Gammon Construction Limited	Gammon

Proposal for Land-Based Theodolite Tracking of Chinese White Dolphins

for

Contract No. HY/2012/07 Tuen Mun Chek Lap Kok Link – Southern Connection Viaduct Section

J3518

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Hong Kong-Zhuhai-Macao Bridge
Tuen Mun – Chek Lap Kok Link (Southern Connection Viaduct Section)
Proposal for Land-based Dolphin Behavioural and Movement Monitoring

Prepared by Hong Kong Cetacean Research Project
(Professor Bernd Würsig, Dr. David Lundquist and Dr. Samuel Hung)

September 5, 2013

1. INTRODUCTION

The Tuen Mun-Chek Lap Kok Link (TM-CLKL) comprises a 1.6 km long dual 2-lane viaduct section between the Hong Kong Boundary Crossing Facilities (HKBCF) and the North Lantau Highway and associated roads at Tai Ho. Gammon Construction Limited (hereinafter called the "Contractor") was awarded as the main contractor of "Contract No. HY/2012/07 – Hong Kong-Zhuhai-Macao Bridge Tuen Mun-Chek Lap Kok Link – Southern Connection Viaduct Section".

According to the TM-CLKL EM&A Manual, a number of environmental monitoring and audit (EM&A) works related to Chinese white dolphins (a.k.a Indo-Pacific humpback dolphins, *Sousa chinensis*) shall be conducted during baseline, construction and post-construction phases, including land-based dolphin behavioural and movement monitoring, to record and note any changes in response of dolphins to the bored piling noise. Such monitoring shall be undertaken by qualified dolphin specialist, who have sufficient relevant post-graduate experience and publication in the respective aspects. Approval on the specialist responsible for land-based dolphin behavioural and movement monitoring shall be sought from AFCD and EPD.

This land-based dolphin behavioural and movement monitoring proposal will detail the methodology as well as personnel arrangement/qualification to meet the requirement in the particular specification and EM&A Manual. It is prepared and submitted for approval of the baseline, construction and post-construction monitoring works. It should also be noted that the land-based theodolite monitoring will not be carried out concurrently with the underwater noise monitoring and acoustic behaviour monitoring for both baseline and construction phase monitoring.

2. LAND-BASED DOLPHIN BEHAVIOURAL AND MOVEMENT MONITORING PROGRAMME

2.1. Requirements under the EM&A Manual

Under the TM-CLKL EM&A Manual, the land-based dolphin behavioural and movement monitoring in relation to bored piling activities is required with several clauses:

- *Clause 6.4.5.7:* The objective of the land-based theodolite tracking of dolphins is to monitor their movements and behaviour near the bored piling works site before, during and after the works and record and note any changes in response to the bored piling noise. The details of the land-based dolphin tracking methodology and frequency will be defined in a specification prepared during detailed design phase. However, as a minimum the monitoring is likely to comprise 30 days before, 30 days during and 30 days after bored piling works.

- *Clause 6.4.5.8:* This monitoring would consist of data acquisition and analyses of movement and behavioural information of CWD, as gained from a 5-sec. resolution conventional theodolite and a 5-sec. resolution "total station" theodolite with laser range-finding capability, appropriate hand-held range finders, binoculars with distance-measuring reticles and built-in compass, recording gear of digital voice recorder, data sheets, and computer slaved to theodolites.

- *Clause 6.4.5.9*: Two experienced theodolite/behavioural data gathering operators should undertake the monitoring. The primary and secondary theodolite operators should have at least ten years of theodolite and behavioural data gathering and analysis experience, at least three technical publications to cover the subject, and appropriate long-term familiarity with the latest version of the tracking program "Pythagoras". These experienced operators need to have further experience in detailed power analyses for efficient evaluation of number of samples and time/energy needed for statistical evaluations.

2.2. Monitoring Location – Pak Mong Station

To conduct the land-based monitoring on dolphin behaviour and movement, HKCRP research team has set up a theodolite-tracking station at Pak Mong near Tai Ho Wan in August 2013 with the assistance of Professor Bernd Würsig and Ms. Sarah Piwetz, following the same methodology that was used to set up other well-established theodolite tracking stations in Hong Kong since 2011 (Hung 2012, 2013; Piwetz et al. 2012).

The Pak Mong station near Tai Ho Wan is located near the northeast coast of Lantau Island (GPS position: 22°17.86' N and 113°57.98' E; Figure 1). The station was selected based on its height above sea level (minimum requirement of over 20 m; Würsig et al. 1991), close proximity to shore, and relatively unobstructed views of the TM-CLKL alignment (see panoramic view from the station in Figure 2). The height of Pak Mong station established by HKCRP team is 24.88 m high at mean low water (or 24.73 m relative to mPD) and 170 m from shore. Moreover, the station is only situated 650-780 m from the six bored piling sites of TM-CLKL southern viaduct section that will be monitored during the present study (i.e. Piers B1-3, B5-7; Figure 1), which will be ideal for the purpose of the present behavioural and movement monitoring in relation to the TM-CLKL bored piling works.

2.3. Monitoring Frequency

According to the EM&A Manual, dolphin behaviour in response to bored piling works and movement near the bored piling sites should be monitored for a minimum of 30 days before, 30 days during and 30 days after bored piling works near the works site. The monitoring frequency is consistent with other EM&A programs for the HZMB works, including the Hong Kong Link Road bored piling monitoring programme.

Thirty days (with 5-6 hours on each survey day) of monitoring will be planned for the baseline, construction and post-construction phases respectively, with the tentative commencement date of baseline monitoring to be late August 2013. It should be noted that every attempt will be made to conduct the monitoring works in favourable weather conditions (Beaufort Sea State 3 or below; good visibility of 3 km or above), and such works will not be conducted under adverse weather condition (e.g. with heavy rain, poor visibility and monsoon). Due to the fluctuating weather condition in the area during different times of the day and among the four seasons, the HKCRP team will aim to collect at least 80% of the total survey effort in favourable conditions in order to generate an adequate amount of data for various analyses.

2.4. Monitoring Methodology

The methodology of the present monitoring programme generally follows the one established under the Piwetz et al. 2012 study, which is also part of the AFCD long-term marine mammal monitoring programme (Hung 2012, 2013). On each survey day, observers will search systematically for Chinese white dolphins using the unaided eye and handheld binoculars (7 x 50) from the Pak Mong Station, overlooking the viaduct alignment to the northeast coast of Lantau

Island, in particular the area around the six bored pile sites as indicated in Figure 1. Notably, all six bored piling sites will be monitored during baseline phase, while three of these six sites will be chosen for construction phase and post-construction phase monitoring when the initial phase of the construction schedule is confirmed.

A theodolite tracking session will be initiated when an individual dolphin or group of dolphins is located, and focal follow methods will be used to track the dolphins. Within a group, a focal individual will be selected for the purposes of tracking the behaviour and movement of the group, based on its distinctive feature such as colouration or severe injury mark. The focal individual will then be tracked continuously via the theodolite, with positions recorded whenever the dolphin surfaces. If an individual cannot be positively distinguished from other members, the group will be tracked by recording positions based on a central point within the group when the dolphins surface.

Tracking will continue until animals are lost from view, move beyond the range of reliable visibility (> 5 km), or when environmental conditions obstruct visibility (e.g. intense haze). Behavioural state data (Table 1) will also be recorded every 5 minutes for the focal individual or group. This interval is long enough to allow for determination of the behavioural state, and short enough to capture behavioural responses to the bored piling activities. Moreover, when multiple groups or individuals are present in the study area, attempts will be made to record the behaviours of all groups/individuals every 10 minutes, with spotters assisting in determining behaviour of the dolphins.

Positions of dolphins, boats and construction activities will be measured using a Sokkisha DT5 digital theodolite with ± 5-sec precision and 30-power magnification connected to a laptop computer running the program *Pythagoras* Version 1.2 (Gailey and Ortega-Ortiz 2002). This program calculates a real-time conversion of horizontal and vertical angles collected by the theodolite into geographic positions of latitude and longitude each time a fix is initiated. *Pythagoras* also displays positions, movements, and distances in real-time. When possible, the position of the focal dolphin will be recorded at every surfacing with use of *Pythagoras*. The position, type, and activity of all vessels within 5 km of the focal dolphin will also be recorded. An effort will be made to obtain at least several positions for each vessel, and additional positions will be acquired when vessels change course or speed.

While the primary source of human disturbance to dolphins of interest in this study is bored piling works for the TM-CLKL Project, the presence of vessels may also have an effect on the behaviour and movement patterns of dolphins. Prior to the construction phase (i.e. baseline phase), the simultaneous tracking of dolphins and boats over time will provide information on the speed and orientation of dolphins, as well as their movements in relation to vessel activities. This data will be used as a baseline for comparison once construction begins. Other construction activities and vessel movements in relation to the bored piling works will be recorded during the construction phase monitoring, and the same theodolite tracking and behavioural procedures will be followed as during baseline phase.

2.5. Data Analysis

2.5.1. Assessment on potential impacts from bored piling activities

2.5.1.1. Movement patterns

To evaluate if dolphin behaviour or movement patterns vary in the presence of vessels in the baseline phase, it is necessary to determine how many vessels are present with the focal group at any time. A vessel will be considered to be present with the focal dolphin when the two are within 500 metres of each other. Data recorded in *Pythagoras* will be used to calculate dolphin and vessel positions in latitude and longitude for this comparison. If two consecutive fixes in a track for one dolphin are more than 300 seconds apart, the track will be split at this point, which will be analysed separately. Dolphin and vessel positions will be interpolated every 150 seconds, assuming linear travel at a constant speed between subsequent positions. Distance between the focal individual/group and each vessel will be calculated to determine how many vessels are within 500 metres of the group at each point.

Tracks will be split into 10-minute segments and the maximum number and type of vessels present calculated for each segment, as well as bored piling activity state during the construction phase. Response variables, including mean leg speed, mean inter-breath interval, reorientation rate and linearity, will be calculated for each segment for both baseline and construction phases of monitoring. These response variables have been commonly used by many researchers, including the dolphin specialists of the present project (Lunquist et al. 2012a; Lundquist 2012; Lundquist and Markowitz 2009). Leg speed (km/hr) is the displacement between two successive points divided by the time interval. Inter-breath interval (s) is the length of time between successive surfacings. Reorientation rate (˚/min) is a measure of how much the group changed course over time. It is calculated as the sum of the absolute values of heading changes (defined as 0 to 180 degrees relative to the current bearing) divided by the duration of the track in minutes. Linearity is a dimensionless index ranging from 0 (no net movement) to 1 (straight line). It is calculated by dividing net distance from the first to last fix of a track by the sum of all the distances for each leg.

Multiple segments within a track cannot be considered statistically independent, thus analysis of each as a single sample results in pseudoreplication. The time interval required between two segments from the same track for them to no longer show autocorrelation will be calculated in a preliminary analysis using linear mixed-effect modelling in *R*. Segments will be filtered based upon the results of the autocorrelation analysis.

Generalised additive models will be fitted using package mgcv in *R* to describe heterogeneity in dolphin responses to vessels and bored piling activities. This package uses thin-plate regression splines to fit smooth terms for the explanatory variables. It includes a penalty for excessive flexibility, which is determined by the number of knots used to model the smoothed relationship for each model term. Smoothing is automated for all model terms simultaneously, with the multiple generalised cross-validation (GCV) score used within a maximum likelihood framework to evaluate fit of the model. Simultaneous evaluation (rather than one-by-one) avoids problems inherent to many step-wise procedures.

To aid model convergence, the number of knots in each spline will be left at the default of 10 (9 degrees of freedom). Histograms will be evaluated for each response variable to determine the appropriate distribution and link function to use. The fully saturated model is:

$$y \sim s(NumberOfBoats) + TypeOfBoats + ConstructionActivity$$

The procedure for dropping terms from the model is based on rules specified by Wood (2001). Smooth terms will be dropped if three conditions are met:

1. The estimated degrees of freedom (e.d.f.) is close to 1
2. The confidence interval for the term includes zero everywhere
3. The GCV score drops and deviance explained increases when the term is removed

If the first condition is met but not the other two, the smooth term will be replaced with a linear term for that variable. Linear terms will be dropped if:

1. The parameter coefficient is close to 0
2. The significance of the term is near to 1
3. The GCV score drops and deviance explained increases when the term is removed

In summary, the abovementioned analytical technique (based on a previous study by Bain et al. 2006) utilizes a model which includes all factors of interest in which the dolphin movement might be affected (hence called "fully saturated model", which includes all factors). A statistical technique (i.e. generalized addictive modeling) is then used to fit the data to the model and determine which factors predict differences in dolphin movement and describe the heterogeneity in the response. From these results, it can be determined whether human activities have influenced dolphin movements.

For comparison of monitoring data collected between different phases, the analysis of data from the baseline phase will first be performed to determine whether there are influences due to vessel presence in the absence of construction activity. Then the construction phase data will also be added into the model (while keeping the baseline data as well) and recalculated. If the construction activity (i.e. bored piling works) is a significant factor in the best-fitting model, then it is evident that dolphin movements were in fact affected by the construction activity.

2.5.1.2. Behavioural state

Since consecutive behavioural observations are not likely to be statistically independent, they will be analyzed as a series of time-discrete Markov chains. First-order Markov chain analyses will be used to quantify the dependence of each behaviour event on the preceding event in the behavioural sequence. Defining a set of mutually exclusive and wholly inclusive behaviours (Table 1) permits analysis of variation in behaviour of dolphin groups using Markov chains. Notably, the same set of variables for behavioural state (see Table 1) will be collected in both baseline, construction and post-construction phases of monitoring to maintain consistency. This form of analysis of behavioural impacts of human activity has been widely used in past cetacean studies (Lusseau 2003; Lundquist et al. 2012a, b).

Each 10 min sample will be classified according to the behavioural state and number of vessels present, as well as bored piling activity state during the construction phase. Markov chains will be used to build transition matrices of preceding behaviour (at time 0) versus succeeding behaviour (at time 1) for each transition split by vessel presence/absence and bored piling activity state. A transition will only be included in the "no vessel" chain when no vessels are present for at least 15 min prior to the observation period in order to reduce the likelihood that dolphin behaviour was altered due to a vessel interaction.

In the baseline phase, two chains (behaviour when no vessels are present vs. behaviour when vessels are present) will be compared using log-linear analysis as described below. In the construction phase, two sets of chains (baseline vs. construction with vessels present, and baseline vs. construction with no vessels present) will also be compared. Any differences between these chains will help determine if human activities have a significant effect on behavioural transitions of dolphins, and indicate whether dolphins have behaved differently due to the construction activity. Notably, if no difference is found between the two chains in the baseline phase, all of the baseline data can then be combined for comparison to the data collected in the construction phase. In that case, the comparison during construction phase will simply be between two chains: baseline phase behavioural data vs. construction phase behavioural data (i.e. there will be no need to split the data by vessel presence).

Log-linear analysis (LLA) will be conducted in *R* to test whether the likelihood of dolphins moving from one behavioural state to another is affected by human activities. This will be accomplished by using count data from the transition matrices and testing models in *R* for all combinations of parameters and interactions between parameters: 5 preceding behaviours x 5 succeeding behaviours x 2 vessel conditions x different bored piling activity states. The two vessel conditions would be: 1) no vessels present, and 2) vessels present. The different bored piling activity states will be further defined when different stages of bored piling procedure are confirmed with the engineers before construction commences, but will at least include two activity states: 1) no construction activity being conducted, and 2) construction activity being conducted. Maximum likelihood for the model being tested is approximated by G^2. Comparing the goodness-of-fit for each model to the goodness-of-fit for the fully saturated model (ΔG^2) approximates the effect of the missing variables. Degrees of freedom are the difference in degrees of freedom between the two models being compared. Evaluating the significance of this difference determines which variables are significant. Akaike Information Criteria (AIC) values will be calculated and used to choose the best-fitting model.

Based on the results from the LLA, the transition matrices will be used to calculate the behavioural budget of dolphins in the absence and presence of human activities. The left eigenvector of the dominant eigenvalue of each transition matrix will be used to approximate the behavioural budget of dolphins under the conditions of the matrix. A Z test for proportions will be used to test for differences between behavioural budgets, and 95% confidence intervals will be calculated.

3. KEY PERSONNEL AND QUALIFICATIONS

According to the EM&A requirement, the present land-based dolphin behaviour and movement monitoring should be undertaken by suitably qualified specialist(s) with sufficient (at 10 years) experience in theodolite and behavioural data gathering and analysis, at least three technical publications to cover the subject, and appropriate long-term familiarity with the latest version of the tracking program “Pythagoras”. Approval on the specialist(s) responsible for this ecological monitoring survey should be sought from AFCD and EPD.

To satisfy this requirement, HKCRP will employ **Professor Bernd Würsig**, the Senior Research Consultant of HKCRP, and **Dr. David Lundquist**, the Research Consultant of HKCRP, to serve as dolphin specialists for this project. Professor Würsig is a world-renowned marine mammal biologist, and has been studying many cetacean species in the past 30 years. Professor Würsig has pioneered several major research techniques, including theodolite tracking and photographic recognition of marine mammals, that are widely applied across the marine mammal field of science, and his experience in theodolite tracking on cetaceans is unparalleled in the world. Professor Würsig has published over 140 peer-reviewed journal articles and book chapters, with many on the topic of land-based theodolite tracking works to study the behaviour and movement of cetaceans. In fact, the only two publications on theodolite tracking works on Chinese white dolphins in Hong Kong were authored (Würsig et al. 2000) and supervised/co-authored (Piwetz et al. 2012) by Professor Würsig (both were included in the appendix for reference) . His unique experience in shore-based theodolite tracking and extensive knowledge on Chinese white dolphins and Hong Kong marine environment will greatly enhance the success of the present study. For the presents study, Professor Würsig will be responsible to oversee the entire study, by developing the methodology proposal, supervising the local field works with Dr. Samuel Hung, conducting data analyses with the assistance of Dr. David Lundquist, writing up the reports, and answering any queries in relation to the land-based study. His detailed CV is included in the Appendix.

Dr. David Lundquist will serve as another dolphin specialist for the project, and will assist Professor Würsig in various data analyses under the present study. Dr. Lundquist has over ten years of theodolite tracking experience, and the topics of his master’s thesis and Ph.D. dissertation were on behaviour and movement patterns of southern right whales and dusky dolphins respectively, utilizing land-based theodolite tracking data to examine the effects of ecotourism activities. Dr. Lundquist is very experienced in advanced analysis of theodolite tracking and behavioural data, and has published several papers on such works, including the movements of Chinese white dolphins in

Hong Kong in response to vessel movements (Piwetz et al. 2012). He will assist Professor Würsig for the writing up of various reports and answering any queries in relation to the present study. The CV of Dr. Lundquist is included in the Appendix.

For the local field works, Professor Würsig and Dr. Lundquist will supervise the HKCRP research team, led by **Dr. Samuel Hung**, the Director of HKCRP. Since 1997, Dr. Hung has been extensively involved in the multi-disciplinary research on Chinese white dolphins in Hong Kong and nearby regions, and has been widely recognized as the leading marine mammal expert in Hong Kong. He has 16 years of field experience in studying Chinese white dolphins, and has profound knowledge and experience on different cetacean research and monitoring techniques. In 2011, under the close supervision of Professor Würsig, Dr. Hung and his research team have successfully initiated a long-term study on investigating dolphin behaviour and movements using shore-based theodolite tracking technique (Hung 2012). This pioneer study has helped to understand the potential disturbance effects of vessel movements and associated underwater noises on dolphins (Piwetz et al. 2012). The CV of Dr. Hung is included in the Appendix.

The local theodolite tracking team will be composed of three main personnel: one primary theodolite operator, one computer operator, and one dolphin observer (i.e. spotter). The primary theodolite operator would require the most relevant experience, and this important role will be fulfilled by two key staff of HKCRP, **Mr. Vincent Ho** and **Mr. Perry Chan**. Mr. Ho and Mr. Chan were both trained and endorsed by Professor Würsig in April 2011, and their field works have been regularly audited by Professor Würsig in 2012 and 2013. Both have over two years of extensive theodolite tracking experience in Hong Kong, including all tracking works from various theodolite tracking stations in Hong Kong. They have helped Professor Würsig to set up the theodolite tracking station at Pak Mong in August 2013, and have been extensively involved in the field works of theodolite tracking for AFCD long-term monitoring project since then. Moreover, both have been extensively involved with the recent land-based theodolite tracking works for the EIA study of the Third Runway Expansion Project commissioned by the Airport Authority, the EM&A study of the Hong Kong Link Road (section between HKSAR Boundary and Scenic Hill) for Dragages-China Harbour-VSL Joint Venture, and the feasibility study for Increasing Land Supply by Reclamation and Rock Cavern Development commissioned by CEDD, all under the close supervision of Professor Würsig and Dr. Samuel Hung. Their unique field experience in land-based theodolite tracking on small cetaceans in Hong Kong is unparalleled, and both are uniquely qualified to undertake the specialized field works for the present study. Their CVs are included in the Appendix.

Besides Mr. Ho and Mr. Chan as the primary theodolite operators, the theodolite tracking works will be supported by the strong field team of HKCRP. All HKCRP research assistants, with the training and supervision of Professor Würsig, Dr. Samuel Hung, Mr. Ho and Mr. Chan, will be allocated to rotate into the positions of computer operator and dolphin observer. Dr. Hung will supervise the field work team closely, and will audit the field works periodically to ensure the data quality is consistent.

4. REPORTING

According to EM&A Manual, the Environmental Team (ET) Leader shall prepare and submit a Baseline Environmental Monitoring Report within 10 working days of completion of the baseline monitoring. The baseline monitoring report will include at least the following information:

- up to half a page executive summary;
- brief project background information;
- drawings showing locations of the baseline monitoring stations;
- monitoring results together with the following information:
  - monitoring methodology;
  - parameters monitored;
  - monitoring locations; and
  - monitoring date, time frequency and duration;
- details of influencing factors, including:
  - major activities, if any, being carried out on the site during the period;
  - weather conditions during the period; and
  - other factors which might affect the monitoring results;
- determination of the Action and Limit Levels for each monitoring parameter and statistical analysis of the baseline data; and
- comments, recommendations and conclusions.

For the reporting schedule, the results and findings from the 30-day baseline period shall be prepared and submitted as a Baseline Environmental Monitoring Report within 10 working days of completion of the baseline monitoring. Moreover, a Interim Monitoring Report including the results and findings from the 30-day construction phase period will also be prepared and submitted within 30 days of completion of the construction phase monitoring. Finally, upon the completion of the 30 days of post-construction phase monitoring, a Final Monitoring Report shall be prepared and submitted within 30 days. Copies of the Baseline Environmental Monitoring Report, Interim Monitoring Report and Final Monitoring Report on dolphin behaviour and movement in response to bored piling activities shall be submitted to the Contractor, the IEC, the SOR, AFCD, EPD as appropriate.

5. EVENT AND ACTION PLAN

According to Section 6.5 of the EM&A Manual, the Action and Limit Levels and event-action plan for ecology shall be proposed upon the baseline monitoring data, and agreed by AFCD and EPD. Since the baseline condition has yet to be established, only a conceptual Event and Action Plan is included here based on response variables for dolphin movement patterns (i.e. mean leg speed, mean inter-breath interval, reorientation rate and linearity) and dolphin behaviours (five different behavioural states), which will be recorded during both baseline and construction phase monitoring works.

To determine the Action and Limit Levels, we propose to take all baseline data into account, including times with no apparent anthropogenic activities near the dolphins, various vessel activities, and time of day and other variables. Departures of any of these variables between baseline and construction phases with a 20% difference will be of concern and should trigger the Action Level under the Event Action Plan. If a 40% difference in any of these variables between baseline and construction phases is detected, then the Limit Level under the Event Action Plan should be triggered and immediate action will be required. The detailed Event and Action Plan is presented as follow:

Conceptual Event and Action Plan

EVENT	ACTION			
	ET Leader	**IEC**	**SO**	**Contractor**
Action Level If any of the response variable for dolphin movement patterns (speed, inter-breath interval, reorientation rate & linearity) and behaviour (proportion of time spent in each behavioural state) recorded in the construction phase monitoring is **20% higher or lower** than that recorded in the baseline monitoring, action level should be triggered	1. Repeat statistical data analysis to confirm findings; 2. Review all available and relevant data to ascertain if differences are as a result of natural variation or seasonal differences; 3. Identify source(s) of impact; 4. Inform the IEC, SO and Contractor; 5. Check monitoring data; 6. Carry out audit to ensure all dolphin protective measures are implemented fully and additional measures be proposed if necessary	1. Check monitoring data submitted by ET and Contractor; 2. Discuss monitoring with the ET and the Contractor;	1. Discuss with the IEC the repeat monitoring and any other measures proposed by the ET; 2. Make agreement on measures to be implemented.	1. Inform the SO and confirm notification of the non-compliance in writing; 2. Discuss with the ET and the IEC and propose measures to the IEC and the SO; 3. Implement the agreed measures.
Limit Level If any of the response variable for dolphin movement patterns (speed, inter-breath interval, reorientation rate & linearity) and behaviour (proportion of time spent in each behavioural state) recorded in the construction phase monitoring is **40% higher or lower** than that recorded in the baseline monitoring, limit level should be triggered	1. Repeat statistical data analysis to confirm findings; 2. Review all available and relevant data to ascertain if differences are as a result of natural variation or seasonal differences; 3. Identify source(s) of impact; 4. Inform the IEC, SO and Contractor; 5. Check monitoring data; 6. Carry out audit to ensure all dolphin protective measures are implemented fully and additional measures be proposed if necessary 7. Discuss additional dolphin monitoring and any other potential mitigation measures (e.g. consider to temporarily stop relevant portion of construction activity) with the IEC and Contractor.	1. Check monitoring data submitted by ET and Contractor; 2. Discuss monitoring with the ET and the Contractor; 3. Review proposals for additional monitoring and any other measures submitted by the Contractor and advise ER accordingly.	1. Discuss with the IEC the repeat monitoring and any other measures proposed by the ET; 2. Make agreement on measures to be implemented.	1. Inform the SO and confirm notification of the non-compliance in writing; 2. Discuss with the ET and the IEC and propose measures to the IEC and the SO; 3. Implement the agreed measures.

Abbreviations: ET – Environmental Team, IEC – Independent Environmental Checker, SO – Supervising Officer

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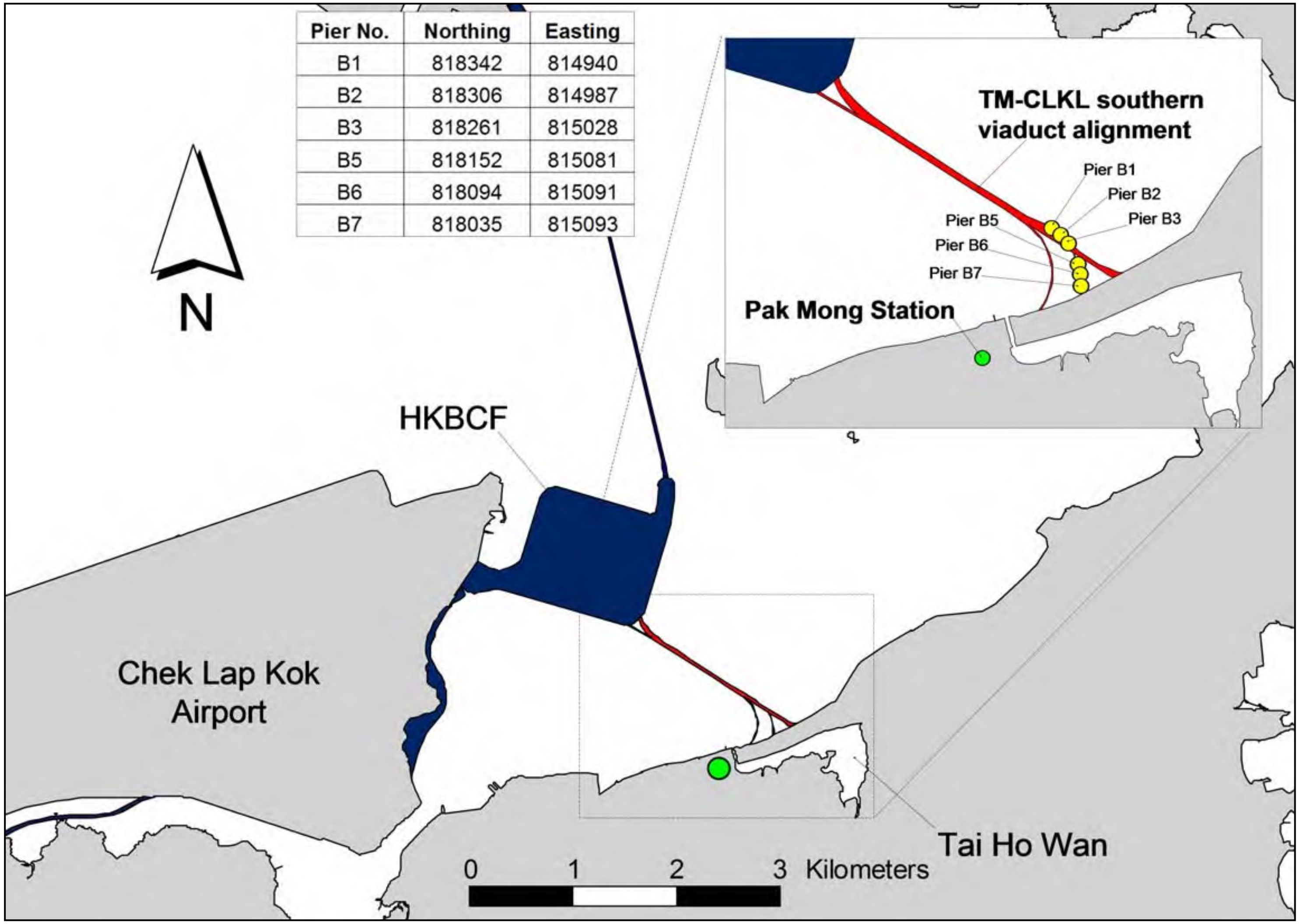
Table 1. Definitions of group behavioural states of dolphins.

State	**Definition**
Resting	Dolphins close to the surface and each other, surfacing at regular intervals and in a coordinated fashion. Movement very slow.
Traveling	All individuals oriented and moving in the same direction. This behavioural state includes all high-speed, directional behaviours (e.g. porpoising).
Milling	Individuals within the group simultaneously moving in different directions, with no overall clear direction of travel.
Socialising	Physical interactions taking place among members of the group, including chasing, high levels of body contact, coordinated clean leaps and noisy leaps.
Feeding	Dolphins observed either capturing or pursuing fish at the surface. High number of non-coordinated re-entry leaps, rapid changes in direction and long dives. Dolphin rostrum or body covered with mud. Associations with operating fishing boats.

FIGURES

Figure 1. Location of Pak Mong Station in NE Lantau with alignment of TM-CLKL southern connection viaduct



Pier No.	Northing	Easting
B1	818342	814940
B2	818306	814987
B3	818261	815028
B5	818152	815081
B6	818094	815091
B7	818035	815093

Figure 2. Panoramic View from Pak Mong Theodolite Tracking Station (photos taken on August 2013)

APPENDIX

CVs of Key Personnel for the Monitoring Work