Gammon Construction Limited

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Proposal for Underwater Noise and Dolphin Acoustic Behavioural Monitoring

for

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

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

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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 Section 6.4.5. of the the TM-CLKL EM&A Manual, a bored piling monitoring programme in relation to Chinese white dolphins (a.k.a Indo-Pacific humpback dolphins, *Sousa chinensis*) shall be conducted during baseline and construction phases. These include underwater noise levels measurements to evaluate the details of frequency and intensity spectra of the bored piling noise in relation to dolphin acoustic behaviours, and dolphin acoustic behavioural monitoring to record and note any changes in response of dolphins to the bored piling noise. Such monitoring shall be undertaken by qualified dolphin specialists who have sufficient relevant post-graduate experience and publication in the respective aspects. Approval of the specialists responsible for these bored piling monitoring studies shall be sought from AFCD and EPD.

The present proposal will detail the methodology of the underwater noise study and dolphin acoustic behavioural study, 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.

2. BASELINE AND CONSTRUCTION PHASE MONITORING PROGRAMME

2.1. Requirements under the EM&A Manual

According to Section 6.4.5 of the TM-CLKL EM&A Manual, a bored piling monitoring programme should be implemented to determine the actual magnitude of impacts of bored piling works. As part of the monitoring programme, the underwater noise study is required to examine the characteristics of underwater noise associated with the bored piling activities within the work site, while the dolphin acoustic behavioural study is required to study the acoustic behaviour of dolphins near the bored piling works site. These studies will provide a basis to examine whether the acoustic behaviour of dolphins near the work site would be affected by the bored piling activity noise. Both studies will be undertaken during the construction phase and commence at the start of the bored piling works, and will consist of data acquisition and analysis of sound to be gathered by experienced bio-acousticians with specialized experience in processing of appropriate sound data of low to high frequency. The bio-acousticians should have at least ten years of data gathering and analysis experience of underwater noise and dolphin sound, and at least three relevant technical publications.

2.2. Overall Objective and Scheme

For the underwater noise study, the primary objectives are to measure and characterize: (1) baseline ambient noise levels during the pre-construction phase of development; and (2) industrial noise levels associated with bored piling activities during the construction phase. The results obtained from this study, in conjunction with the concurrent dolphin acoustic behavioural and shore-based theodolite tracking studies, will provide guidance with respect to mitigation for the resident dolphin population.

On the other hand, the primary objective of the dolphin acoustic behavioural study is to investigate their 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, the primary approach will be to conduct dedicated acoustic surveys of focal follows of Chinese white dolphins in North Lantau with sound recordings taken from a dipping hydrophone deployed from the 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 of the dolphins (e.g. rate of sound production, types of sounds), and its relation to visually determined dolphin 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 dipping 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 dipping 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. Notably, based on past experience in other areas, the effective detection range of EARs on dolphin signals in Hong Kong waters is estimated to be between 500-1,000 metres.

2.3. Bored Piling Programme

As the present monitoring study is closely tied with the bored piling programme of TM-CLKL, the tentative work schedule as well as the bored piling work sequence are attached in Appendix I and Appendix II respectively for reference. It should be noted that the tentative bored piling work schedule represents only the best estimation at the moment of the timing of each bored pile site, and would be subject to further adjustments as the works are progressing.

For the work sequence for marine piling works, there will be three phases, including the preparation works to construct temporary working platform for pre-drilling and marine bored piles construction, the pre-drilling to explore ground conditions for determination of founding levels for piles, and the actual marine bored piles construction works. We consider that the last phase for the marine bored piling construction would be the period when underwater noise study and dolphin acoustic behavioural study should be conducted. For this phase, underwater noise measurement would be taken during four processes that would be of concern to potentially create acoustic disturbance to the dolphins: 1) driving steel casings for marine bored pile, 2) excavation of soil by grabbing, 3) formation of rocky socket by RCD, and 4) concreting. The methodology of how underwater noise measurement will be taken during these processes is further explained in Section 2.5.1.

2.4. Monitoring Location

To characterize the local soundscape, underwater sound data collection will be conducted mostly in the northeastern waters of Lantau Island during baseline and construction phases where bored piling activities in association with TM-CLKL construction occur. Sound measurements will be made at various distances from six bored piling sites along the TM-CLKL alignment, to allow estimation of a simple acoustic propagation model for the region where bored piling activities will occur (Figure 1). The numberings and locations of these six bored piling sites to be monitored during baseline phase are listed as follow (some of the bored piling works from different pier sites will be conducted concurrently), and three of these six sites will be chosen for impact phase monitoring from the start of the bored piling activities when the initial phase of the construction schedule is confirmed:

Pier No.	Northing	Easting	Number of Bored Piles	Tentative Starting and Ending Months since Commencement of Marine Bored Pile Construction**
B1	818342	814940	3	Month 9-14
B2	818306	814987	2	Month 9-14
B3	818261	815028	2	Month 9-14
B5	818152	815081	2	Month 9-14
B6	818094	815091	3	Month 9-14
B7	818035	815093	2	Month 9-11

** As the commencement date of the works under the contract was 22 June 2013, which is month 0, Month 9-14 would represent March-August 2014, while Month 9-11 would represent March-May 2014.

Moreover, the dolphin acoustic behavioural study will be conducted concurrently with the underwater noise study mostly in the northeastern waters of Lantau Island where the bored piling activities will occur. For this study, the research vessel will follow a predefined route for systematic search effort in Northeast Lantau region to cover the area overlapped with the TM-CLKL alignment (Figure 2), where dolphins will be potentially disturbed by the bored piling works. The acoustic surveys will also cover some part of Northwest Lantau waters as control sites, where dolphins are likely to be encountered for acoustic data collection but will not be disturbed by the bored piling activities (e.g. Sha Chau, Lung Kwu Chau, Black Point).

The EARs will be deployed at two locations: 1) within 500 m of the bridge alignment, and 2) a less disturbed site relatively far away from the bridge alignment as control site (the water between Sha Chau and Lung Kwu Chau will be chosen as the control site; Figure 2). 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. The scientific permit obtained from AFCD to deploy EAR within the Sha Chau and Lung Kwu Chau Marine Park has been attached with this proposal.

2.5. Monitoring Frequency and Scheme

2.5.1. Underwater noise study

According to the EM&A Manual, underwater noise level measurements from and near the bored piling sites should be monitored for 10 days from the start of bored piling activities near the TM-CLKL. However, the number of days for underwater noise monitoring is not well specified for the baseline period. In making reference to a similar study for the bored piling monitoring programme for the Hong Kong Link Road Project, we propose to conduct 30 days of baseline monitoring to establish baseline conditions before construction commences, and another 30 days of construction phase monitoring from the start of bored piling activities.

Acoustic recordings of varying lengths but no less than two-minutes in duration will be made throughout each survey day in the Northeast Lantau region where bored piling activities will occur. The two-minute minimum duration ensures reduced statistical variability in subsequent signal processing of the acoustic data. Recordings will be made opportunistically to adequately characterize the local soundscape. In particular, recordings made throughout each of the two 30-day monitoring periods will include data acquired with the following criteria:

(1) at different times of day (including night-time period),
(2) in the presence of a variety of vessel sizes/types,
(3) under different weather conditions, and
(4) under different tidal conditions.

The largest contributor to ambient noise levels in the study area is anticipated to be vessel traffic, some of which may have a time-dependency, such as the increased noise levels resulting from regular ferry transits. Criterion (1) is intended to help characterize overall vessel noise as a function of time, as well as identifiable biological noise with a diurnal pattern. Criterion (2) enables quantitative associations between vessel noise and vessel type. In the absence of anthropogenic noise, the greatest contributor to ambient noise levels is typically wind-generated noise, and Criterion (3) would address this. Tidal conditions are generally not a contributing factor to ambient noise levels. However, in the presence of high tidal currents, turbulent pressure fluctuations ("flow noise" or "pseudonoise") can contaminate underwater noise measurements. In addition, some marine animals, such as croaker and drum fish (Family Sciaenidae) produce sounds at different times of day, possibly under different tidal conditions. Criterion (4) will help confirm the lack of pseudonoise contamination as well as identify possible biological contributors to the soundscape.

In addition to the above criteria, we plan to measure sound at different distances from the aforementioned bored piling sites (refer to Section 2.3) during both the baseline and construction phases, to allow estimation of a simple acoustic propagation model for the region where bored piling activities will occur. Appropriate distances for the study area's shallow depths and presumed high ambient noise levels are 100, 200, 300, and 500 m from the six bored piling sites. These noise levels as a function of distance measurements will be performed at least once during a relatively noise-stationary period during the baseline phase (i.e. when vessels are largely absent from the study area) and during the construction phase (i.e. during different work procedures of the bored piling activities, see Appendix II and Section 2.3).

The aforementioned propagation model will be a regression equation of the form:

$$SPL = C_1 + C_2 \log(R) + C_3 R$$

where SPL is in units of dB re 1 μPa for a given range R in metres and regression coefficients C_1, C_2, and C_3. The second, logarithmic term in the above equation represents spreading loss for the study site. For this shallow-water environment, it is anticipated that the second term will a combination of spherical (20logR) and cylindrical spreading (10logR), a result of reflection, absorption, and refraction of sound energy in this waveguide. The third, linear term represents scattering and absorption losses in the seawater and sub-bottom and at seafloor and sea surface interfaces. Such a mathematical model of acoustic propagation in the study area helps frame the results in appropriate context and allows application of the model to sites with similar waveguide properties.

2.5.2. Dolphin acoustic behavioural study

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 30 days from the start of bored piling activities near the TM-CLKL. 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 from the start of bored piling activities. This study will be conducted concurrently with the underwater noise study.

A total of 30 days (approximately 5-6 hours on each survey day) of dolphin acoustic behavioural monitoring using the dipping 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. During the construction phase, the acoustic monitoring team with the dipping hydrophone will be present in the vicinity of the TM-CLKL alignment, 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. Notably, the underwater noise monitoring works will be conducted concurrently with the dolphin acoustic behaviour monitoring works throughout the baseline and construction phases of monitoring.

Complementarily, the EARs will be deployed in early September, and will remain in the two study sites (i.e. one near bored piling site and another at a control site) for 30 days during the baseline phase and another 30 days during the construction phase. The EARs will be recovered, refurbished, and re-deployed approximately every 2-4 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) at a sampling rate of 64,000 samples per second, providing a bandwidth of approximately 30 kHz. In the recent bored piling monitoring programme of Hong Kong Link Road that also involved the deployment of

EARs, this recording bandwidth has been determined to be sufficient for the detection of the communication and echolocation signals from Chinese white dolphins.

2.6. Data Collection

2.6.1. Underwater noise study using dipping hydrophone

The underwater sound recording system consists of a high-sensitivity, high-bandwidth hydrophone (International Transducer Corporation ITC-6050c) and two-channel audio recorder (Sound Devices 702T). The hydrophone will be deployed from the stern of the research vessel, a deployment scheme sometimes referred to as a “dipping hydrophone”, approximately mid-water column at a depth of 5 m beneath a 2 m spar buoy. The hydrophone cable is faired to streamline water flow around the cable, reducing pseudonoise and eliminating cable vibration. The vessel will “go quiet” (its engine, generator, bilge pump, and depth sounder turned off) and drift for the duration of each recording. The recording system and deployment method generally follow that of another well-established study of underwater sounds in Hong Kong waters (Würsig and Greene 2002).

The ITC-6050c is a wide-band hydrophone with a built-in, low-noise preamplifier for optimum noise performance. Its nominal operating band is 30 Hz to 70 kHz, and its self-noise level is well below Knudsen Sea State 0 up to 20 kHz. The hydrophone signal will be amplified as needed via a postamplifier with user-selectable gains from 0 to 60 dB in 10 dB increments. The audio recorder will be configured to sample 16-bit data received on each of its two channels at a rate of 192 kHz, thus allowing analysis of the acoustic data up to 96 kHz. According to Section 6.4.5 of the EM&A Manual, “the acoustic results of the monitoring should be analyzed in terms of both the broadband range (100 Hz to 25.6 kHz) and, also, the dolphin sensitive range (400 Hz to 12.6 kHz).” The acoustic data collected from the present underwater noise study will be analyzed between 30 Hz and 40 kHz, avoiding a hydrophone resonance frequency at 50 kHz and also in compliance with the EM&A Manual requirement.

For the two channels of the recording system, the first channel will contain the acoustic signals received by the hydrophone, and the second channel will be connected to an in-air microphone for registered voice annotations to document any observations potentially relevant to the underwater soundscape. The voice annotations will supplement logs maintained by the survey team. These logs document the recording date, start and end times, hydrophone and water depths, Beaufort sea state, survey area, and postamplifier gain. Wind speed, often directly correlated with underwater levels, will be measured and documented in the survey team’s logs. The wind speed measurements will be performed with a handheld Kestrel 1000 anemometer, containing an impeller with precision axle and low-friction bearings, providing 0.1 m/s resolution between 0.6–40.0 m/s and an accuracy (calculated using two standard deviations) of the larger of 3% of the reading, least significant digit, or 0.1 m/s.

2.6.2. Dolphin acoustic behavioural study using dipping hydrophone

During dedicated acoustic surveys, the survey team of 2-3 HKCRP researchers will conduct systematic search for dolphins within the study area. The survey protocol to search for dolphins is similar to the line-transect survey methodology adopted in the vessel survey under the AFCD long-term marine mammal monitoring programme (Hung 2012, 2013) as well as various HZMB EM&A dolphin monitoring programmes. 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 dipping 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 the same set of underwater sound recording system as mentioned in Section 2.6.1 (see previous paragraph for detailed description). According to Section 6.4.5 of the EM&A Manual, "the acoustic results of the monitoring should be analyzed in terms of both the broadband range (100 Hz to 25.6 kHz) and, also, the dolphin sensitive range (400 Hz to 12.6 kHz)." Dolphin acoustic data collected from the recording system will be analyzed from 100 Hz and up to 40 kHz, which avoids a hydrophone resonance frequency at 50 kHz. This range would be sufficient to detect the presence of dolphin acoustic signals and their temporal parameters (e.g. click intervals), while it is also in compliance with the EM&A Manual requirement.

During the dipping hydrophone deployment, the date, start and end times, hydrophone and water depths, Beaufort sea state, survey area, locations, gain, event, and notes will be taken for each recording in five-minute intervals. 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 groups 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 movements in detail, especially when they occur in the vicinity of the TM-CLKL alignment.

2.6.3. Passive acoustic monitoring using EARs

Two sets of EARs will be deployed at two sites in North Lantau, one near the bored piling site and another at a control site, and the exact location will be chosen where the risk of vessel or trawler damage or removal can be minimized. The EARs will be deployed and recovered 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.

2.7. Data Analysis

2.7.1. Dipping hydrophone data for underwater noise measurement

The acoustic data will be analysed for narrowband spectra, one-third-octave band levels, and broadband levels. The levels will be tabulated and summarized with respect to various noise contributors including but not limited to vessels, wind, piling activity, and biological sounds. Due to the transient nature of vessel noise and the anticipated highly variable ambient noise levels likely to be encountered, the estimation of a single baseline noise level representative of the study area will not be possible. However, ambient noise levels will be quantitatively characterized and their potential masking effect on dolphin vocalization will be discussed.

Underwater acoustic measurements made during the 30-day construction phase and informed by the estimated propagation model described in Section 2.5.1 can be used to determine a safety radius (i.e. exclusion zone) for subsequent marine mammal monitoring in relation to the bored piling noise. For cetaceans and pinnipeds, the current U.S. National Marine Fisheries Service guidelines suggest that broadband received noise levels of a 180 dB re 1µPa (rms) is the lower limit for concern regarding temporary hearing impairment, while the lower limit for concern regarding permanent hearing impairment would be 190 dB re 1 µPa (rms) (NMFS 2003). Thus, a threshold for immediate action for the rest of the construction phase can be established to reduce or cease piling activity when a dolphin swims within the safety radius (i.e. exclusion zone) associated with the 180 dB re 1µPa (rms) received level.

2.7.2. Dipping hydrophone data for dolphin acoustic behaviour

To evaluate if dolphin acoustic behaviour varies between baseline and construction phases, a number of parameters will be examined at both phases for comparison. For the dipping 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 and click production 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. The parameters quantified in these analyses will then be compared between the pre-construction and construction phases of the study to determine whether differences occurred. 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.

2.7.3. EARs data for passive acoustic monitoring

A number of parameters on both occurrence patterns and acoustic behaviour of Chinese white dolphins collected from EARs will be examined at both baseline and construction phases for comparison. The Matlab-based program *Triton* will be used to visually examine the data. Due to the noisy conditions that characterize Hong Kong waters (from both biological and anthropogenic sources), each recording will have to be examined individually for the presence of dolphin signals. Once identified, each acoustic encounter (or standardized time bins, for example one hour) will be quantified so that it can be compared to other encounters or time periods. These metrics will be quantified during EAR data analysis include: the daily percentage of recordings with dolphin signals present, the number of daily dolphin acoustic encounters, the average daily duration of dolphin acoustic encounters, and the occurrence of dolphin detections binned hourly from 00:00 to 23:59 during the course of the study. These metrics will be used to make comparisons between baseline and construction phase activities to infer whether any differences are present.

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 bored piling monitoring programme should be undertaken by suitably qualified specialist(s) with sufficient (at least 10 years) relevant post-graduate experience and publication in the respective aspects (in this case, experienced bio-acousticians specialized in underwater and dolphin sound data acquisition and analysis). Approval on the specialist(s) responsible for this monitoring programme 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 Katherine Kim, Marc Lammers and Lisa Munger**, the Research Consultant of HKCRP, to serve as dolphin specialists for this project.

For the present work, Professor Würsig will be responsible to oversee the entire study, while Dr. Kim (of Greeneridge Sciences), Dr. Lammers and Dr. Munger (of Oceanwisde Science Insitute) will develop the methodology proposal, supervise the local field studies with Dr. Samuel Hung, and coordinating the data analysis. They will also assist Dr. Hung in the report write-up, and answer any queries in relation to the underwater noise study and dolphin acoustic behavioural study. Their detailed CVs are attached with this proposal, and their relevant experience is highlighted as follow.

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, University Distinguished 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 (including several current studies such as the third runway EIA study and the EM&A study on impact of bored piling activities for Hong Kong Link Road). Professor Würsig and his colleagues are the pioneers to develop an air bubble curtain to reduce underwater noise of percussive piling during the construction of the Temporary Aviation Fuel Receiving Facility (AFRF) for the Airport Authority (Würsig et al. 2000), and was also responsible for a follow-up study to measure underwater noise from fuel-offloading ships at AFRF with relevance to local Chinese white dolphins (Würsig and Greene 2002). He has also supervised several important studies to describe the vocal repertoire of Chinese white dolphins in Hong Kong, and investigate the impact of anthropogenic noises on local dolphins (Sims et al. 2011, 2012). His unique experience in cetacean acoustic studies and extensive knowledge of Chinese white dolphins and the Hong Kong underwater acoustic environment will greatly enhance the success of the dolphin-related acoustic studies for the present project.

Dr. Kim has 20 years of research experience in ocean acoustics and signal processing research and has dedicated the past 8 years to bioacoustics applications. She received her Ph.D. in a joint program in Electrical Engineering and Oceanography from Scripps Institution of Oceanography (SIO) in 2002, where she studied under esteemed signal processing and ocean acousticians Dr. William Hodgkiss and Dr. William Kuperman, and continued as a post-doctoral fellow at SIO until 2005. From 2005–2008, Dr. Kim continued to further her experience under the mentorship of ocean acoustic modeling authority Dr. Michael Porter at Heat, Light, and Sound Research, where she also began collaborating with Dr. John Hildebrand, director of SIO's Whale Acoustics Laboratory. In 2008, Dr. Kim joined Greeneridge Sciences in order to concentrate solely on bioacoustics work under the mentorship of Dr. Charles Greene, Jr., from whom she assumed leadership of the company upon Dr. Greene's retirement in February 2013. Dr. Kim has extensive sea-going experience and holds advanced SCUBA and coastal cruising certifications. Her current research areas involve the passive acoustic monitoring of marine mammals, especially as it relates to anthropogenic noise, and the signal processing and acoustic propagation associated with their vocalizations, ranging from a variety of dolphin in the Pacific Ocean to sperm whales in the Gulf of Mexico to bowhead whales in the Arctic Ocean. As an additional benefit for the continuity of dolphin-related acoustics research in Hong Kong, Dr. Kim is President of Greeneridge Sciences, the same organization responsible for groundbreaking research about one decade ago (Würsig et al. 2000 and Würsig and Greene 2002).

Dr. Marc Lammers has over 17 years of research experience in bioacoustics and cetacean behaviour. Currently, he is an Associate 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. Along with Professor Würsig and Dr. Munger, Dr. Lammers is currently involved with an EIA study for the third runway expansion project, an EM&A study for the Hong Kong Link Road (section between HKSAR Boundary and Scenic Hill), and a feasibility study for CEDD on Increasing Land Supply by Reclamation and Rock Cavern Development. He is responsible for the passive acoustic monitoring study with the application of the EARs in West and North Lantau waters for these various projects.

Dr. Lisa Munger has 12 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 is currently a Senior Research at Oceanwide Science Institute. 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.

For the local field studies, Professor Würsig, Dr. Kim, 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 Island (Sims et al. 2012).

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 that provides expert marine ecology research and consultancy services. OCL scientists have recent experience on successful deployment of a number of EARs for various studies in Hong Kong 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. However, due to the complexity of the present study with large volume of data involved for the analysis, we aim to submit the baseline report for this specific study within 20 working days upon completion of the baseline data collection. 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 Monitoring Report within 20 working days of completion of the baseline monitoring. Moreover, upon completion of the 30 days of construction phase monitoring, a Final Report shall be prepared and submitted within 30 days of completion of impact phase monitoring. Copies of the Baseline Monitoring Report and Final Monitoring Report on underwater noise and dolphin behaviour and movement in response to bored piling activities shall be submitted to the Contractor, the IEC, the SOR, AFCD and 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. More specifically, as described in Table 6.9 of the EM&A Manual, the event-action plan should be triggered when dolphin numbers and behaviour patterns recorded in the pre- and post-construction monitoring are significantly lower or different than those recorded in the pre-construction monitoring. Therefore, the Event and Action Plan should be developed to examine changes in the dolphin acoustic behaviour between baseline and impact phases of monitoring. Notably, such plan would not be needed for the underwater noise study, as it is not required by the EM&A Manual. and the mitigation measures including the 250-m dolphin exclusion zone during bored piling works as well as avoidance of the peak calving season of May and June for installation of metal caisson are already in place to keep the dolphins at a distance from the noise source of bored piling sites.

Since the baseline condition has yet to be established, only a conceptual Event and Action Plan is included here based on the response variables for dolphin acoustic behaviour (e.g. clicking and whistling rates per 5-minute recording time bin as a function of the size of dolphin group, their behavioural state and time of day). These will be recorded during both baseline and construction phase monitoring works. To implement the Event and Action Plan, we propose to take all response variables into account. 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. If a 40% difference in any of these variables between baseline and construction phase is detected, then the Limit Level should be triggered and immediate action should 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 further proposed in the Baseline Monitoring Report.

Conceptual Event and Action Plan

EVENT	ACTION			
	ET Leader	**IEC**	**SO**	**Contractor**
Action Level If any of the response variable for dolphin acoustic behaviour recorded in the construction phase monitoring is **20% lower or higher** than that recorded in the baseline monitoring, the 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 acoustic behaviour recorded in the construction phase monitoring is **40% lower or higher** than that recorded in the baseline monitoring, the 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

6. REFERENCE

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

Hung, S. K. 2013. Monitoring of Marine Mammals in Hong Kong waters: final report (2012-13). An unpublished report submitted to the Agriculture, Fisheries and Conservation Department, 168 pp.

NMFS. 2003. Taking marine mammals incidental to conducting oil and gas activities in the Gulf of Mexico. U.S. Federal Register 68, pp. 9991–9996.

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.

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 the 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 Marine 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.

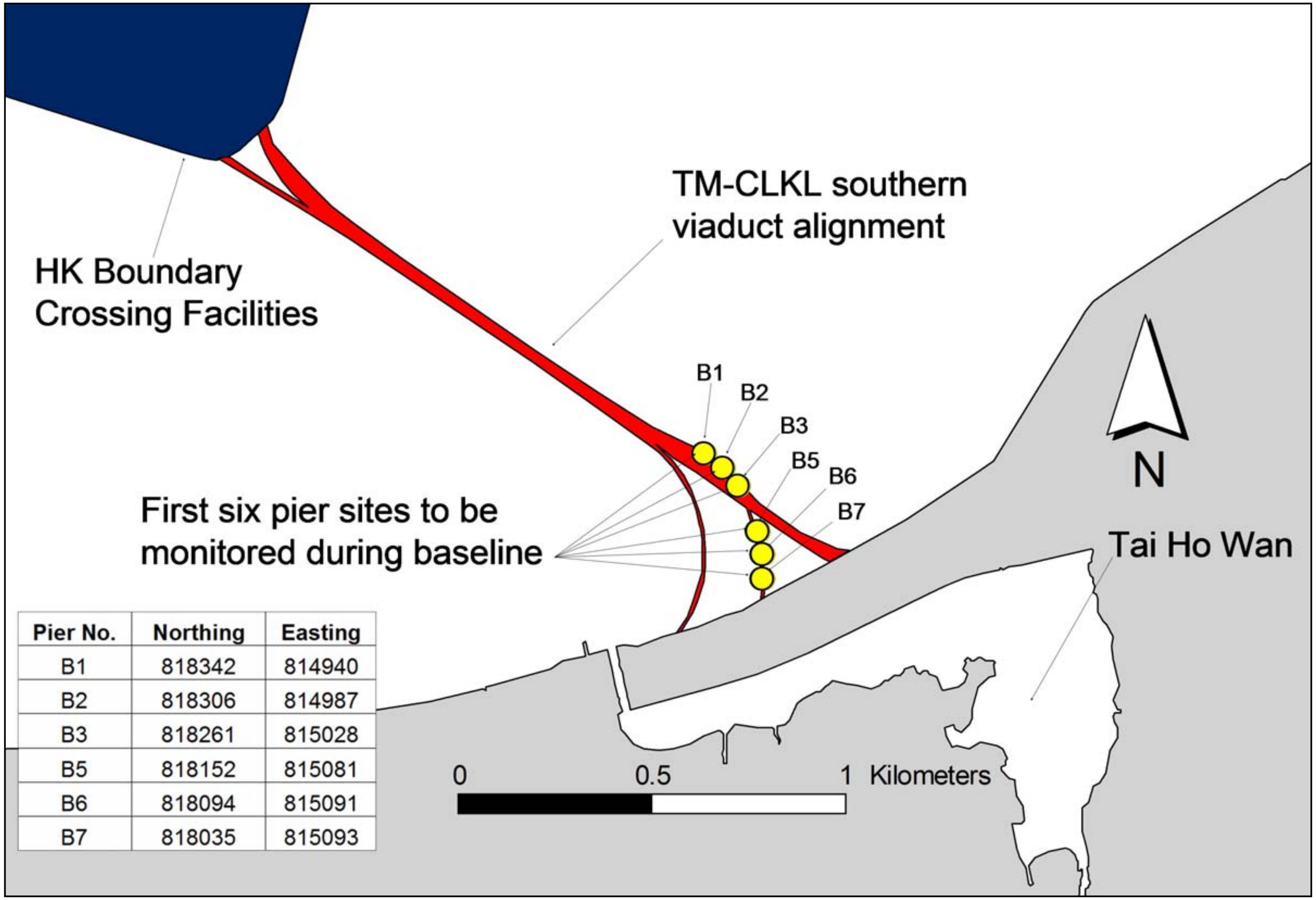
Würsig, B. and Greene, C. R., Jr. 2002. Underwater sounds near a fuel receiving facility in western Hong Kong: relevance to dolphins. Marine Environmental Research 54: 129–145.

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 Research 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.

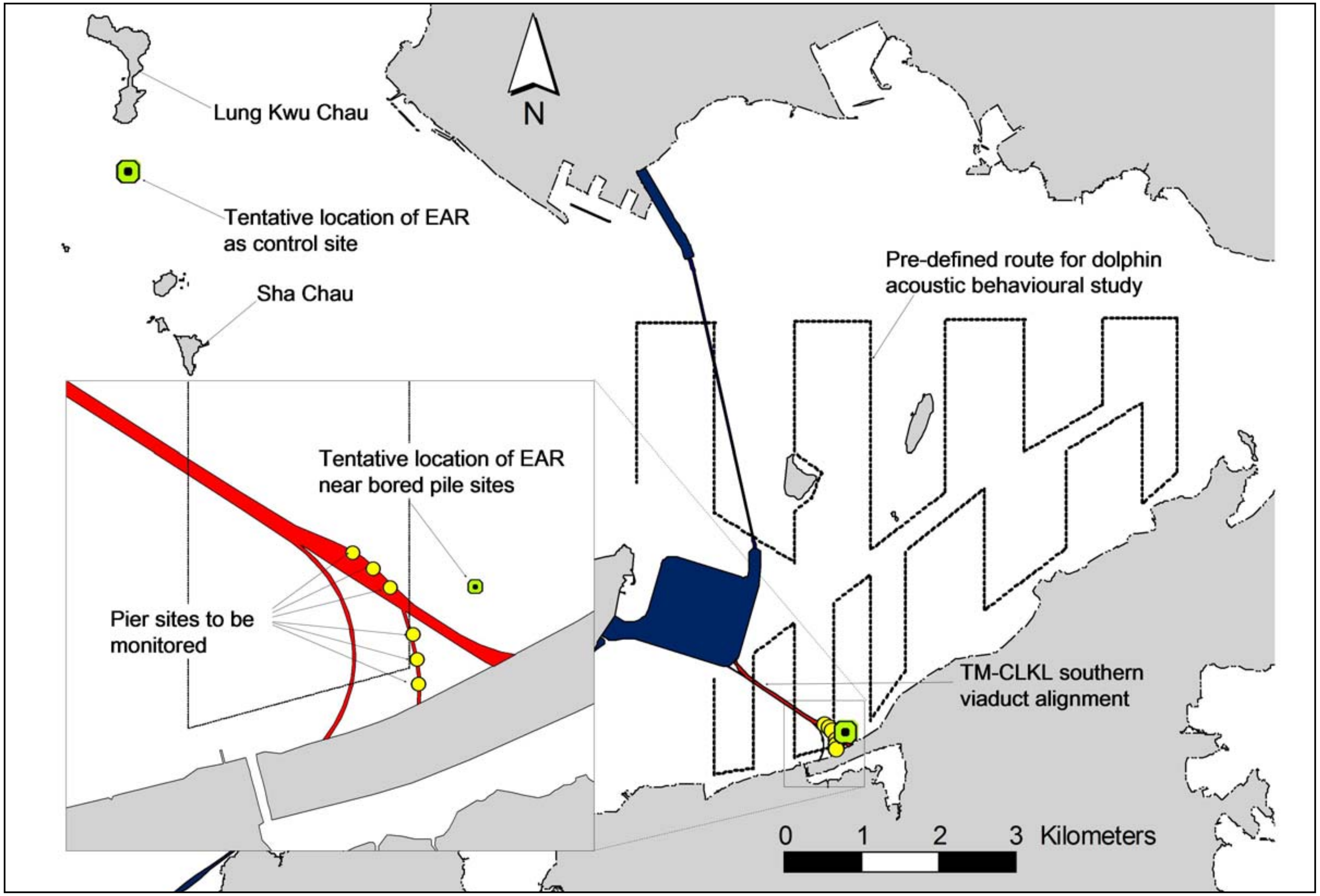
Würsig, B. and Richardson, W. J. 2009. Noise, effects of. In: Perrin, W. F., Würsig, B. and Thewissen, J. G. M. (editors). The Encyclopedia of Marine Mammals (second edition). Academic Press, Amsterdam, pp. 765-772.

Figure 1. Location of the bored pile pier sites to be monitored for the underwater noise measurement study of TM-CLKL construction



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

Figure 2. Map showing the tentative location of EAR deployments, pier sites to be monitored as well as pre-defined route for dolphin acoustic behavioural study



APPENDIX

I. Tentative Bored Piling Programme
II. Marine Bored Pile Construction Sequence

Appendix I. Tentative Marine Bored Piling Programme for HY/2012/07 - TMCLK Link Southern Connection Viaduct Section

Activity ID	Activity Name	Start (month)	Finish (month)
CONSTRUCTION			
Approach from Lantau			
Structure A1			
A107000	Marine Bored Piling Work Pier A6 - Pier A7	24	29
Structure A2			
A201000	Marine Bored Piling Work Pier A1 - Pier A5	21	29
Structure B2			
A204000	Marine Bored Piling Work Pier B7	9	11
Structure B3			
A301000	Marine Bored Piling Work Pier B1 - Pier B3, Pier B5 - Pier B6	9	14
Structure C3			
A304000	Marine Bored Piling Work Pier C6	21	23
Structure C4			
A401000	Marine Bored Piling Work Pier C1 - Pier C5	18	23
Structure D3			
A304000	Marine Bored Piling Work Pier D7	13	17
Structure D4			
A401000	Marine Bored Piling Work Pier D1 - Pier D6	14	21
Structure E1-A/B/C/D to E2-A/B/C/D (E1)			
E101000	Marine Bored Piling Work Pier E1-D	18	20
E102000	Marine Bored Piling Work Pier E1-C	18	20
E103000	Marine Bored Piling Work Pier E1-B	18	20
E104000	Marine Bored Piling Work Pier E1-A	18	20
E105000	Marine Bored Piling Work Pier E2-D/ Pier E2-C	15	17
E106010	Marine Bored Piling Work Pier E2-B	15	17
E107000	Marine Bored Piling Work Pier E2-A	15	17
Main Marine Crossing			
Structure E3-A/B/C/D to E10-A/B (E2)			
E201000	Marine Bored Piling Work Pier E3-D/ E3-C/ E3-B/ E3-A	15	18
E202000	Marine Bored Piling Work Pier E4-B/ E4-A	9	12
E203000	Marine Bored Piling Work Pier E5-A	13	18
E204000	Marine Bored Piling Work Pier E6-B/ E6-A	19	23
E205000	Marine Bored Piling Work Pier E7-B/ E7-A	9	11
E206000	Marine Bored Piling Work Pier E8-B/ E8-A	9	11
E207000	Marine Bored Piling Work Pier E9-B/ E9-A	17	24
E208000	Marine Bored Piling Work Pier E10-B/ E10-A	10	16
Structure E11-14 (E5), E11-14 (E6), E11-14 (E7) & E11-14 (E8)			
E501000	Marine Bored Piling Work Pier E11-B/ E11-A	10	17
E502000	Marine Bored Piling Work Pier E12-B/ E12-A	9	21
E502002	Marine Bored Piling Work (Dolphin N/S)	19	21
E503002	Marine Bored Piling Work Pier E13-D/ E13-C	9	16
E503004	Marine Bored Piling Work Pier E13-D Dolphin	14	16
E503100	Marine Bored Piling Work Pier E13-B/ E13-A	17	24
E503102	Marine Bored Piling Work Pier E13-A Dolphin	22	24

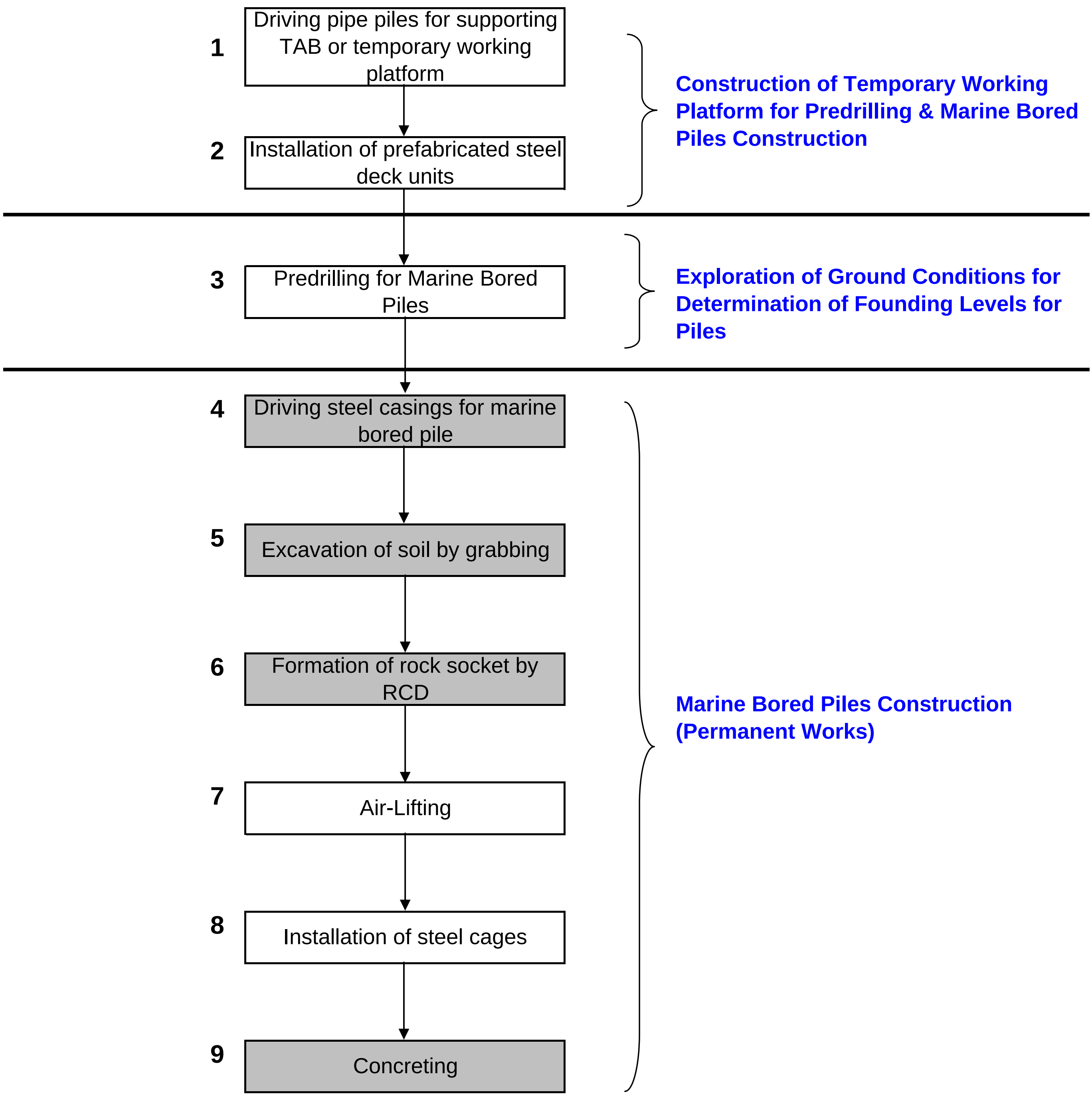
Month: 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Note

"Month" no. started from the commencement date of the works under the contract, which was 22 June 2013. For example, "Month 9" represents March 2014, while "Month 14" represents August 2014

[red dashed box] Peak calving season of Chinese White Dolphin when no formation of rock sockets will be carried out

Appendix II. Working Sequences for Marine Piling Works



LEGEND

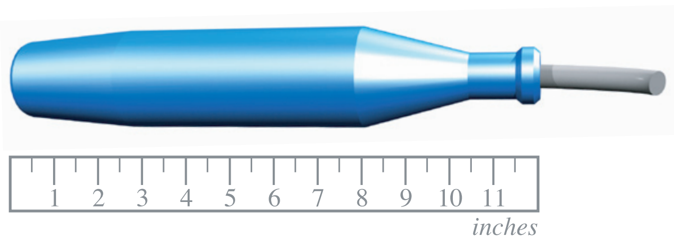
Activities of Underwater Acoustic Concern

Specification and Calibration Record of Hydrophone (ITC-6050C)

Model ITC-6050C

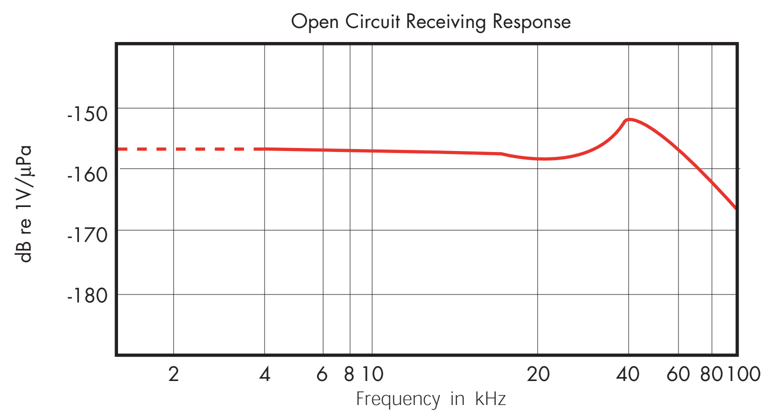
Preamplified Hydrophone

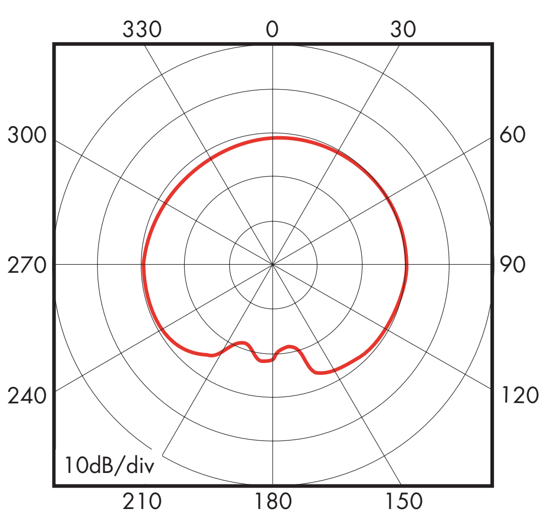
The Model ITC-6050C is a popular broadband hydrophone. The unit has a built-in, low noise preamplifier making it excellent for many field applications. Fully encapsulated in high quality polyurethane, it is well suited for rigorous conditions.



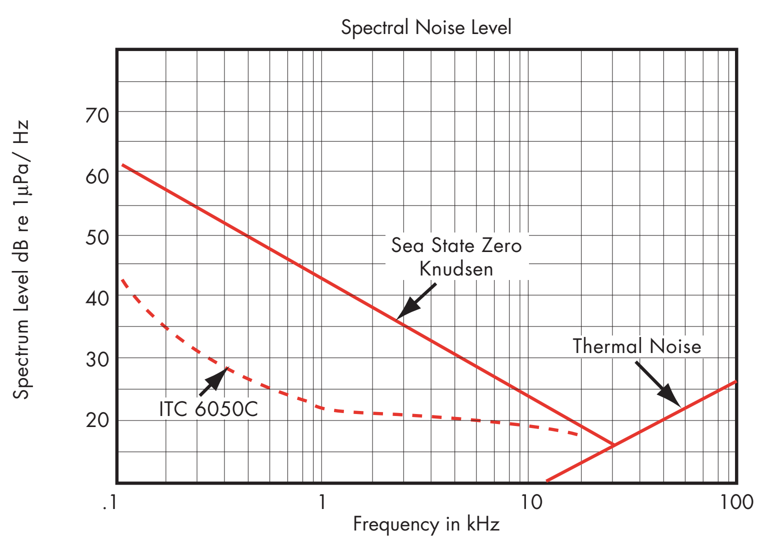
Specifications (Nominal)

Type	Hydrophone w/ Preamplifier
Resonance f_r	50 kHz
Depth	900 meters
Envelope Dimensions (in.)	2D x 12L
Midband OCV	-157 dB//1V/µPa
Suggested Band	.03 - 70 kHz
Beam Type	Spherical





Directivity Pattern at 50.0 kHz



Model ITC-6050C

International Transducer Corporation

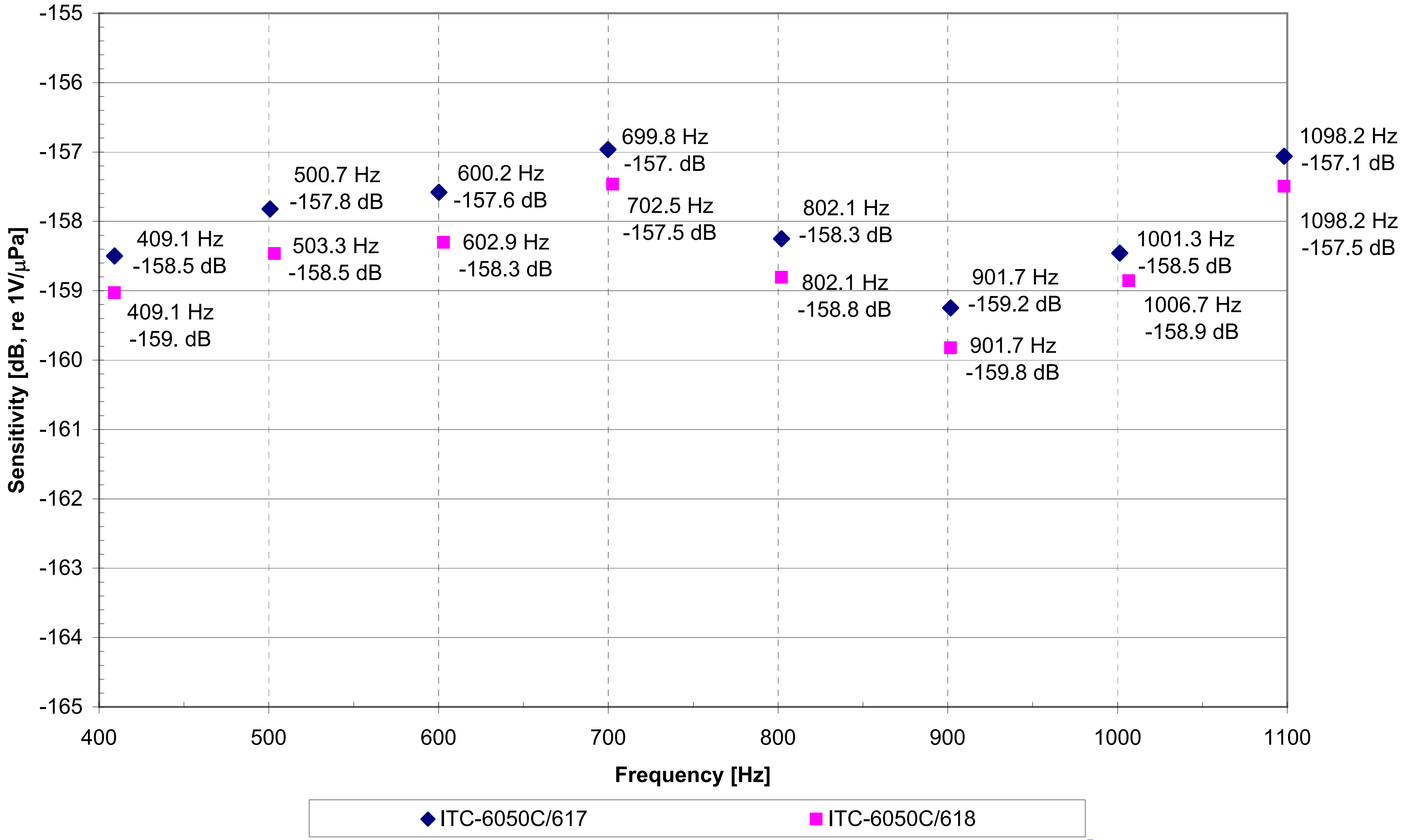
869 Ward Drive, Santa Barbara, CA 93111

805.683.2575 • 805.967.8199 FAX

www.itc-transducers.com

Cetacean Research Technology
4728 12th Ave. NE
Seattle, WA 98105
www.cetaceanresearch.com

ITC-6050C/617 Mean Sensitivity = -158.0dB
ITC-6050C/618 Mean Sensitivity = -158.5dB



Method: USRD C100 Hydrophone Calibrator + ST191DSA
Water Temperature: 80F

Measurement Date: 26 August 2013

Gammon

Calibration Reports for Ecological Acoustic Recorders (EARs)

Oceanway Corporation Limited

Unit. 3, G/F., N0. 34, Tai Chung Hau Village, Sai Kung, Hong Kong(S.A.R.), P.R.C.
Tel: (852) 2791 5331 Fax: (852) 2792 5331

REPORT ON ACOUSTICAL MEASUREMENTS
CONDUCTED FOR

Hong Kong Cetacean Research Project

EQUIPMENT TESTED
Hydrophone on an Environmental Acoustic Recorder (EAR)
EAR S/N : 9300708B088
(B1)

REPORT NUMBER : EARS-001

PREPARED BY: Gus ZHANG Cheng

PREPARED ON: 13th September 2013

TABLE OF CONTENTS

TEST OBJECTIVE

The test objective for this report was designed to reproduce the frequency testing carried for the hydrophone model SQ26-01, fitted to an Environmental Acoustic Recorder (EAR).

The SQ26-01 is manufactured by Sensor Technology Limited, a Canadian Company with an address given as P.O. Box 97, Collingwood, Ontario, Canada L9Y 3Z4. The hydrophone SQ26-01 is described as a general purpose, low-cost electrically shielded hydrophone.

The Environmental Acoustic Recorder (EAR) is supplied by Oceanwide Science Institute with an address given as 3620 Baldwin Ave. Ste 204, Makawao, HI 96768, U.S.A.

MEASUREMENT INSTRUMENTATION

The measurement Instrumentation was comprised of a calibrated hydrophone probe, an Agilent Technologies DSO-X-3024A Digital Oscilloscope, and an 8116A Hewlett Packard Pulse/Function Generator. All results were recorded in a Dell Laptop running Excel.

Two calibrated by-laminar membrane hydrophones were used. One used for the frequency range from 0.1KHz to 20KHz, the other from 15KHz to 50KHz. The overlap of frequency was used to check the calibration of both of the equipment used.

MEASUREMENT SETUP

The 0.1KHz to 20KHz by-laminar membrane hydrophone was connected to the Hewlett Packard Signal Generator. The unit was set to give a single frequency sine wave at a voltage level of 30Vp-p.

The hydrophone on the EAR's unit (model SQ26-01) was electrically disconnected from the electronic circuit and directly connected to the Agilent Digital oscilloscope. The latter was configured to display the signal being received by the hydrophone as well as the Fast Fourier Transformation (FFT) of that signal.

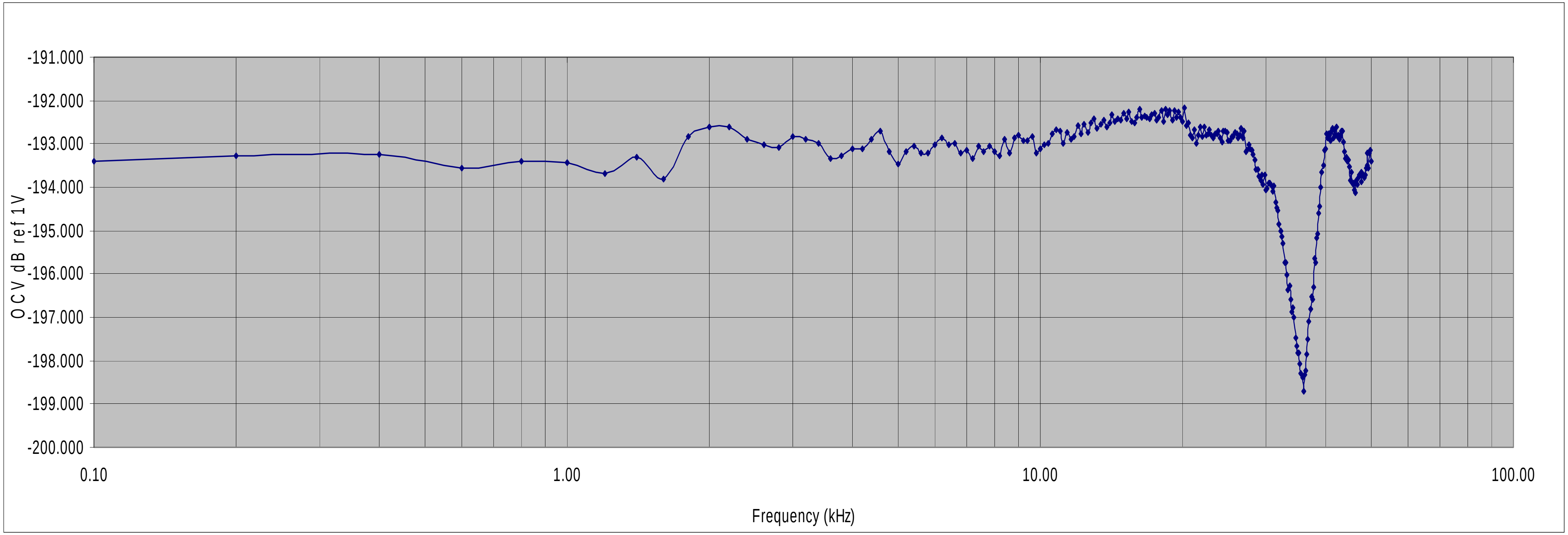
The by-laminar membrane hydrophone was mechanically connected to the top of the SQ26-01 hydrophone.

The frequency of the signal Generator was varied in 200Hz graduations through the range of 0.1KHz to 50KHz and the corresponding height of the FFT displayed result was measured using the calibrated internal cursor on the oscilloscope screen. In all a total of 250 readings were taken.

Agilent Technologies DSO-X-3024A serial number : MY52161670
Hewlett Packard Function Generator serial number : 178667-03

RESULTS

The results of the testing for frequencies from 0.1KHz to 50KHz are shown in the Received Voltage Response graph below:



Temperature during the test = 20ºC.
Pressure was 1.001mB
Location of test : HKU Laboratory
Date of test = 7th September 2013.

PERFORMANCE STATEMENT

The results of these tests shows that the maximum received frequency attenuation deviation of the SQ26-01 hydrophone fitted to the EAR unit with serial number 9300708B088, as compared to the manufacturers quoted specification (see Appendix A for details) is less than 0.5dBA. This gives a worst case deviation of <±1dBA. This is an acceptable result for such a sensor given the specification quotes a deviation of ±1dBA is acceptable (see Appendix A).

Signed : ______________________________

Date : _13th September 2013.

APPENDIX A - SQ23-01 Data Sheet

The SQ23-01 data sheet showing the frequency attenuation response.

SENSOR

Sensor Technology Limited

Hydrophone SQ26-01

Features

- Low cost
- Rugged
- Good depth capability

Applications

- General purpose research
- Towed arrays

Overview

The SQ26-01 is a general-purpose low-cost electrically shielded hydrophone. It has good sensitivity, wide bandwidth, and good stability. Custom configurations of these hydrophones are also available. For additional data on frequency response or outline drawings, please call our technical support. All parameters are measured after hydrophones have been subjected to pressures of 70 bar. The polyurethane-encapsulated hydrophone will withstand continuous immersion in isoparaffinic hydrocarbon fluids and sea water.

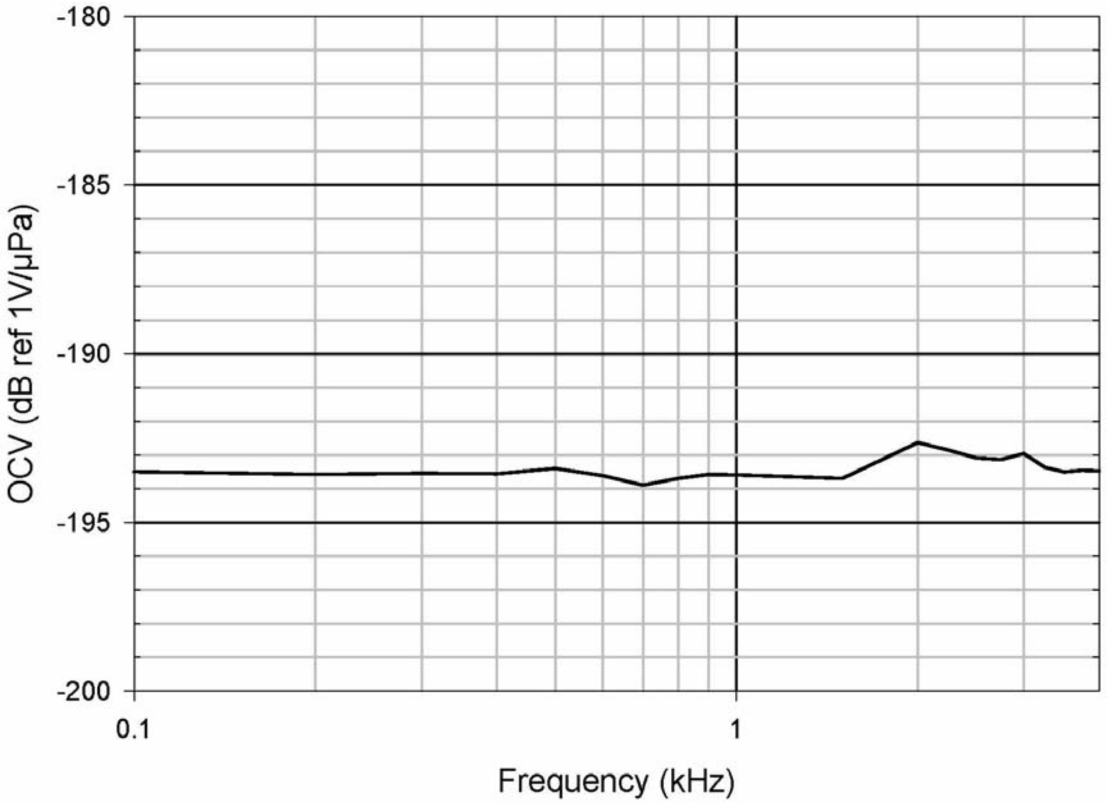
Specifications

Voltage sensitivity	-193.5 ± 1.0 dBV re 1 μPa @ 20 °C, 20 V/bar
Charge sensitivity	24 nC/bar
Capacitance	1.4 nF ± 10 % @ 20 °C
Sensitivity variation with temperature	less than 1 dB loss from 0 to 35 °C
Capacitance variation with temperature	0.33% increase per °C
Capacitance variation with depth	7% loss per 1,000 m
Operating depth	down to 1,000 m
Frequency response	flat from 1 Hz to 28,000 Hz
Acceleration sensitivity	< 0.2 mbar/g when properly mounted
Storage and operating temperature	-30 to +60 °C
Diameter	25.4 mm (1.0”)
Length	25.4 mm (1.0”) max
Mass	16 grams
Electrical leads	two-wire shielded, 28AWG, 30cm (12”) long
Shielding	integral Faraday cage type
Electrical insulation	> 500 M Ohms
Water blocked leads	No

Sensor Technology Limited, PO Box 97, Collingwood Ontario, Canada L9Y 3Z4
Tel (705) 444-1440 Fax (705) 444-6787 www.Sensortech.ca Email: techsupport@Sensortech.ca

Rev. 09/03

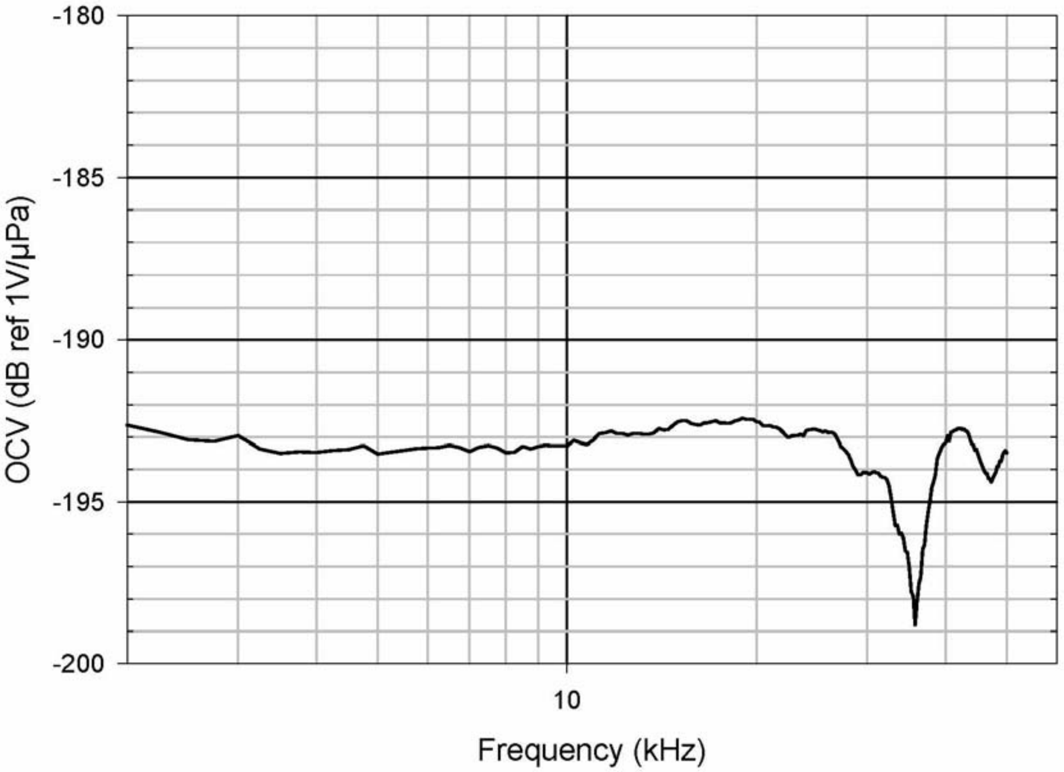
Receive Voltage Response
SQ26 (typical)



Date: October 4, 2004
Acoustic Test Facility: Newport Rhode Island
Transducer Model: SQ26
Test Frequency: 100 - 3000Hz
Spacing: 2.32 meters
Depth: 12 meters
Plane: XZ

SENSOR
Sensor Technology Limited

Receive Voltage Response
SQ26 (typical)



Date: Sept 16, 2004
Acoustic Test Facility: Seneca Lake Sonar Test Facility
Transducer Model: SQ26
Test Frequency: 2 - 50kHz
Spacing: 2.32 meters
Depth: 12 meters
Plane: XZ

SENSOR
Sensor Technology Limited

APPENDIX B - Raw Data

The raw data collected during the testing:

Frequency KHz	Log10 (v) dB
0.10	-193.403
0.20	-193.271
0.40	-193.241
0.60	-193.557
0.80	-193.394
1.00	-193.422
1.20	-193.678
1.40	-193.321
1.60	-193.797
1.80	-192.845
2.00	-192.598
2.20	-192.621
2.40	-192.901
2.60	-193.011
2.80	-193.073
3.00	-192.842
3.20	-192.897
3.40	-192.979
3.60	-193.346
3.80	-193.282
4.00	-193.112
4.20	-193.106
4.40	-192.895
4.60	-192.703
4.80	-193.175
5.00	-193.448
5.20	-193.184
5.40	-193.052
5.60	-193.224
5.80	-193.212
6.00	-193.028
6.20	-192.861
6.40	-193.035
6.60	-192.981
6.80	-193.201
7.00	-193.153
7.20	-193.338
7.40	-193.046
7.60	-193.184
7.80	-193.055
8.00	-193.178
8.20	-193.274
8.40	-192.902
8.60	-193.225
8.80	-192.873
9.00	-192.813
9.20	-192.918
9.40	-192.931
9.60	-192.845
9.80	-193.214
10.00	-193.104
10.20	-193.008
10.40	-192.999
10.60	-192.766
10.80	-192.689
11.00	-192.708
11.20	-192.984
11.40	-192.728
11.60	-192.888
11.80	-192.827
12.00	-192.582
12.20	-192.783
12.40	-192.554
12.60	-192.744
12.80	-192.509
13.00	-192.429
13.20	-192.641
13.40	-192.535
13.60	-192.445
13.80	-192.610

Frequency KHz	Log10 (v) dB
14.00	-192.520
14.20	-192.336
14.40	-192.477
14.60	-192.417
14.80	-192.454
15.00	-192.287
15.20	-192.435
15.40	-192.279
15.60	-192.474
15.80	-192.505
16.00	-192.384
16.20	-192.190
16.40	-192.380
16.60	-192.349
16.80	-192.402
17.00	-192.411
17.20	-192.328
17.40	-192.303
17.60	-192.440
17.80	-192.380
18.00	-192.217
18.20	-192.487
18.40	-192.194
18.60	-192.341
18.80	-192.233
19.00	-192.439
19.20	-192.226
19.40	-192.387
19.60	-192.251
19.80	-192.403
20.00	-192.485
20.20	-192.169
20.40	-192.570
20.60	-192.515
20.80	-192.810
21.00	-192.874
21.20	-192.660
21.40	-192.975
21.60	-192.804
21.80	-192.602
22.00	-192.837
22.20	-192.615
22.40	-192.797
22.60	-192.769
22.80	-192.671
23.00	-192.790
23.20	-192.872
23.40	-192.781
23.60	-192.760
23.80	-192.708
24.00	-192.856
24.20	-192.949
24.40	-192.695
24.60	-192.714
24.80	-192.748
25.00	-192.939
25.20	-192.916
25.40	-192.843
25.60	-192.824
25.80	-192.735
26.00	-192.766
26.20	-192.865
26.40	-192.809
26.60	-192.656
26.80	-192.854
27.00	-192.709
27.20	-193.172
27.40	-193.148
27.60	-193.035
27.80	-193.119

Frequency KHz	Log10 (v) dB
28.00	-193.161
28.20	-193.244
28.40	-193.373
28.60	-193.578
28.80	-193.589
29.00	-193.736
29.20	-193.831
29.40	-193.713
29.60	-193.925
29.80	-193.702
30.00	-194.070
30.20	-194.016
30.40	-193.893
30.60	-193.896
30.80	-193.976
31.00	-194.104
31.20	-193.959
31.40	-194.362
31.60	-194.479
31.80	-194.547
32.00	-194.844
32.20	-195.025
32.40	-195.137
32.60	-195.290
32.80	-195.729
33.00	-195.733
33.20	-196.015
33.40	-196.356
33.60	-196.283
33.80	-196.582
34.00	-196.882
34.20	-196.784
34.40	-196.985
34.60	-197.486
34.80	-197.665
35.00	-197.824
35.20	-197.827
35.40	-198.077
35.60	-198.298
35.80	-198.398
36.00	-198.697
36.20	-198.311
36.40	-198.217
36.60	-197.842
36.80	-197.493
37.00	-197.080
37.20	-196.823
37.40	-196.529
37.60	-196.597
37.80	-196.315
38.00	-195.656
38.20	-195.731
38.40	-195.181
38.60	-195.073
38.80	-194.599
39.00	-194.453
39.20	-194.009
39.40	-193.661
39.60	-193.499
39.80	-193.158
40.00	-193.125
40.20	-192.755
40.40	-192.864
40.60	-192.753
40.80	-192.807
41.00	-192.930
41.20	-192.695
41.40	-192.646
41.60	-192.876
41.80	-192.662

Frequency KHz	Log10 (v) dB
42.00	-192.790
42.20	-192.597
42.40	-192.832
42.60	-192.787
42.80	-192.909
43.00	-192.809
43.20	-192.817
43.40	-192.710
43.60	-192.702
43.80	-192.962
44.00	-193.165
44.20	-193.335
44.40	-193.299
44.60	-193.386
44.80	-193.380
45.00	-193.517
45.20	-193.826
45.40	-193.651
45.60	-193.903
45.80	-193.950
46.00	-193.905
46.20	-194.049
46.40	-194.121
46.60	-193.841
46.80	-193.944
47.00	-193.775
47.20	-193.707
47.40	-193.704
47.60	-193.658
47.80	-193.874
48.00	-193.679
48.20	-193.726
48.40	-193.764
48.60	-193.712
48.80	-193.561
49.00	-193.498
49.20	-193.222
49.40	-193.552
49.60	-193.225
49.80	-193.157
50.00	-193.390

Oceanway Corporation Limited
Unit. 3, G/F., N0. 34, Tai Chung Hau Village, Sai Kung, Hong Kong(S.A.R.), P.R.C.
Tel: (852) 2791 5331 Fax: (852) 2792 5331

REPORT ON ACOUSTICAL MEASUREMENTS
CONDUCTED FOR

Hong Kong Cetacean Research Project

EQUIPMENT TESTED
Hydrophone on an Environmental Acoustic Recorder (EAR)
EAR S/N : 9300479B100
(B2)

REPORT NUMBER : EARS-002

PREPARED BY: Gus ZHANG Cheng

PREPARED ON: 13th September 2013

TABLE OF CONTENTS

TEST OBJECTIVE

The test objective for this report was designed to reproduce the frequency testing carried for the hydrophone model SQ26-01, fitted to an Environmental Acoustic Recorder (EAR).

The SQ26-01 is manufactured by Sensor Technology Limited, a Canadian Company with an address given as P.O. Box 97, Collingwood, Ontario, Canada L9Y 3Z4. The hydrophone SQ26-01 is described as a general purpose, low-cost electrically shielded hydrophone.

The Environmental Acoustic Recorder (EAR) is supplied by Oceanwide Science Institute with an address given as 3620 Baldwin Ave. Ste 204, Makawao, HI 96768, U.S.A.

MEASUREMENT INSTRUMENTATION

The measurement Instrumentation was comprised of a calibrated hydrophone probe, an Agilent Technologies DSO-X-3024A Digital Oscilloscope, and an 8116A Hewlett Packard Pulse/Function Generator. All results were recorded in a Dell Laptop running Excel.

Two calibrated by-laminar membrane hydrophones were used. One used for the frequency range from 0.1KHz to 20KHz, the other from 15KHz to 50KHz. The overlap of frequency was used to check the calibration of both of the equipment used.

MEASUREMENT SETUP
The 0.1KHz to 20KHz by-laminar membrane hydrophone was connected to the Hewlett Packard Signal Generator. The unit was set to give a single frequency sine wave at a voltage level of 30Vp-p.

The hydrophone on the EAR's unit (model SQ26-01) was electrically disconnected from the electronic circuit and directly connected to the Agilent Digital oscilloscope. The latter was configured to display the signal being received by the hydrophone as well as the Fast Fourier Transformation (FFT) of that signal.

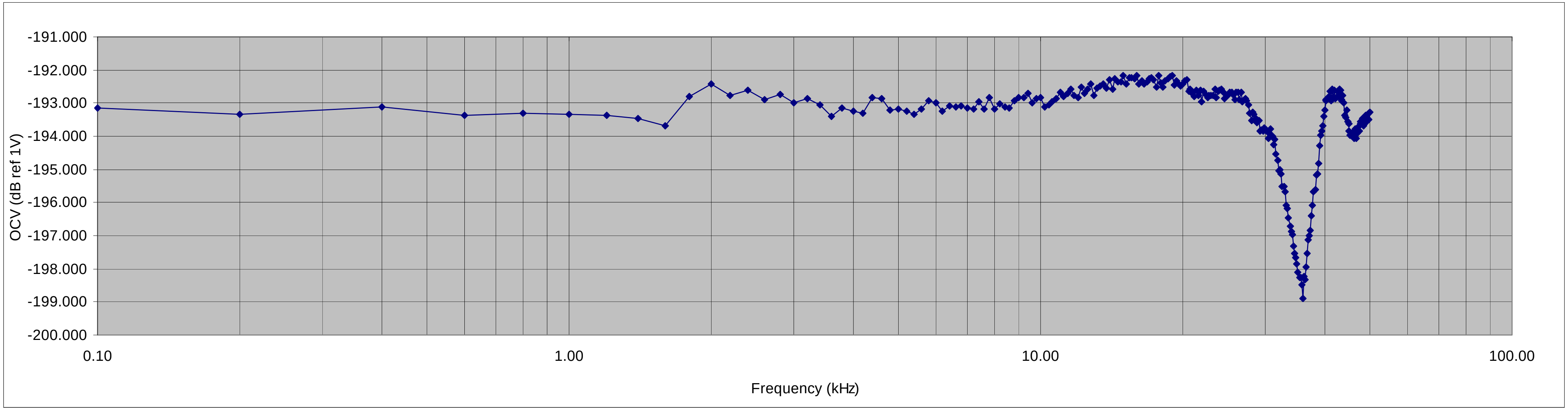
The by-laminar membrane hydrophone was mechanically connected to the top of the SQ26-01 hydrophone.

The frequency of the signal Generator was varied in 200Hz graduations through the range of 0.1KHz to 50KHz and the corresponding height of the FFT displayed result was measured using the calibrated internal cursor on the oscilloscope screen. In all a total of 251 readings were taken.

Agilent Technologies DSO-X-3024A serial number : MY52161670
Hewlett Packard Function Generator serial number : 178667-03

RESULTS

The results of the testing for frequencies from 0.1KHz to 50KHz are shown in the Received Voltage Response graph below:



Temperature during the test = 20ºC.
Pressure was 1.003mB
Location of test : HKU Laboratory
Date of test = 10th September 2013.

PERFORMANCE STATEMENT

The results of these tests shows that the maximum received frequency attenuation deviation of the SQ26-01 hydrophone fitted to the EAR unit with serial number 9300479B100, as compared to the manufacturers quoted specification (see Appendix A for details) is less than 0.4dBA. This gives a worst case deviation of <±1dBA. This is an acceptable result for such a sensor given the specification quotes a deviation of ±1dBA is acceptable (see Appendix A).

Signed :  ______________________________

Date : 13th September 2013

APPENDIX A - SQ23-01 Data Sheet

The SQ23-01 data sheet showing the frequency attenuation response.

SENSOR Sensor Technology Limited

Hydrophone SQ26-01

Features

- Low cost
- Rugged
- Good depth capability

Applications

- General purpose research
- Towed arrays

Overview

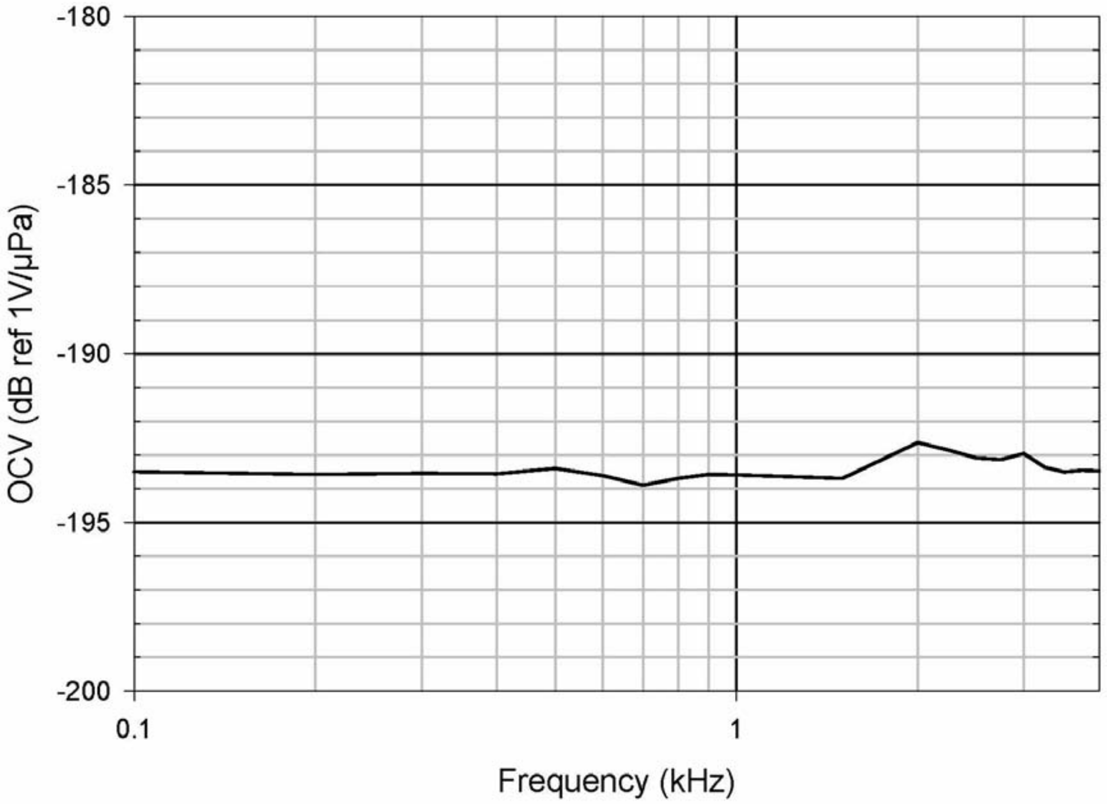
The SQ26-01 is a general-purpose low-cost electrically shielded hydrophone. It has good sensitivity, wide bandwidth, and good stability. Custom configurations of these hydrophones are also available. For additional data on frequency response or outline drawings, please call our technical support. All parameters are measured after hydrophones have been subjected to pressures of 70 bar. The polyurethane-encapsulated hydrophone will withstand continuous immersion in isoparaffinic hydrocarbon fluids and sea water.

Specifications

Voltage sensitivity	-193.5 ± 1.0 dBV re 1 μPa @ 20 °C, 20 V/bar
Charge sensitivity	24 nC/bar
Capacitance	1.4 nF ± 10 % @ 20 °C
Sensitivity variation with temperature	less than 1 dB loss from 0 to 35 °C
Capacitance variation with temperature	0.33% increase per °C
Capacitance variation with depth	7% loss per 1,000 m
Operating depth	down to 1,000 m
Frequency response	flat from 1 Hz to 28,000 Hz
Acceleration sensitivity	< 0.2 mbar/g when properly mounted
Storage and operating temperature	-30 to +60 °C
Diameter	25.4 mm (1.0")
Length	25.4 mm (1.0") max
Mass	16 grams
Electrical leads	two-wire shielded, 28AWG, 30cm (12") long
Shielding	integral Faraday cage type
Electrical insulation	> 500 M Ohms
Water blocked leads	No

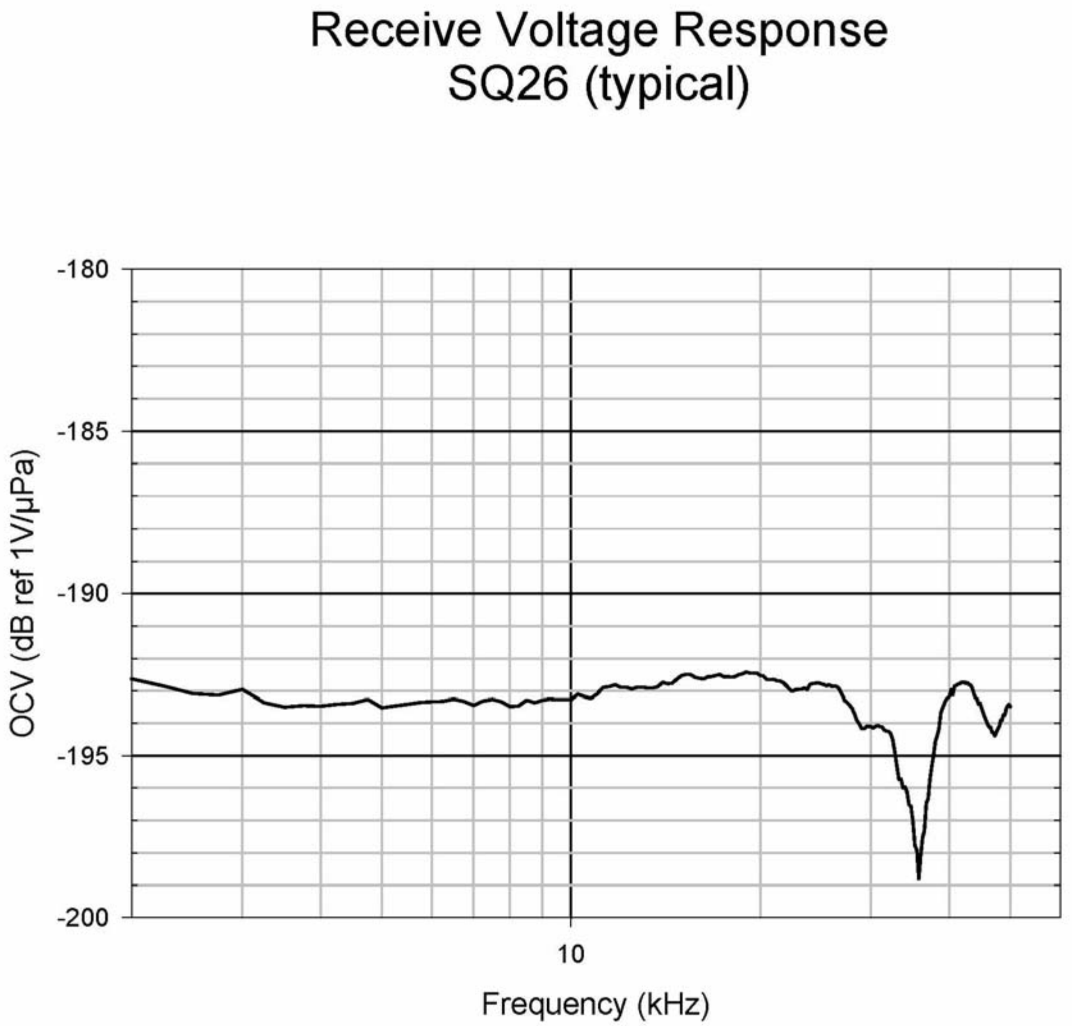
Sensor Technology Limited, PO Box 97, Collingwood Ontario, Canada L9Y 3Z4
Tel (705) 444-1440 Fax (705) 444-6787 www.Sensortech.ca Email: techsupport@Sensortech.ca
Rev. 09/03

Receive Voltage Response
SQ26 (typical)



Date: October 4, 2004
Acoustic Test Facility: Newport Rhode Island
Transducer Model: SQ26
Test Frequency: 100 - 3000Hz
Spacing: 2.32 meters
Depth: 12 meters
Plane: XZ

SENSOR
Sensor Technology Limited



Date: Sept 16, 2004
Acoustic Test Facility: Seneca Lake Sonar Test Facility
Transducer Model: SQ26
Test Frequency: 2 - 50kHz
Spacing: 2.32 meters
Depth: 12 meters
Plane: XZ

SENSOR
Sensor Technology Limited

APPENDIX B - Raw Data

The raw data collected during the testing:

Frequency KHz	Log10 (v) dB
0.100	-193.134
0.200	-193.349
0.400	-193.114
0.600	-193.356
0.800	-193.320
1.000	-193.341
1.200	-193.370
1.400	-193.478
1.600	-193.684
1.800	-192.800
2.000	-192.409
2.200	-192.780
2.400	-192.603
2.600	-192.908
2.800	-192.737
3.000	-192.988
3.200	-192.851
3.400	-193.045
3.600	-193.408
3.800	-193.151
4.000	-193.238
4.200	-193.300
4.400	-192.845
4.600	-192.856
4.800	-193.219
5.000	-193.164
5.200	-193.234
5.400	-193.322
5.600	-193.177
5.800	-192.918
6.000	-192.993
6.200	-193.230
6.400	-193.080
6.600	-193.103
6.800	-193.082
7.000	-193.154
7.200	-193.174
7.400	-192.946
7.600	-193.178
7.800	-192.828
8.000	-193.170
8.200	-193.027
8.400	-193.112
8.600	-193.149
8.800	-192.921
9.000	-192.833
9.200	-192.818
9.400	-192.690
9.600	-192.982
9.800	-192.859
10.000	-192.825
10.200	-193.130
10.400	-193.040
10.600	-192.961
10.800	-192.869
11.000	-192.685
11.200	-192.790
11.400	-192.712
11.600	-192.575
11.800	-192.771
12.000	-192.824
12.200	-192.525
12.400	-192.701
12.600	-192.570
12.800	-192.424
13.000	-192.782
13.200	-192.536
13.400	-192.495
13.600	-192.416
13.800	-192.563

Frequency KHz	Log10 (v) dB
14.000	-192.293
14.200	-192.567
14.400	-192.274
14.600	-192.353
14.800	-192.372
15.000	-192.159
15.200	-192.416
15.400	-192.242
15.600	-192.235
15.800	-192.269
16.000	-192.154
16.200	-192.411
16.400	-192.334
16.600	-192.410
16.800	-192.351
17.000	-192.271
17.200	-192.240
17.400	-192.290
17.600	-192.512
17.800	-192.155
18.000	-192.391
18.200	-192.500
18.400	-192.337
18.600	-192.251
18.800	-192.186
19.000	-192.167
19.200	-192.445
19.400	-192.342
19.600	-192.429
19.800	-192.489
20.000	-192.428
20.200	-192.331
20.400	-192.303
20.600	-192.648
20.800	-192.575
21.000	-192.692
21.200	-192.789
21.400	-192.610
21.600	-192.753
21.800	-192.619
22.000	-192.946
22.200	-192.652
22.400	-192.739
22.600	-192.830
22.800	-192.779
23.000	-192.766
23.200	-192.777
23.400	-192.577
23.600	-192.847
23.800	-192.648
24.000	-192.619
24.200	-192.563
24.400	-192.676
24.600	-192.848
24.800	-192.756
25.000	-192.780
25.200	-192.683
25.400	-192.669
25.600	-192.744
25.800	-192.904
26.000	-192.679
26.200	-192.674
26.400	-192.897
26.600	-192.679
26.800	-192.946
27.000	-192.906
27.200	-192.863
27.400	-192.936
27.600	-193.068
27.800	-193.319

Frequency KHz	Log10 (v) dB
28.000	-193.526
28.200	-193.260
28.400	-193.341
28.600	-193.449
28.800	-193.576
29.000	-193.522
29.200	-193.833
29.400	-193.798
29.600	-193.852
29.800	-193.749
30.000	-193.779
30.200	-193.830
30.400	-194.057
30.600	-193.921
30.800	-193.789
31.000	-194.000
31.200	-194.263
31.400	-194.096
31.600	-194.534
31.800	-194.718
32.000	-195.050
32.200	-195.012
32.400	-195.149
32.600	-195.528
32.800	-195.516
33.000	-195.678
33.200	-196.071
33.400	-196.176
33.600	-196.466
33.800	-196.717
34.000	-196.858
34.200	-196.959
34.400	-197.301
34.600	-197.523
34.800	-197.652
35.000	-197.850
35.200	-198.104
35.400	-198.270
35.600	-198.277
35.800	-198.473
36.000	-198.884
36.200	-198.246
36.400	-198.323
36.600	-197.958
36.800	-197.543
37.000	-197.135
37.200	-196.988
37.400	-196.846
37.600	-196.396
37.800	-196.097
38.000	-195.666
38.200	-195.605
38.400	-195.172
38.600	-195.144
38.800	-194.835
39.000	-194.277
39.200	-193.983
39.400	-193.829
39.600	-193.696
39.800	-193.386
40.000	-193.195
40.200	-192.936
40.400	-192.886
40.600	-192.876
40.800	-192.838
41.000	-192.795
41.200	-192.650
41.400	-192.922
41.600	-192.572
41.800	-192.827

Frequency KHz	Log10 (v) dB
42.000	-192.597
42.200	-192.870
42.400	-192.817
42.600	-192.816
42.800	-192.680
43.000	-192.574
43.200	-192.597
43.400	-192.925
43.600	-192.892
43.800	-192.773
44.000	-192.977
44.200	-193.356
44.400	-193.446
44.600	-193.209
44.800	-193.559
45.000	-193.629
45.200	-193.845
45.400	-193.956
45.600	-193.981
45.800	-193.919
46.000	-193.975
46.200	-194.059
46.400	-193.863
46.600	-193.780
46.800	-194.056
47.000	-193.917
47.200	-193.722
47.400	-193.827
47.600	-193.635
47.800	-193.564
48.000	-193.548
48.200	-193.477
48.400	-193.681
48.600	-193.571
48.800	-193.623
49.000	-193.375
49.200	-193.553
49.400	-193.324
49.600	-193.312
49.800	-193.489
50.000	-193.265

AFCD Scientific Permit for Deployment of EAR within Sha Chau and Lung Kwu Chau Marine Park

漁農自然護理署
郊野公園及海岸公園管理局
九龍長沙灣道 303 號
長沙灣政府合署六樓

Agriculture, Fisheries & Conservation Department
Country & Marine Parks Authority
Cheung Sha Wan Government Offices
303 Cheung Sha Wan Road 6th floor
Kowloon, Hong Kong

本署檔號 OUR REF: (64) AF GR MPA 01/5/2 Pt.14
來函檔號 YOUR REF:
電　話 TEL NO.: (852) 2150 6870
圖文傳真 Faxline No: (852) 2152 0060

Room 2004, 20/F,
Tamson Plaza, 161 Wai Yip Street,
Kwun Tong, Kowloon
Hong Kong

Attn: Dr. Hung Ka Yiu Samuel

18 September 2013

Dear Dr. Hung,

Application for Permission to Undertake Scientific Study in Sha Chau and Lung Kwu Chau Marine Park

I refer to your application, seeking permission to undertake a research project entitled "Application of Passive Acoustic Monitoring using Ecological Acoustic Recorder (EAR) within Sha Chau and Lung Kwu Chau Marine Park".

The permission is hereby given under Section 17 (5)(a) of the Marine Parks and Marine Reserves Regulation (Cap. 476A) to you for carrying out experimental devices installation activities in relation to the above research in the captioned Marine Park during the period from 18 September 2013 to 30 June 2014 subject to the conditions attached.

If you have any enquiry, please contact Ms. Hiu-yan LI at 2150 7150.

Yours sincerely,

(Alan Chan)
for Director of Agriculture, Fisheries and Conservation

Encl.

cc.
Internal
MP/W

All replies must be addressed to Director of Agriculture, Fisheries & Conservation
覆函請寄交「漁農自然護理署署長」

Curriculum Vitae of Bio-acousticians and Dolphin Specialists

Samples of Publications of Bio-acousticians and Dolphin Specialists