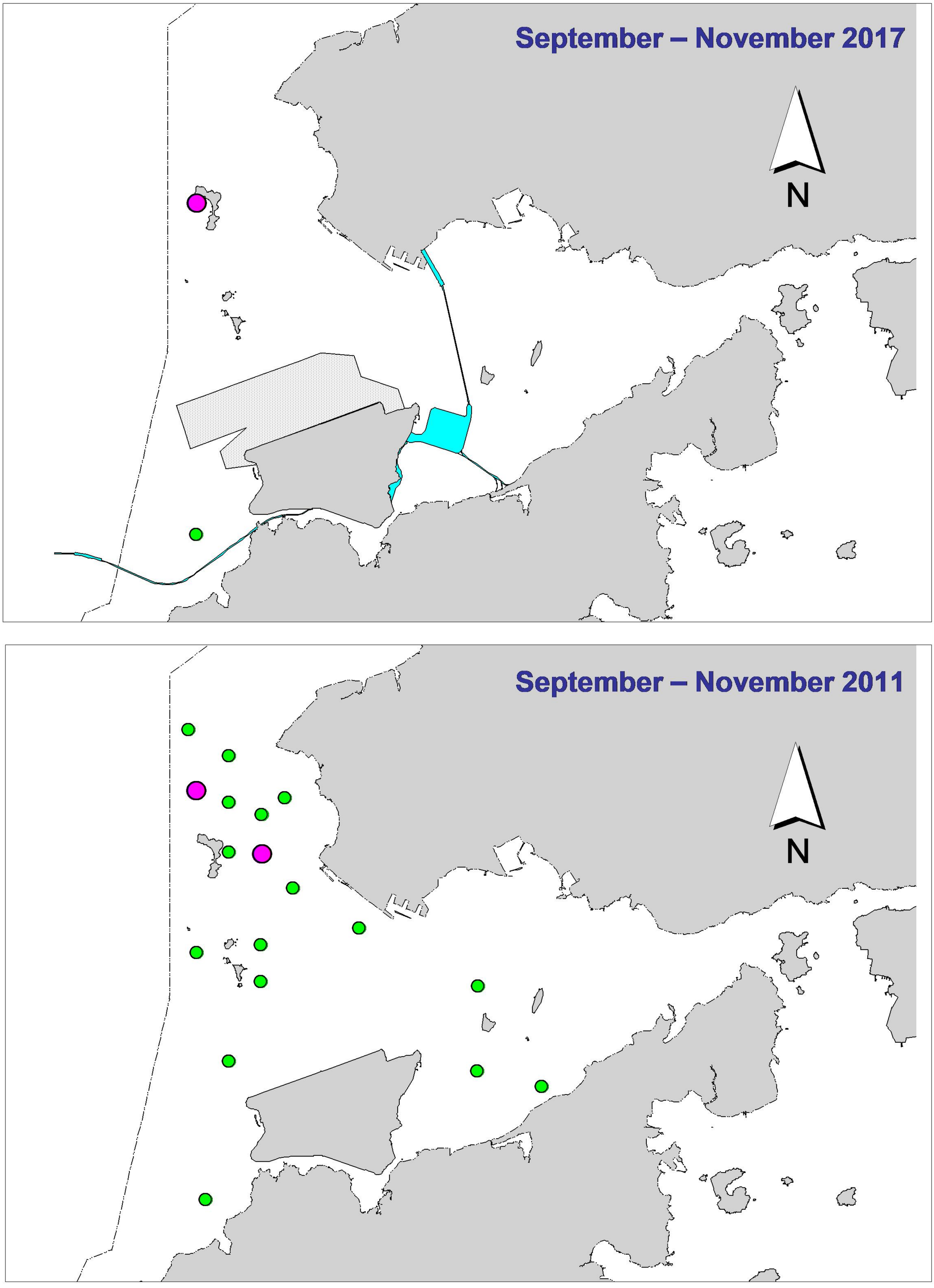


Figure 2. Distribution of Chinese white dolphins with larger group sizes during HKBCF impact phase (top) and baseline monitoring surveys (bottom) (green dots: group sizes of 5 or more; purple dots: group sizes of 10 or more)

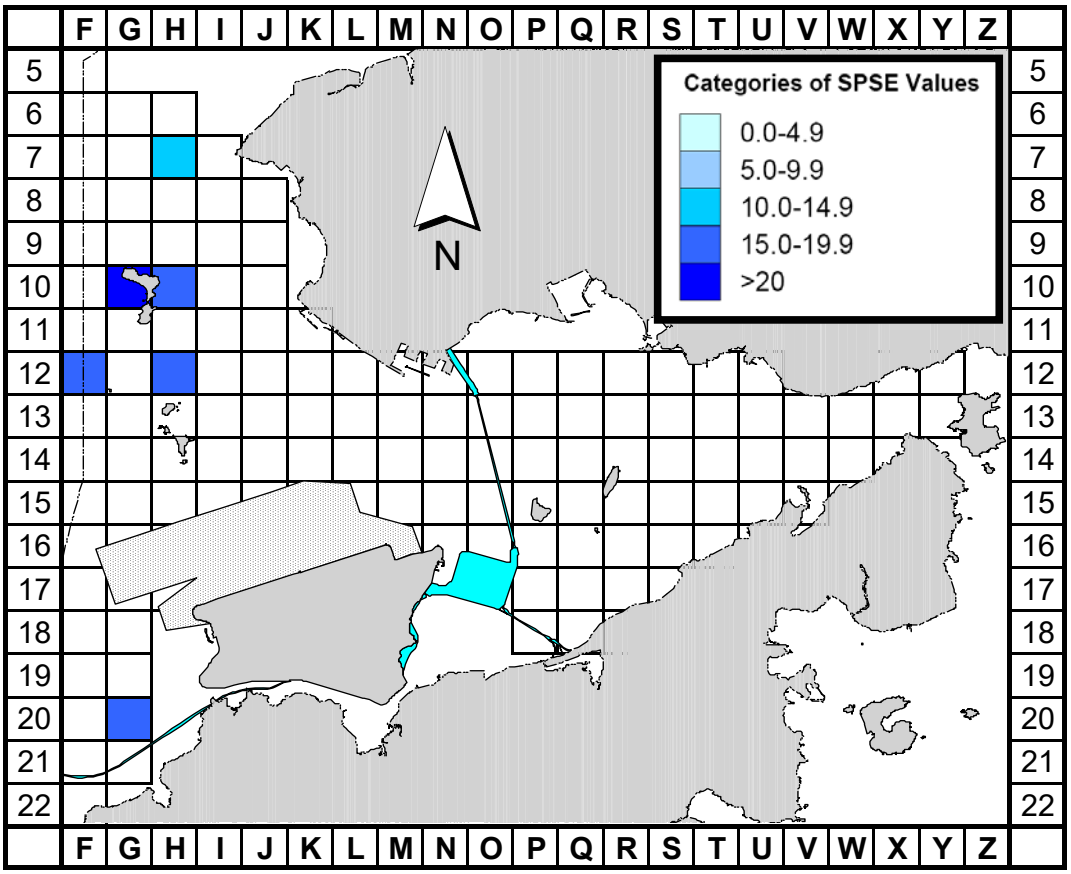


Figure 3a. Sighting density of Chinese white dolphins with corrected survey effort per km^2 in Northeast and Northwest Lantau survey areas, using data collected during HKBCF impact monitoring period monitoring period (Sep-Nov 17) (SPSE = no. of on-effort sightings per 100 units of survey effort)

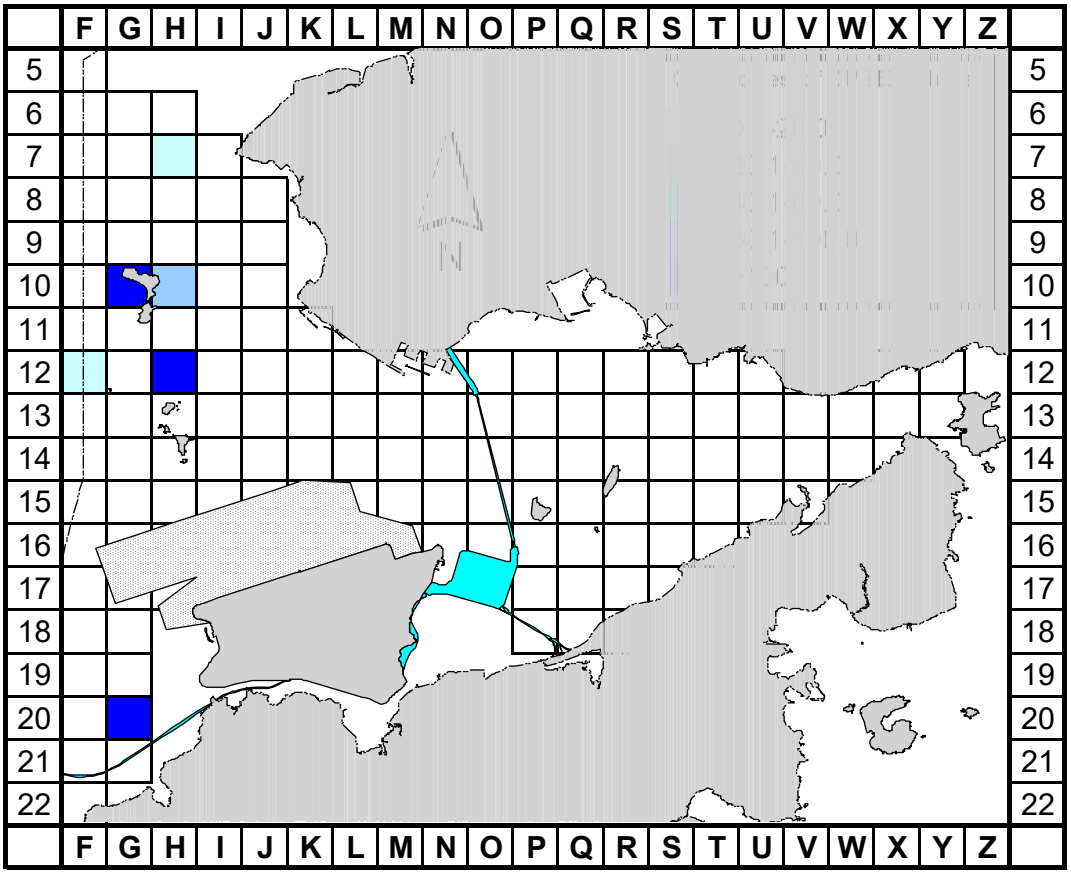


Figure 3b. Density of Chinese white dolphins with corrected survey effort per km^2 in Northeast and Northwest Lantau survey areas, using data collected during HKBCF impact monitoring period (Sep-Nov 17) (DPSE = no. of dolphins per 100 units of survey effort)

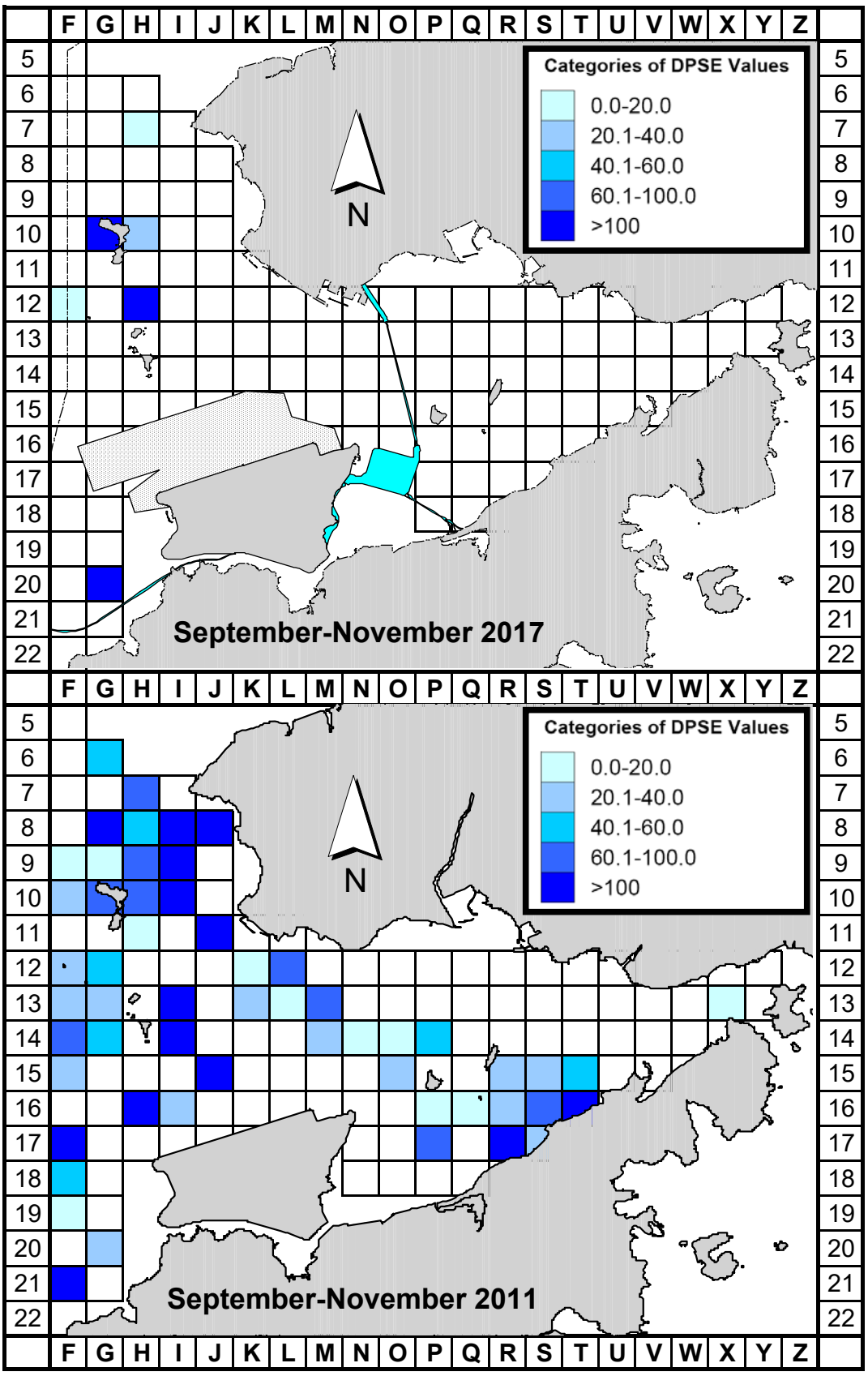


Figure 4. Comparison of density of Chinese white dolphins with corrected survey effort per km^2 in Northwest and Northeast Lantau survey area between the HKBCF impact monitoring period September-November 2017) and baseline monitoring period (September-November 2011) (DPSE = no. of dolphins per 100 units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

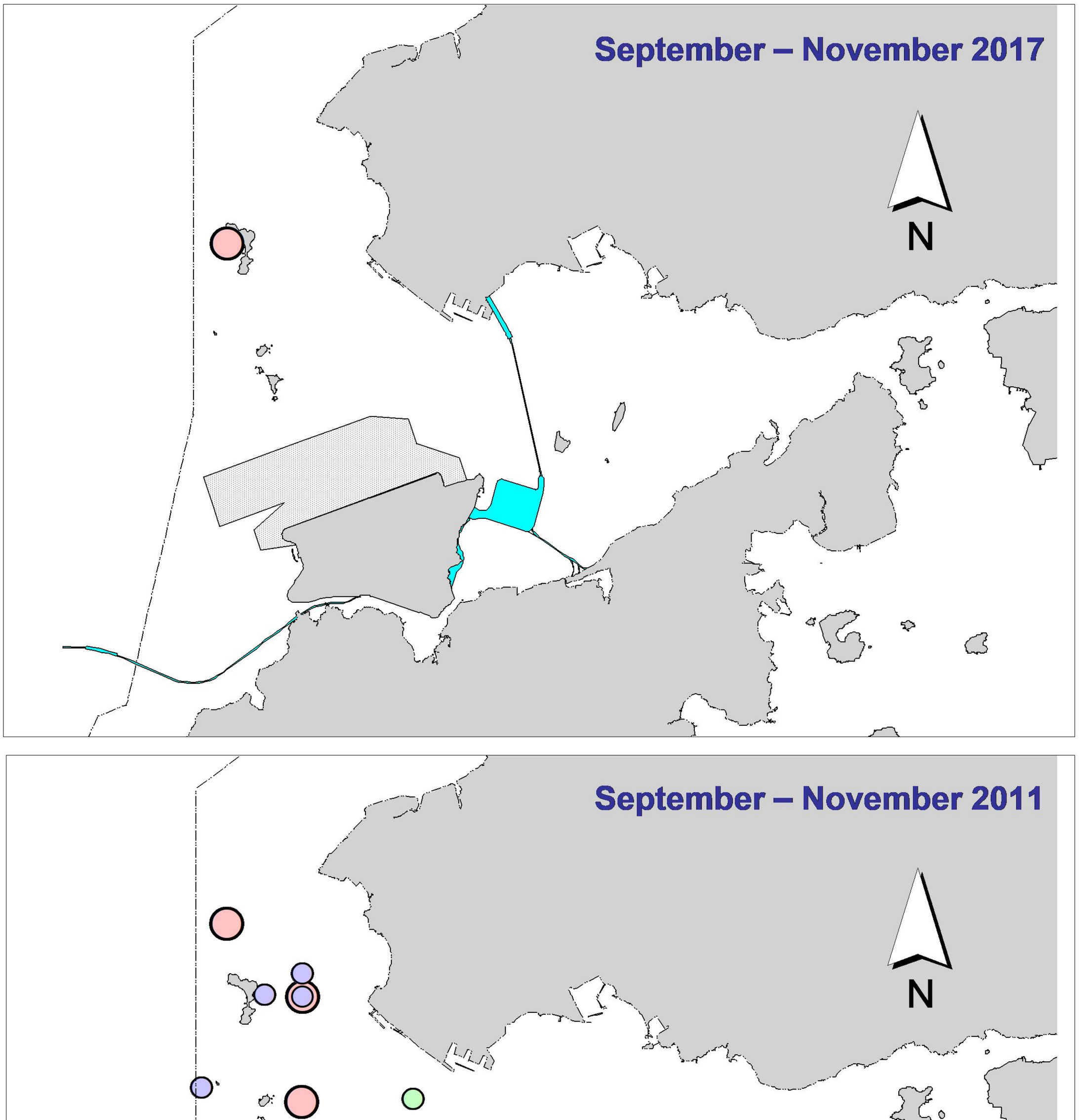


Figure 5. Distribution of Chinese white dolphins engaged in feeding (purple dots), socializing (pink dots) and traveling (green dots) activities during HKBCF impact phase (top) and baseline monitoring surveys (bottom)

Annex I. HKBCF Survey Effort Database (September-November 2017)

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

DATE	AREA	BEAU	EFFORT	SEASON	VESSEL	TYPE	P/S
5-Sep-17	NW LANTAU	2	16.02	AUTUMN	STANDARD36826	HKBCF	P
5-Sep-17	NW LANTAU	3	8.63	AUTUMN	STANDARD36826	HKBCF	P
5-Sep-17	NW LANTAU	2	6.47	AUTUMN	STANDARD36826	HKBCF	S
5-Sep-17	NW LANTAU	3	4.47	AUTUMN	STANDARD36826	HKBCF	S
5-Sep-17	NE LANTAU	2	21.92	AUTUMN	STANDARD36826	HKBCF	P
5-Sep-17	NE LANTAU	3	13.97	AUTUMN	STANDARD36826	HKBCF	P
5-Sep-17	NE LANTAU	2	10.56	AUTUMN	STANDARD36826	HKBCF	S
5-Sep-17	NE LANTAU	3	1.85	AUTUMN	STANDARD36826	HKBCF	S
14-Sep-17	NW LANTAU	2	9.06	AUTUMN	STANDARD36826	HKBCF	P
14-Sep-17	NW LANTAU	3	25.07	AUTUMN	STANDARD36826	HKBCF	P
14-Sep-17	NW LANTAU	2	5.67	AUTUMN	STANDARD36826	HKBCF	S
14-Sep-17	NW LANTAU	3	6.90	AUTUMN	STANDARD36826	HKBCF	S
21-Sep-17	NW LANTAU	1	10.28	AUTUMN	STANDARD36826	HKBCF	P
21-Sep-17	NW LANTAU	2	24.36	AUTUMN	STANDARD36826	HKBCF	P
21-Sep-17	NW LANTAU	1	1.22	AUTUMN	STANDARD36826	HKBCF	S
21-Sep-17	NW LANTAU	2	12.10	AUTUMN	STANDARD36826	HKBCF	S
21-Sep-17	NE LANTAU	2	23.33	AUTUMN	STANDARD36826	HKBCF	P
21-Sep-17	NE LANTAU	3	4.20	AUTUMN	STANDARD36826	HKBCF	P
21-Sep-17	NE LANTAU	2	7.47	AUTUMN	STANDARD36826	HKBCF	S
21-Sep-17	NE LANTAU	3	0.90	AUTUMN	STANDARD36826	HKBCF	S
25-Sep-17	NE LANTAU	2	6.73	AUTUMN	STANDARD36826	HKBCF	P
25-Sep-17	NE LANTAU	3	2.11	AUTUMN	STANDARD36826	HKBCF	P
25-Sep-17	NE LANTAU	2	2.36	AUTUMN	STANDARD36826	HKBCF	S
25-Sep-17	NW LANTAU	2	8.74	AUTUMN	STANDARD36826	HKBCF	P
25-Sep-17	NW LANTAU	3	16.74	AUTUMN	STANDARD36826	HKBCF	P
25-Sep-17	NW LANTAU	2	3.18	AUTUMN	STANDARD36826	HKBCF	S
25-Sep-17	NW LANTAU	3	7.54	AUTUMN	STANDARD36826	HKBCF	S
6-Oct-17	NW LANTAU	2	15.46	AUTUMN	STANDARD36826	HKBCF	P
6-Oct-17	NW LANTAU	3	19.54	AUTUMN	STANDARD36826	HKBCF	P
6-Oct-17	NW LANTAU	2	7.20	AUTUMN	STANDARD36826	HKBCF	S
6-Oct-17	NW LANTAU	3	6.20	AUTUMN	STANDARD36826	HKBCF	S
6-Oct-17	NE LANTAU	2	16.90	AUTUMN	STANDARD36826	HKBCF	P
6-Oct-17	NE LANTAU	3	18.40	AUTUMN	STANDARD36826	HKBCF	P
6-Oct-17	NE LANTAU	2	7.60	AUTUMN	STANDARD36826	HKBCF	S
6-Oct-17	NE LANTAU	3	6.40	AUTUMN	STANDARD36826	HKBCF	S
12-Oct-17	NW LANTAU	2	19.17	AUTUMN	STANDARD36826	HKBCF	P
12-Oct-17	NW LANTAU	3	6.73	AUTUMN	STANDARD36826	HKBCF	P
12-Oct-17	NW LANTAU	2	5.59	AUTUMN	STANDARD36826	HKBCF	S
12-Oct-17	NW LANTAU	3	4.33	AUTUMN	STANDARD36826	HKBCF	S
17-Oct-17	NW LANTAU	2	11.40	AUTUMN	STANDARD36826	HKBCF	P
17-Oct-17	NW LANTAU	3	14.40	AUTUMN	STANDARD36826	HKBCF	P
17-Oct-17	NW LANTAU	2	3.90	AUTUMN	STANDARD36826	HKBCF	S
17-Oct-17	NW LANTAU	3	6.90	AUTUMN	STANDARD36826	HKBCF	S
17-Oct-17	NE LANTAU	2	36.66	AUTUMN	STANDARD36826	HKBCF	P
17-Oct-17	NE LANTAU	2	12.04	AUTUMN	STANDARD36826	HKBCF	S
19-Oct-17	NW LANTAU	2	13.37	AUTUMN	STANDARD36826	HKBCF	P
19-Oct-17	NW LANTAU	3	17.70	AUTUMN	STANDARD36826	HKBCF	P
19-Oct-17	NW LANTAU	4	1.20	AUTUMN	STANDARD36826	HKBCF	P
19-Oct-17	NW LANTAU	2	7.63	AUTUMN	STANDARD36826	HKBCF	S
19-Oct-17	NW LANTAU	3	10.20	AUTUMN	STANDARD36826	HKBCF	S

Annex 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-17	NW LANTAU	2	10.92	AUTUMN	STANDARD36826	HKBCF	P
6-Nov-17	NW LANTAU	3	21.13	AUTUMN	STANDARD36826	HKBCF	P
6-Nov-17	NW LANTAU	2	7.10	AUTUMN	STANDARD36826	HKBCF	S
6-Nov-17	NW LANTAU	3	4.45	AUTUMN	STANDARD36826	HKBCF	S
6-Nov-17	NE LANTAU	1	4.96	AUTUMN	STANDARD36826	HKBCF	P
6-Nov-17	NE LANTAU	2	28.51	AUTUMN	STANDARD36826	HKBCF	P
6-Nov-17	NE LANTAU	3	2.80	AUTUMN	STANDARD36826	HKBCF	P
6-Nov-17	NE LANTAU	1	2.40	AUTUMN	STANDARD36826	HKBCF	S
6-Nov-17	NE LANTAU	2	7.23	AUTUMN	STANDARD36826	HKBCF	S
6-Nov-17	NE LANTAU	3	1.00	AUTUMN	STANDARD36826	HKBCF	S
14-Nov-17	NW LANTAU	2	12.06	AUTUMN	STANDARD36826	HKBCF	P
14-Nov-17	NW LANTAU	3	14.63	AUTUMN	STANDARD36826	HKBCF	P
14-Nov-17	NW LANTAU	2	4.60	AUTUMN	STANDARD36826	HKBCF	S
14-Nov-17	NW LANTAU	3	5.11	AUTUMN	STANDARD36826	HKBCF	S
23-Nov-17	NW LANTAU	3	16.80	AUTUMN	STANDARD36826	HKBCF	P
23-Nov-17	NW LANTAU	4	10.19	AUTUMN	STANDARD36826	HKBCF	P
23-Nov-17	NW LANTAU	2	1.00	AUTUMN	STANDARD36826	HKBCF	S
23-Nov-17	NW LANTAU	3	6.61	AUTUMN	STANDARD36826	HKBCF	S
23-Nov-17	NW LANTAU	4	4.40	AUTUMN	STANDARD36826	HKBCF	S
23-Nov-17	NE LANTAU	2	18.00	AUTUMN	STANDARD36826	HKBCF	P
23-Nov-17	NE LANTAU	3	17.50	AUTUMN	STANDARD36826	HKBCF	P
23-Nov-17	NE LANTAU	4	0.70	AUTUMN	STANDARD36826	HKBCF	P
23-Nov-17	NE LANTAU	2	6.00	AUTUMN	STANDARD36826	HKBCF	S
23-Nov-17	NE LANTAU	3	7.40	AUTUMN	STANDARD36826	HKBCF	S
28-Nov-17	NW LANTAU	2	21.36	AUTUMN	STANDARD36826	HKBCF	P
28-Nov-17	NW LANTAU	3	12.50	AUTUMN	STANDARD36826	HKBCF	P
28-Nov-17	NW LANTAU	2	10.14	AUTUMN	STANDARD36826	HKBCF	S

Annex II. HKBCF Chinese White Dolphin Sighting Database (September-November 2017)

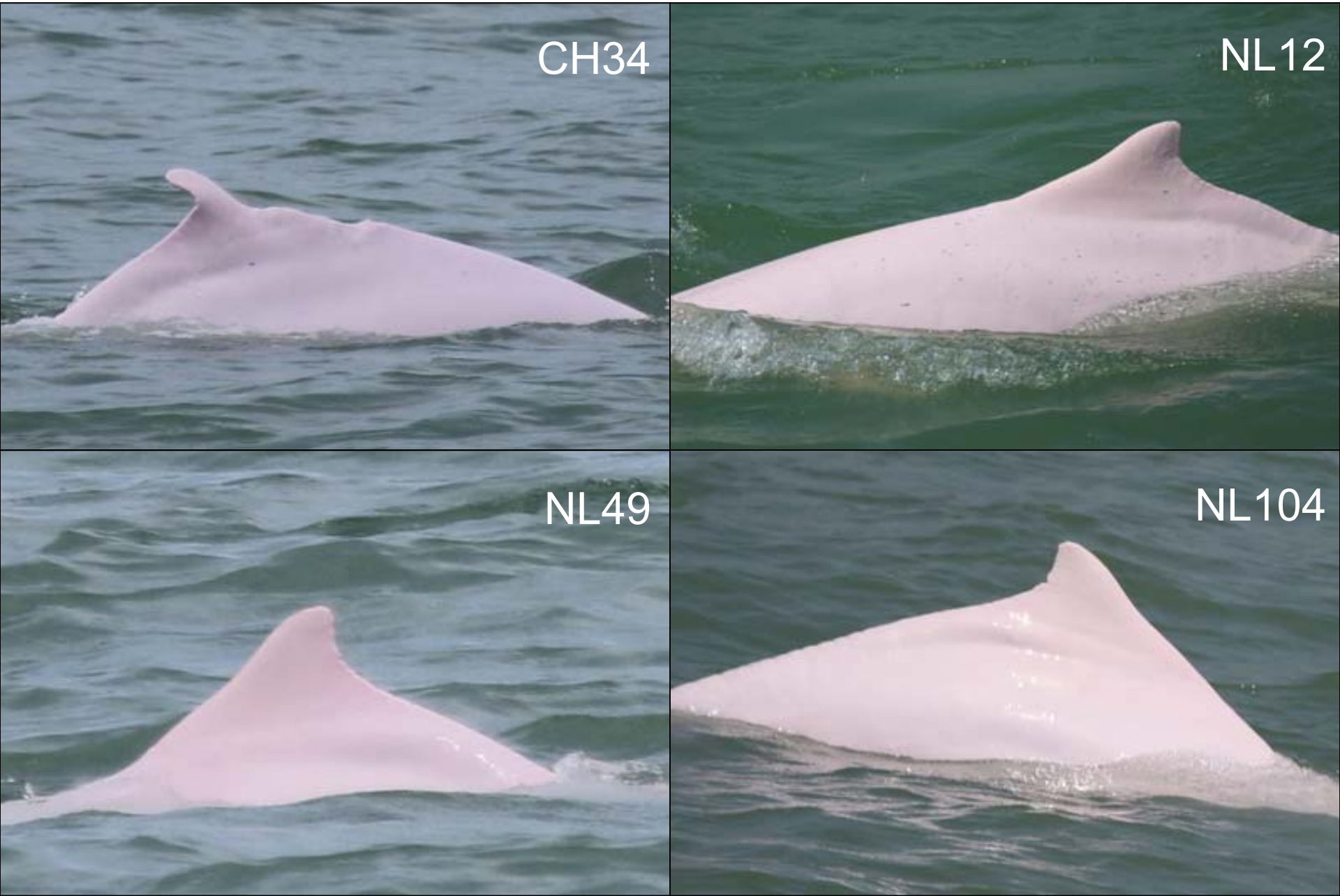
(Abberviations: STG# = Sighting Number; HRD SZ = Dolphin Herd Size; BEAU = Beaufort Sea State; PSD = Perpendicular Distance; BOAT ASSOC. = Fishing Boat Association; P/S: Sighting Made on Primary/Secondary Lines)

DATE	STG #	TIME	HRD SZ	AREA	BEAU	PSD	EFFORT	TYPE	NORTHING	EASTING	SEASON	BOAT ASSOC.	P/S
5-Sep-17	1	1014	5	NW LANTAU	2	101	ON	HKBCF	816642	805426	AUTUMN	NONE	P
5-Sep-17	2	1214	2	NW LANTAU	2	670	ON	HKBCF	826960	806796	AUTUMN	NONE	P
21-Sep-17	1	1054	1	NW LANTAU	1	796	ON	HKBCF	824041	804659	AUTUMN	NONE	P
21-Sep-17	2	1200	4	NW LANTAU	2	73	ON	HKBCF	824247	806431	AUTUMN	NONE	P
12-Oct-17	1	1158	12	NW LANTAU	2	460	ON	HKBCF	826486	805415	AUTUMN	NONE	S
6-Nov-17	1	1133	1	NW LANTAU	2	285	ON	HKBCF	829220	806451	AUTUMN	NONE	P

Annex III. Individual dolphins identified during HKBCF monitoring surveys in September - November 2017

ID#	DATE	STG#	AREA
CH34	05/09/17	1	NW LANTAU
	06/11/17	1	NW LANTAU
NL12	12/10/17	1	NW LANTAU
NL49	05/09/17	1	NW LANTAU
NL104	12/10/17	1	NW LANTAU
NL136	05/09/17	1	NW LANTAU
NL182	12/10/17	1	NW LANTAU
NL202	05/09/17	2	NW LANTAU
NL233	12/10/17	1	NW LANTAU
NL259	05/09/17	1	NW LANTAU
NL280	12/10/17	1	NW LANTAU
NL302	21/09/17	2	NW LANTAU
NL317	12/10/17	1	NW LANTAU
NL320	12/10/17	1	NW LANTAU
NL321	12/10/17	1	NW LANTAU
WL05	05/09/17	1	NW LANTAU
WL15	21/09/17	2	NW LANTAU
WL188	12/10/17	1	NW LANTAU
WL278	21/09/17	2	NW LANTAU

Annex IV. Eighteen individual dolphins that were identified during September to November 2017 under HKBCF impact phase monitoring surveys



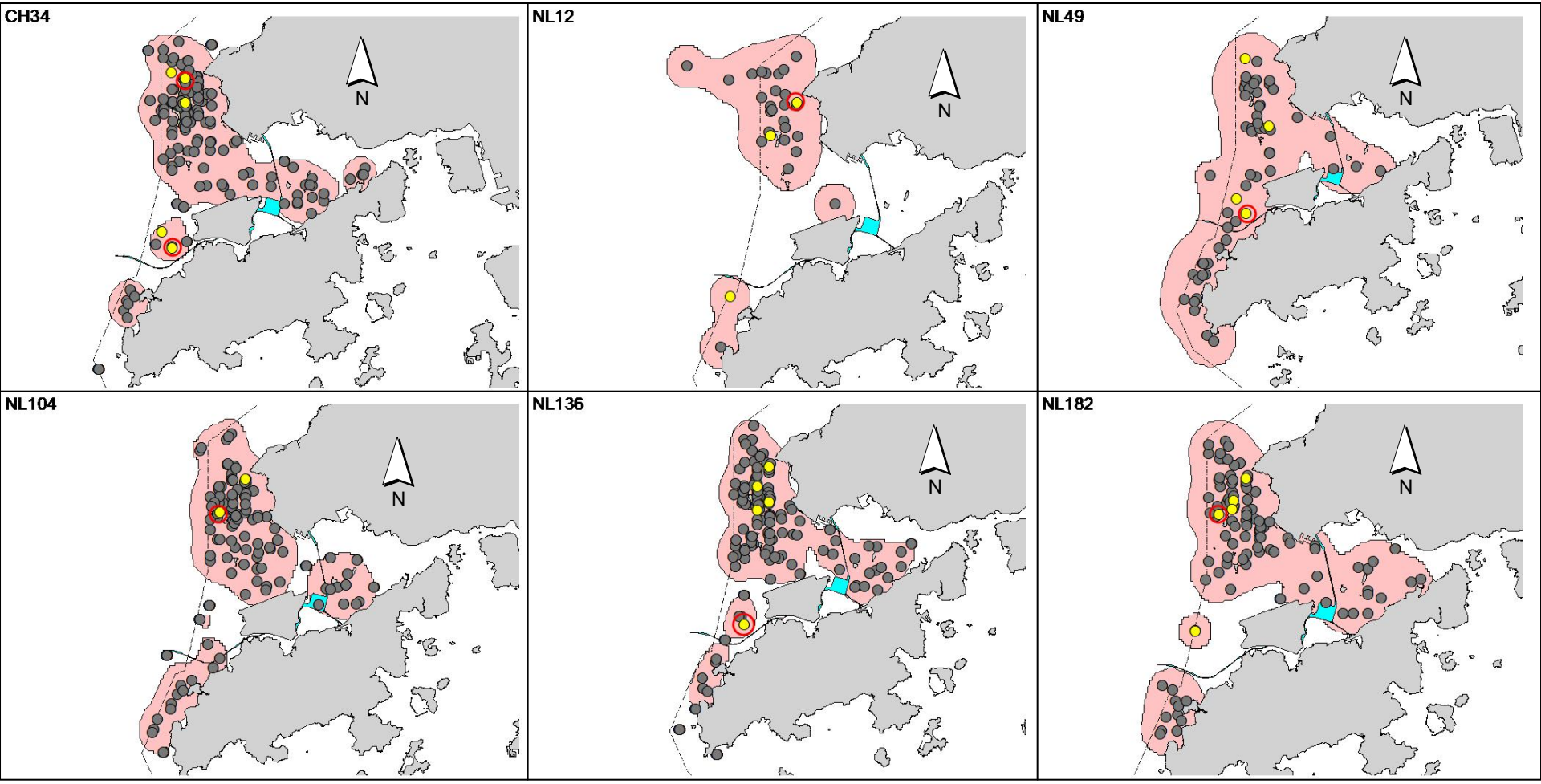
Annex IV. (cont'd)

Annex IV. (cont'd)

Annex IV. (cont'd)

Annex IV. (cont'd)

Annex V. Ranging patterns (95 % kernel ranges) of 18 individual dolphins that were sighted during HKBCF impact phase monitoring period (note: yellow dots with red circles indicate sightings made in September – November 2017 during HKBCF monitoring surveys; other yellow dots indicate the ones made during HKLR03 & HKLR09 monitoring surveys)



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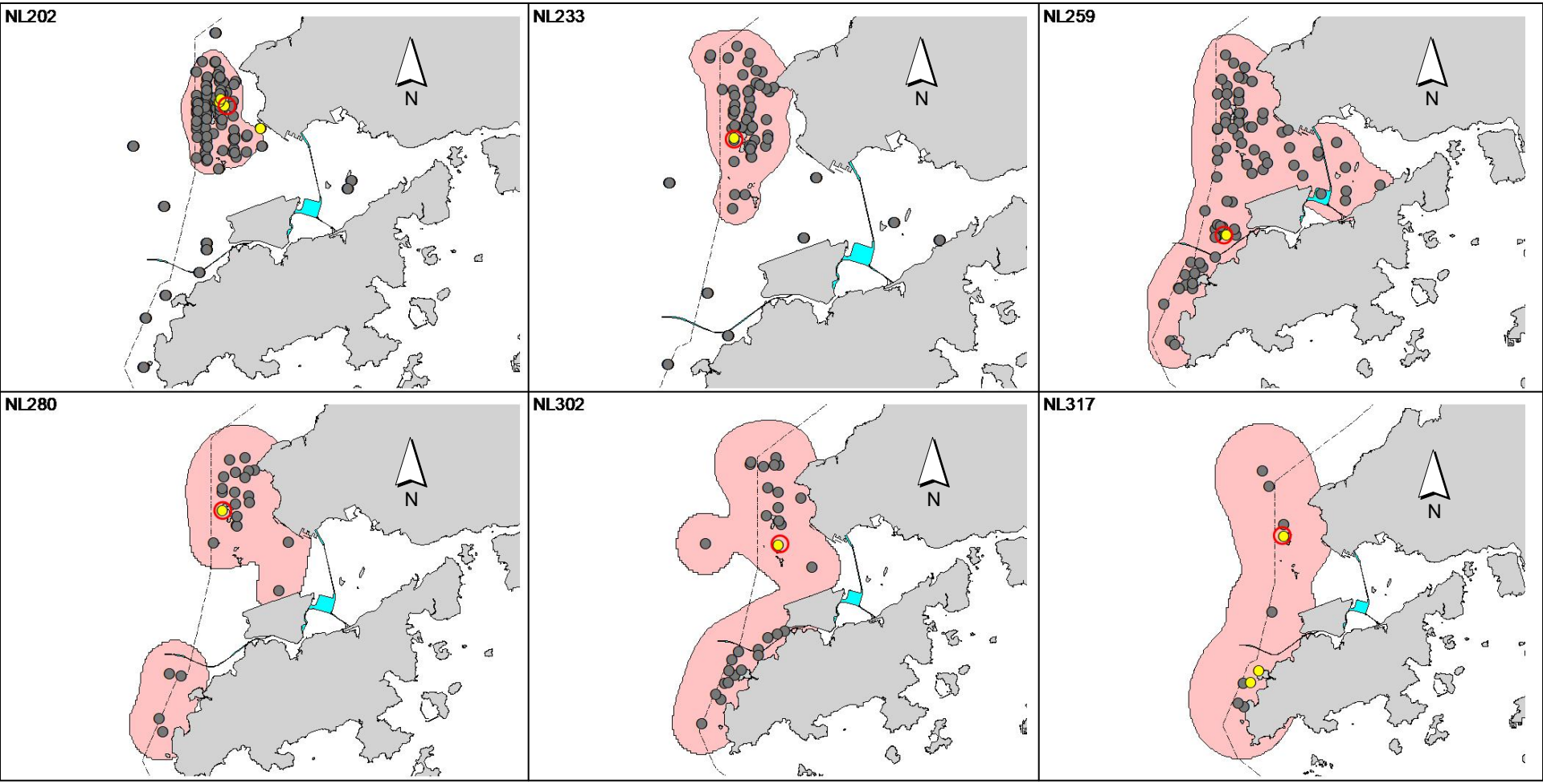
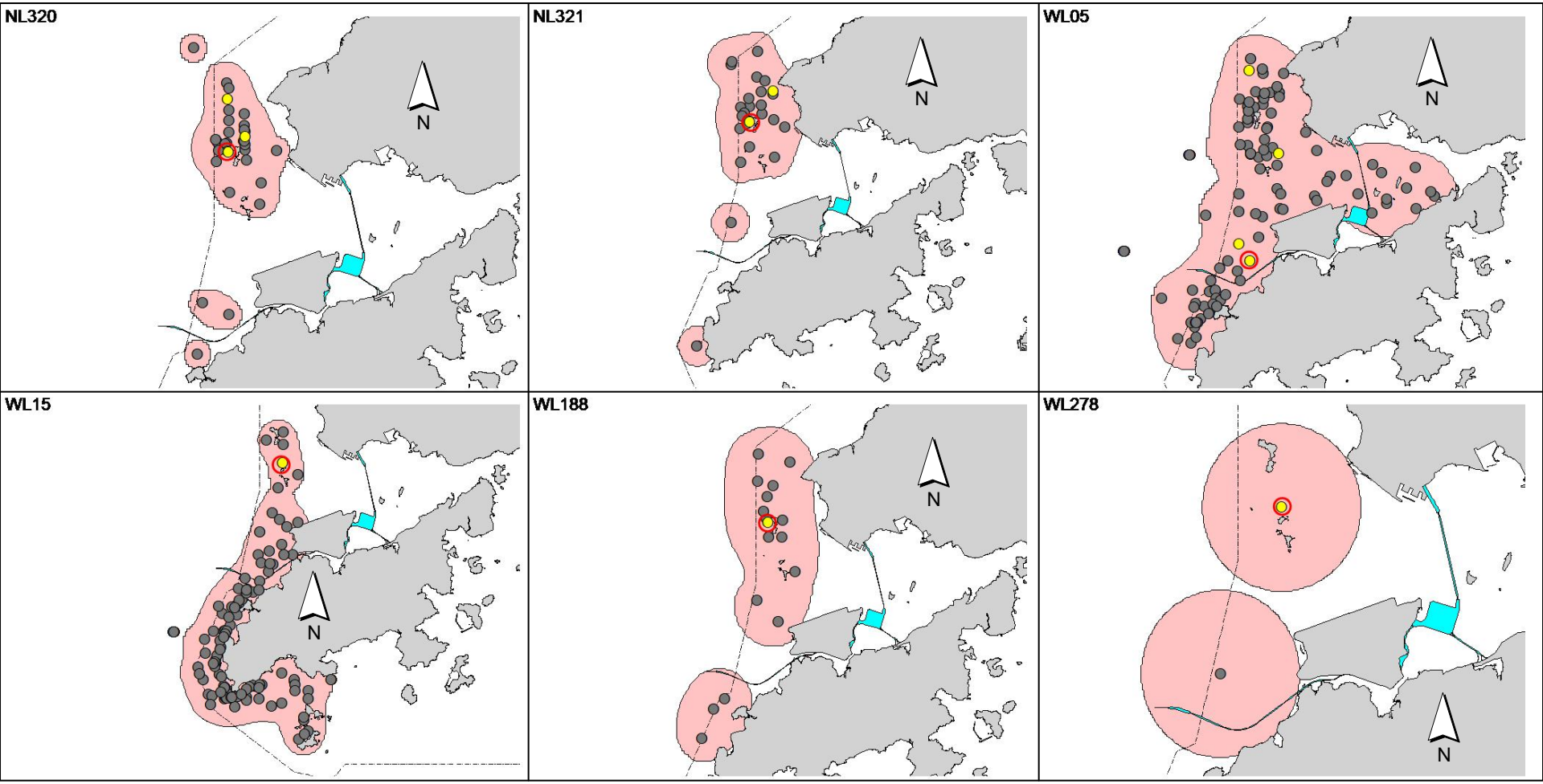
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