CONTRACT HY/2011/09
Hong Kong-Zhuhai-Macao Bridge
Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill
Proposal for Dolphin Acoustic Behaviour Monitoring

Prepared by Hong Kong Cetacean Research Project
(Professor Bernd Würsig, Dr. Marc Lammers, Dr. Lisa Munger and Dr. Samuel Hung)

31 January 2013

1. INTRODUCTION

The Hong Kong Link Road (HKLR) comprises a 9.4 km long viaduct section from the HKSAR boundary to Scenic Hill on the Airport Island; a 1-km tunnel section to the reclamation formed along the east coast of the Airport Island, and a 1.6-km long at-grade road section on the reclamation connecting to the Hong Kong Boundary Crossing Facilities (HKBCF). Dragages – China Harbour – VSL JV (hereinafter called the "Contractor") was awarded as the main contractor of "Contract No. HY/2011/09 – Hong Kong-Zhuhai-Macao Bridge Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill".

According to the HKLR EM&A Manual, a number of environmental monitoring and audit 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 dolphin acoustic behaviour monitoring in relation to bored piling activities. Such monitoring shall be undertaken by qualified dolphin specialist(s), who have sufficient (at least 5-10 years) relevant post-graduate experience and publication in the respective aspects. Approval of the specialist responsible for the dolphin acoustic behaviour monitoring shall be sought from AFCD and EPD.

This dolphin acoustic behaviour 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 and construction monitoring works. Post-construction phase monitoring will be further proposed and arranged by the Permit Holder.

2. BASELINE AND CONSTRUCTION PHASE DOLPHIN ACOUSTIC BEHAVIOUR MONITORING

2.1. Requirements under the EM&A Manual

Under the HKLR EM&A Manual, the dolphin acoustic behaviour monitoring in relation to bored piling activities is required with several clauses:

- *Clause 10.3.4*: Dolphin behaviour monitoring to monitor the acoustic behaviour and movement near the bored piling sites of Chinese white dolphin during bridge construction
- *Clause 10.6.3:* Dolphin behaviour in response to bored piling and movement near the bored piling sites will be monitored at the three pier sites for 30 days from the start of bored piling activities in the waters to the west of Airport.

Supplementary information of such dolphin acoustic behaviour monitoring in relation to bored piling activities was also provided in the Tuen Mun-Chek Lap Kok Link (TMCLKL) EM&A Manual, which can also be used as reference for the present monitoring programme:

- The monitoring will study the acoustic behaviour of dolphins near the bored piling works site and at a control site for comparison, to determine whether foraging and other behaviours are affected by the bored piling activities and whether (and if so, to what degree) dolphin echolocation clicks and other types of sounds used for communication are masked by bored piling activity noise.
- The acoustic monitoring will be undertaken during the construction phase and commence at the start of the bored piling works. The exact monitoring period will be determined and detailed in the specification to be prepared during the detailed design stage but is likely to comprise the study of acoustic behaviour of dolphins from a small boat during periods with and without bored piling for 30 days from the start of bored piling activities.

2.2. Overall Objective and Research Scheme

For the present dolphin acoustic behaviour monitoring study, the primary objective is to investigate dolphin acoustic behaviour and movement in response to bored piling sites during both baseline and construction phases. Overall, a set of parameters such as the presence of dolphin acoustic signaling, durations of periods of acoustic activity, relative occurrence of different kinds of signals per unit time and shifts in the time of day of acoustic activity will be quantified. Other factors will also need to be measured concurrently during baseline and construction phases in order to understand whether any observed differences in acoustic behaviour of dolphins may represent a reaction to the bored piling works, or are an artifact of other factors.

To achieve this primary goal, several approaches in acoustic data collection will be adopted by the team of dolphin specialists (i.e. experienced bio-acousticians) and local research team of HK Cetacean Research Project (HKCRP). The primary approach will be to conduct dedicated acoustic surveys of focal follows of Chinese White Dolphins in West Lantau with sound recordings from calibrated hydrophone deployed from research vessel, and their movements near the bored piling site will also be monitored during focal follow sessions for both baseline and construction phases. These recordings will be used to establish baseline acoustic behaviour (e.g. rate of sound production, types of sounds) and its relation to visually determined group size, behaviour (e.g. foraging, socializing, traveling, milling) and covariates such as the time of day, Beaufort sea state, and occurrence of nearby vessels. Types, distances, and behaviours of vessels will be determined from the recording vessel using laser rangefinder.

A complementary approach for the acoustic data collection will be to deploy two sets of ecological acoustic recorders (EARs) near the bored piling site and at a control site for passive acoustic monitoring during both baseline and construction phases. The EARs are bottom-moored, autonomous acoustic recording systems that are used to monitor ambient sounds on a programmable duty cycle (see detailed specifications of EAR in Lammers et al. 2008). They have a programmable bandwidth up to 40 kHz and can be deployed from days to months at a time. The advantages of EARs as a passive acoustic monitoring technique over the calibrated hydrophone are: 1) they can collect data 24 hours a day and during periods (e.g. inclement weather conditions) that are unsuitable for vessel surveys; 2) they can provide detailed information on the frequency and duration of dolphin habitat use near their mooring site; and 3) they can collect long-term acoustic data to quantify ambient noise over time. However, they cannot replace the calibrated hydrophone deployed from research vessel, as the EARs are stationary and depend on animals being present and vocalizing within the range of the EARs, and no concurrent visual data can be used to confirm the presence or absence of animals, except when land-based theodolite tracking is conducted concurrently at a location near where EAR is deployed.

2.3. Monitoring Location

The dedicated acoustic surveys with calibrated hydrophone deployment will be conducted mostly along the west coast of Lantau Island during baseline and construction phases. The research vessel will follow a predefined route for systematic search effort in West Lantau waters to cover the HKLR alignment in Northwest and West Lantau waters (in particular the area near the first three bored piling sites), where dolphins will be potentially disturbed by the bored piling works. The acoustic surveys will also cover some part of Northwest and Southwest Lantau waters where

dolphins are likely to be encountered for dolphin acoustic data collection (e.g. Sha Chau, Lung Kwu Chau, Black Point, Fan Lau, Kau Ling Chung).

The EARs will be deployed at two locations: 1) within 500 m of the bridge alignment (preferably near the first three bored piling sites), and 2) a less disturbed site relatively far away from the bridge alignment as control site (tentatively either Fan Lau or Tai O will be chosen as the control site). Besides the water depth and current, one important consideration of the deployment locations would be the risk of trawler damage or removal. The exact locations of EARs deployment will be finalized after consultation with the professional dive team and the Marine Department of Hong Kong SAR Government.

2.4. 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 at the first three pier sites for 30 days from the start of bored piling activities in the waters to the west of Airport. However, the number of days for dolphin acoustic monitoring is not well specified for the baseline period. Therefore, we propose to conduct 30 days of baseline monitoring works to establish baseline conditions before construction commences, and another 30 days of construction phase monitoring works at the first three pier sites.

A total of 30 days (with 6-7 hours on each survey day) of acoustic monitoring using the calibrated hydrophone will be planned for the baseline phase, and another 30 days of monitoring will be planned for the construction phase. Every attempt will be made to conduct these acoustic monitoring surveys under favourable weather conditions. Notably, during the construction phase, acoustic behaviour of dolphins during periods with and without bored piling for 30 days from the start of bored piling activities. The acoustic monitoring team with the calibrated hydrophone will be present in the vicinity of the HKLR alignment (especially near the first three bored piling sites) during the construction phase, and will attempt to record dolphin sounds during periods with and without bored piling works in order to examine whether there is any significant change in acoustic behaviour of the dolphins.

On the other hand, the EARs will be deployed in the first week of February, and will remain in the two study sites (i.e. one near bored piling site and another at a control site) until the 30 days of construction phase monitoring is completed. In other words, the EARs will be deployed for approximately three weeks during the baseline phase, and at least 30 days during the construction

phase. The EARs will be recovered, refurbished, and re-deployed approximately every 3-6 weeks, and data will be downloaded during the periodic recovery and re-deployment. Notably, the EARs will collect acoustic data on ambient noise, construction noise and dolphin sounds 24 hours per day, 7 days per week, and will be programmed to record on a 20% duty cycle (1 minute "on" for every 5 minutes)

2.5. Monitoring Methodology

2.5.1. Acoustic survey using calibrated hydrophone

During dedicated acoustic surveys, the survey team of two (an experienced sound operator and another HKCRP research assistant) will conduct systematic search for dolphins within the study area (i.e. along the west coast of Lantau) on a predefined route. The survey protocol to search for dolphins is similar to the line-transect survey methodology adopted in the vessel survey under the HKLR09 EM&A programme. For each survey, a 15-m inboard vessel with an open upper deck will be used to make observations from the flying bridge area, at a visual height of 4-5 m above water surface. The two observers will search with unaided eyes and 7 x 50 marine binoculars ahead of the vessel (between 270^{o} and 90^{o} in relation to the bow, which is defined as 0^{o}). The survey team will record effort data including time, position (latitude and longitude), weather conditions (Beaufort sea state and visibility), and distance travelled in each series (a continuous period of search effort) with the assistance of a handheld GPS.

When dolphins are sighted, the survey team will end the search effort, and the research vessel will be diverted from its course to slowly approach the animals for group size estimation, assessment of group composition, and behavioural observations in the initial 5-10 minutes. The calibrated hydrophone will then be deployed 3 to 7 metres below the sea surface by 2-metre long spar buoy from the stern of the research vessel, with vessel engine noise off and the vessel drifting. Broadband dolphin recordings will be made with a Cetacean Research Technology spot-calibrated hydrophone (model: CR1; sensitivity: -197.7 dB, re. 1 V/μPa; usable frequency response listed as 4 Hz-68 kHz +3/-12 dB connected to a 1 MΩ input impedance; linear frequency range: 0.2-48 kHz ± 3 dB). The spar buoy will act to prevent excessive hydrophone movement from wave and boat motion. The recordings will be streamed into a digital memory field recorder (model: Fostex FR-2; frequency response: 20 Hz-80kHz ±3 dB) with a pre-amplified signal conditioner (model: PC200-ICP; precision gain: x0.1-x100; frequency range: >100 kHz; system response: 1 Hz-100 kHz ± 3 dB) to prevent overloading and minimize cable noise. The recordings will then be stored in a 4 GB Compact Flash Card, to be downloaded onto a laptop computer for further analysis. The above acoustic data collection setup has been used in the long-term monitoring study on Chinese

White Dolphins in Hong Kong since April 2010 (Sims et al. 2011, 2012; also see Hung 2012).

During the hydrophone deployment, the date, start and end times, hydrophone and water depths, Beaufort sea state, survey area, locations, ICP gain, event, and notes will be taken for each recording in five-minute interval. Within each corresponding five-minute interval, observers will also note variables including the group size, group composition and general behaviour during the 5-minute period (i.e. feeding, socializing, travelling, resting, milling and any aerial activity). The number of vessels that passed within 500 m of the dolphin group will also be recorded during the same 5-minute interval, with special notes on close approaches by vessels within 100 m of dolphins, including the time of closest approach and any behavioural reaction being noted. Distances of vessels will be gathered by hand-held laser rangefinder (*Bushnell* Yardage Pro 800; maximum range of detection for most objects: 720 metres; ranging accuracy ± 2 metres under most circumstances). Also, notes will be made on the approximate distance (i.e. 0-250m, 250-500m, >500 m) of the dolphin group to the hydrophone during the 5-minute interval. Notably, positions of dolphin group will be recorded continuously during the entire focal follow session to examine their movement in details, especially when they occur in the vicinity of the HKLR alignment (in particular the area near the first three bored piling sites).

2.5.2. Passive acoustic monitoring using EARs

Two sets of EARs will be deployed at two sites in West Lantau, one near the bored piling site and another at a control site, and the exact location will be chosen where the risk of trawler damage or removal can be minimized. The EARs will be deployed by a professional dive team from Oceanway Corporation Limited. During each deployment, the EAR serial number, as well as the time and date of deployment will be recorded. Moreover, the GPS position, water depth and type of substrate at the deployment location will also be recorded.

The EARs will be programmed to record on a 20% duty cycle (1 minute "on" for every 5 minutes). Recording will be from approximately 20 Hz at the low end to 32 kHz at the high end, which effectively covers a major part of the acoustic channel of the Chinese White Dolphins (Sims et al. 2011). Data from the EARs will be downloaded onto a computer hard disk every 2-4 weeks during the study period, and will then be re-deployed at the same location until the study is completed at the end of the 30 days of construction phase monitoring.

2.6. Data Analysis

2.6.1. Calibrated hydrophone data

To evaluate if dolphin acoustic behaviour vary between baseline and construction phases, a number of parameters will be examined at both phases for comparison. For the calibrated hydrophone data, such parameters include the duration of acoustic encounters of dolphins, rates of their whistling, burst pulsing and echolocation per 5-minute recording time bin. The rates of sound production as a function of dolphin group size and any shifts in different time of day of acoustic activity will also be examined.

For the data analysis in comparison of response variables between baseline and construction phase, each 5-minute recording time bin will be treated as a sample point. The rate of whistling, burst pulsing and echolocation will be quantified for that time period by visually and aurally examining each recording and logging the presence of signals using Adobe Audition or similar program. Recording periods when the dolphins are more than 500 m away or when they are on the bow of the research vessel will be excluded from consideration. Times of day and approximate relative rates of dolphin sounds will be described, and selected sounds will be used for an enhanced description of Chinese White Dolphin vocalizations, such as frequencies, inter-pulse intervals, and other characteristics. These may then be compared during different anthropogenic activities, including baseline and industrial of the present study (Sims et al. 2011). Movement patterns of dolphins during focal follow sessions will also be examined, especially when they occur near the bored piling sites during the construction phase.

2.6.2. EARs data

A number of parameters on both occurrence patterns and acoustic behaviour collected from EARs will be examined at both baseline and construction phases for comparison. On the acoustic occurrence patterns, the EARs data can be used to determine presence of dolphin vocalizations, and the duration and temporal patterns of their occurrence. Moreover, the overall acoustic behaviour (not per individual dolphin) will be determined from the rates of sound production and types of sounds produced by dolphins, any changes in temporal patterns (e.g. from mostly calling at night, to mostly during the day, or vice versa), any increase/reduction and change in average duration of acoustic presence at the location of EAR deployment.

For the comparison of response variables between baseline and construction phases using EARs data, the Matlab-based program *Triton* will be used to create long-term spectral averages (LTSAs) of the data. LTSAs are synoptic representations of portions of the dataset, and they will

be scanned to identify periods of dolphin presence. Once identified, each acoustic encounter (or standardized time bins, for example one hour) will be quantified in a standardized manner that can be statistically compared between encounters or time periods. The response variables to be compared between the two phases will include the number and duration of acoustic encounters, as well as the average characteristics of dolphin vocalizations such as frequencies, inter-pulse intervals, and other characteristics.

In addition to quantifying the presence of dolphins using the EARs data, an automated spectral analysis of ambient noise during the deployment period over several frequency bands will be conducted. Specifically, the root-mean-square (RMS) sound pressure level (SPL) will be measured in the following 1-octave bands: 0-2 kHz, 2-4 kHz, 4-8 kHz, 8-16 kHz and 16-32 kHz.

3. KEY PERSONNEL AND QUALIFICATIONS

According to the EM&A requirement, the present dolphin acoustic behaviour monitoring should be undertaken by suitably qualified specialist(s) with sufficient (at least 5-10 years) relevant post-graduate experience and publication in the respective aspects (in this case, theodolite-tracking technique). 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 **Drs Marc Lammers and Lisa Munger**, the Research Consultant of HKCRP, to serve as dolphin specialists for this project.

Professor Würsig is a world-renowned marine mammal biologist who has been studying numerous cetacean species for the past 41 years. Currently, Professor Würsig serves as Regents Professor and George P. Mitchell ’40 Chair in Sustainable Fisheries at Texas A&M University, and has published over 150 peer-reviewed journal articles and book chapters. One of his primary research focuses is on the effects of noise on cetaceans, and he has published numerous papers on this topic (e.g. Würsig et al. 1998; Würsig and Evans 2001; Würsig and Richardson 2009). Professor Würsig also received funding to lead many acoustic studies in the past, such as the study on effects of industrial noise on gray whales off St. Lawrence Island of Bering Sea in 1985-86; another study on acoustic behaviour of dusky dolphins in 1995-96; and the development and application of undersea recording stations for marine mammals in the Gulf of Mexico in 2006-09.

He has been heavily involved in a number of EIA-related studies in Hong Kong since 1992, and is the pioneer to develop an air bubble curtain to reduce underwater noise of percussive piling during the construction of the Temporary Aviation Fuel Receiving Facility for the Airport Authority (Würsig et al. 2000). His unique experience in cetacean acoustic studies and extensive knowledge on Chinese White Dolphins and the Hong Kong marine environment will greatly enhance the success of the dolphin-related acoustic studies for the present project.

For the present work, Professor Würsig will be responsible to oversee the entire study, by developing the methodology proposal, supervising the local field works with Dr. Samuel Hung, and coordinating the data analysis with Dr. Lammers and Dr. Munger at Oceanwide Science Institute (OSI). He will also write up the baseline report and construction phase report, and answer any queries in relation to the acoustic behaviour study. He will also visit Hong Kong during the study period to assist with project logistics and for consultation with the field team. His detailed CV is included in the Appendix.

Two OSI scientists, Dr. Lammers and Dr. Munger, will also serve as the dolphin specialists for the present study. Both specialists will be responsible to plan, coordinate, analyze and report on the analysis of the calibrated hydrophone data and EARs data. One of them will also visit Hong Kong during the study period to assist with the local survey team as well as the deployments of EARs.

Dr. Marc Lammers has over 17 years of research experience in bioacoustics and cetacean behaviour. Currently, he is Assistant Researcher at the Hawaii Institute of Marine Biology and co-founder and President of Oceanwide Science Institute. He holds a B.A. and Ph.D. in Zoology from the University of Hawai'i, where he studied under Dr. Whitlow Au. His work in this field has yielded numerous scientific publications. Dr. Lammers is an active collaborator with researchers in Hawaii, Washington, Alaska, Spain, Italy, Portugal and Iceland. His interests in marine science are broad and range in scope from research to education and conservation. He has worked on projects focused on a variety of topics and marine organisms including corals, fish, turtles, dolphins and whales. Dr. Lammers is currently involved with an EIA study for the third runway expansion project and is responsible for the passive acoustic monitoring study with the application of the EARs in North Lantau waters.

Dr. Lisa Munger has over 11 years of expertise in analyzing long-term bioacoustic recordings and conducting at-sea field work to provide information on the behavior and ecology of cetaceans

and other marine organisms. She has collected and analyzed data from marine habitats ranging from the Alaskan Arctic to central Pacific coral reefs, and topics of her publications include whale call detection, acoustic behavior, call source levels and propagation, and acoustics-based abundance estimates. She is also experienced at conducting distance-sampling based field surveys and analyses for birds, cetaceans, and fishes. Dr. Munger completed her Ph.D. in Oceanography at the Scripps Institution of Oceanography (SIO) in 2007, in the Scripps Whale Acoustics Laboratory headed by Dr. John Hildebrand. She came to the Hawai`i Institute of Marine Biology (HIMB) (2010-12) and worked with Dr. Whitlow Au and Dr. Marc Lammers as well as researchers at the NOAA Coral Reef Ecosystem Division to analyze long-term acoustic data from central Pacific coral reefs for cetaceans, fishes, and other biological and anthropogenic sounds. Dr. Munger is also currently involved with an EIA study for the third runway expansion project and is responsible for the passive acoustic monitoring study with the application of the EARs in North Lantau waters.

For the local field works, Professor Würsig, Dr. Lammers and Dr. Munger 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. Since 2010, with the supervision of Professor Bernd Würsig and assistance from his research team at Texas A&M University, the PI has initiated a long-term acoustic monitoring study to describe the underwater world of sounds as important to Chinese White Dolphins in Hong Kong. This on-going work has provided new knowledge on acoustic behaviour of Chinese White Dolphins (Sims et al. 2011) and the anthropogenic noise background in their living habitat around Lantau (Sims et al. 2012). The CV of Dr. Hung is included in the Appendix.

The local acoustic survey team will be composed of two HKCRP researchers. **Ms. Michelle Klein**, a graduate student at Trent University under the supervision of Dr. Hung on dolphin-related acoustic studies, will be responsible to be the sound operator. Ms. Klein has assisted with numerous research projects as an undergraduate, to study the behavioural aspects of sound production of marine mammals, their perceptual abilities and the impact of noise on their acoustic communication. She was awarded several fellowships such as the one in Duke University Marine Laboratory to study humpback whale acoustic behaviour. She has also conducted acoustic studies on right whales, humpback whales and West Indian manatees as a research assistant for Allied Whale, College of the Atlantic's marine mammal research organization. Ms. Klein will be

responsible as the experienced sound operator, and will be assisted by one local HKCRP research assistants to conduct the acoustic surveys with calibrated hydrophone deployment during both phases of baseline and construction monitoring.

The EARs deployment, refurbishment, maintenance and recovery will be carried out by the professional team at **Oceanway Corporation Limited** (OCL), led by Mr. Paul Hodgson. OCL is an environmental and engineering company based in Hong Kong which provides expert marine ecology research and consultancy services. OCL scientists have recent experience on successful deployment of a number of EARs for the EIA study for the third runway expansion project under the supervision of Professor Würsig, Dr. Lammers and Dr. Munger. Their unique expertise and experience will ensure the success of acoustic data collection by the two sets of EARs.

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. Copies of the Baseline Environmental Monitoring Report shall be submitted to the Contractor, the IEC, the ER and EPD.

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, according to Section 16.2 of the EM&A Manual, the results and findings from the baseline period shall be prepared and submitted as a supplementary report on Baseline Environmental Monitoring within 10 working days of completion of the baseline monitoring. Moreover, upon the completion of the 30 days of construction phase monitoring on dolphin acoustic behaviour in response to bored piling activities, a final report shall be prepared and submitted within 30 days. Copies of the supplementary report on Baseline Environmental Monitoring and Construction Phase Monitoring Report on dolphin acoustic behaviour in response to bored piling activities shall be submitted to the Contractor, the IEC, the ER and EPD.

5. EVENT AND ACTION PLAN

According to Section 10.8.1 of the EM&A Manual, the Action and Limit Levels and event-action plan for ecology shall be proposed by respective specialists of the Environmental team upon the baseline monitoring data, and agreed by AFCD and EPD. Since the baseline condition has yet to be established, only a preliminary Event and Action Plan is included here based on the response variables for dolphin acoustic behaviour (e.g. rates of sound production and types of sounds, such as whistling, burst pulsing and echolocation click trains per 5-minute recording time bin; any shift in time of day of acoustic activity). These will be recorded during both baseline and construction phase monitoring works.

If these variables recorded in the construction phase are significantly different from those in the baseline phase (such comparison will be conducted using various data analyses as described in Section 2.6), the Action Level or Limit Level will be triggered, and the corresponding follow-up action will be taken. The actual Action Level (AL) and Limit Level (LL) will be determined upon the examination of baseline data, and the AL and LL along with the corresponding follow-up actions will be proposed in the Baseline Environmental Monitoring Report within 10 working days of completion of the baseline monitoring as described in the reporting schedule.

Preliminary Event and Action Plan

EVENT	ACTION			
	ET Leader	**IEC**	**SO**	**Contractor**
Response variables for dolphin acoustic behaviour (e.g. rates of sound production and types of sounds, such as whistling, burst pulsing and echolocation click trains per 5-minute recording time bin; any shift in time of day of acoustic activity) recorded in the construction phase monitoring are significantly different from those recorded in the baseline monitoring	- Repeat statistical data analysis to confirm findings; - Review historical data to ensure differences are as a result of natural variation or previously observed seasonal differences; - Identify source(s) of impact; - Inform the IEC, SO and Contractor; - Check monitoring data; - Discuss additional dolphin monitoring and any other measures, with the IEC and Contractor.	- Discuss monitoring with the ET and the Contractor; - Review proposals for repeat monitoring and any other measures submitted by the Contractor and advise the SO accordingly.	- Discuss with the IEC the repeat monitoring and any other measures proposed by the ET; - Make agreement on the measures to be implemented.	- Inform the FSR and confirm notification of the non-compliance in writing; - Discuss with the ET and the IEC and propose measures to the IEC and the SO; - Implement the agreed measures.

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

6. REFERENCE

Gailey, G. A. and Ortega-Ortiz J. 2002. A note on a computer-based system for theodolite tracking of cetaceans. Journal of Cetacean Research and Management 4: 213-218.

Hung S. K. 2012. Monitoring of Marine Mammals in Hong Kong waters – data collection: final report (2011-12). An unpublished report submitted to the Agriculture, Fisheries and Conservation Department, 171 pp.

Lammers, M. O., Brainard, R. E., Au, W. W. L., Mooney, T. A. and Wong, K. 2008. An ecological acoustic recorder (EAR) for long-term monitoring of biological and anthropogenic sounds on coral reefs and other marine habitats. Journal of Acoustical Society of America 123: 1720-1728.

Lunquist, D., Gemmell, N. J. and Würsig, B. 2012. Behavioural responses of dusky dolphin groups (*Lagenorhynchus obscurus*) to tour vessels off Kaikoura, New Zealand. PLoS One 7: 1-9, e41969.

Piwetz, S., Hung, S. K., Wang J. Y., Lundquist, D. and Würsig, B. 2012. Influence of vessel traffic on movements of Indo-Pacific humpback dolphins (*Sousa chinensis*) off Lantau Island, Hong Kong. Aquatic Mammals 38: 325-331.

Sims, P. Q., Vaughn, R., Hung, S. K. and Würsig, B. 2011. Sounds of Indo-Pacific humpback dolphins (*Sousa chinensis*) in West Hong Kong: A preliminary description. Journal of Acoustical Society of America, EL48-EL53 (doi: 10.1121/1.3663281).

Sims, P., Hung, S. K. and Würsig, B. 2012. High-speed vessel sounds in West Hong Kong waters and their contributions relative to Indo-Pacific humpback dolphins (*Sousa chinensis*). Journal of Marie Biology Volume 2012: Article ID 169103, 11 pages (doi: 10.1155/2012/169103).

Würsig, B. and Evans, P. G. H. 2001. Cetaceans and humans: influence of noise. In: Evans, P. G. H. and Raga, J. A (editors). Marine Mammals: Biology and Conservation. Kluwer Academic/Plenum Press, New York, pp. 565-587.

Würsig, B., Greene, C. R., Jr., and Jefferson, T. A. 2000. Development of an air bubble curtain to reduce underwater noise of percussive piling. Marine Environmental Review 49: 79-93.

Würsig, B., Lynn, S. K., Jefferson, T. A. and Mullin, K. D. 1998. Behavior of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. Aquatic Mammals 24: 41-50.

Würsig, B. and Richardson, W. J. 2009. Noise, effects of. In: Perrin, W. F., Würsig, B. and Thewissen, J. G. M. (editors). The Encyclopedia of Marine Mammals (second edition). Academic Press, San Diego, pp. 765-772.