Dragages -China Harbour-VSL JV

Contract HY/2011/09

Hong Kong-Zhuhai-Macao Bridge

Hong Kong Link Road-Section between HKSAR Boundary and Scenic Hill

Proposal for Baseline and Construction-Phase Underwater Noise Monitoring

August 2013
(Version 7.0)

Certified By 

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Environmental Team Leader

REMARKS:

The information supplied and contained within this report is, to the best of our knowledge, correct at the time of printing.

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TABLE OF CONTENTS

LIST OF FIGURE

LIST OF APPENDIX

1 INTRODUCTION

Background

1.1 The Hong Kong Link Road (HKLR) comprises a 9.4km long viaduct section from the HKSAR boundary to Scenic Hill on the Airport Island; a 1km tunnel section to the reclamation formed along the east coast of the Airport Island and a 1.6km long at-grade road section on the reclamation connecting to the Hong Kong Boundary Crossing Facilities (HKBCF). The tunnel section of HKLR will pass under Scenic Hill, Airport Road and Airport Railway to minimize the environmental and visual impacts to Tung Chung residents.

1.2 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" (hereinafter called the Contract).

1.3 According to the EM&A Manual, a number of environmental monitoring and audit works related to dolphin shall be conducted during construction phase, including baseline and construction-phase underwater noise monitoring.

1.4 This baseline and construction-phase underwater noise monitoring proposal will detail the methodology and monitoring frequency to meet the requirement in the particular specification and EM&A Manual. It was prepared and submitted for approval before commencement of monitoring works.

2 BASELINE AND CONSTRUCTION-PHASE UNDERWATER NOISE MONITORING

Requirements under the EM&A Manual

2.1 The EM&A Manual requires the following underwater noise monitoring to be carried out:

Clause 10.3 on Monitoring and Audit for Ecology

- 10.3.3 – Construction-phase underwater noise monitoring. This is to verify the assessment outcome and to collect field data of this construction activity.

Clause 10.4 on Monitoring Locations

- 10.4.2 – Construction-phase underwater noise monitoring – the actual underwater noise level of bored piling will be monitored during the pile construction in the waters to the west of the Airport for HKLR.

Clause 10.5 on Baseline Monitoring for Ecology

- 10.5.2 – Baseline for underwater noise shall be established prior to the commencement of the works in the waters to the west of Airport, and agreed with AFCD.
- 10.5.5 – the ET Leader should seek approval from the IEC, AFCD and EPD on an appropriate methodology and parameters to be recorded. A detailed monitoring plan with specification and detailed methodology will be prepared prior to the baseline monitoring and submitted to AFCD and EPD for approval.

Clause 10.6 on Impact Monitoring for Ecology

- 10.6.2 – Construction-phase underwater noise monitoring will be constructed for 10 days from the start of the bored piling activities for the first three pier sites during the bored piling process in the first three sits in the waters to the west of Airport.

Baseline Underwater Noise Monitoring

2.2 We will deploy a PAM 004, a proprietary product of SMRU, for baseline underwater noise monitoring. The equipment will comprise the following devices and accessories:

- PAM Core Electronic System in IP65 Enclosure
- Reson TC4014-5 Calibrated Hydrophone (with a linear frequency range of 20 ~250 kHz (+/- 3 dB), sensitivity -180 +/- 3 dB re 1 V/μPa and pre-amplifier gain 18 dB)
- A solid-state data recording medium with USB connection
- 3G/GSM Panel Antenna with wireless modem
- Application software
- Cables, connectors, hatch plates, and other necessary accessories

2.3 The system will be placed at a location to the west of the Airport. The proposed location is shown in **Figure 1**. Baseline underwater noise will be monitored for 28 days. As the background underwater noise is dominated by marine traffic between Hong Kong and Macau which has a cycle time of 7 days. This 28-day period will have covered four cycles of the underwater noise environment. The monitoring equipment will record the underwater noise continuously.

2.4 The equipment will be operated in an autonomous mode, and the data will be sent to shore via the 3G mobile network.

2.5 The commencement date of the baseline monitoring is 24 November 2012.

Construction-phase Underwater Noise Impact Monitoring

2.6 In the previous proposal, PAMBuoy was proposed for the construction phase monitoring. This equipment has the same core as PAM 004 with slightly higher sensitivity and pre-amplifier gain. It can be left floating on the water and transmit recorded data to monitoring station through 3G. To prevent data loss during the transmission process, we will deploy PAM 004 (direct data transmission through cable) during construction phase monitoring. Since it is the same device used in baseline monitoring, the results can be compared directly.

2.7 The monitoring station will be positioned at an appropriate and safe distance from a barge (about 100m away from the center of the pier) where the piling works will be carried out at the first pier site for 10 days, depending on the duration of works, to monitor the underwater noise during the bored piling activities. The data recorded by PAM004 will be transmitted to the receiving station on a boat via cable. The data will be viewed in real time by an operator from Cinotech who has been well trained and technically supported by SMRU for the operation.

2.8 We will repeat the above for the second and third pier sites. The total duration of the monitoring will be no less than 30 days as required.

2.9 The location of construction phase monitoring can be found in **Figure 1**. The first three piers have been changed to P48, P52 and P0 as compared with previous submission (P20, P47, P49) due to the revised construction sequence. In accordance with EM&A Manual for HKLR, Section 10.6.2 stipulated that "*Construction-phase underwater noise monitoring will be conducted for 10 days from the start of the bored piling activities for the first three pier sites during the bored piling process in the first three pier sites in the waters to the west of Airport.*" This will not affect the EM&A Programme and monitoring details such as methodology and equipment as detailed in this proposal.

Data Collection and Analysis

Baseline Monitoring (November - December 2012)

2.10 All underwater sound data will be digitized and stored at a minimum sample rate of 200 kHz at a resolution of 16 bits. This will provide acoustic data to a frequency of minimum 10 Hz to 100 kHz. Recordings will be made on a schedule of one minute every 10 minutes. Subsequent analysis of these acoustic data will be conducted over the frequency range from 10 Hz to 100 kHz. Spectral levels of noise will be presented over the minimum frequency range from 10 Hz to 100 kHz. In addition, continuous calculation of noise levels in third octave bands will be conducted in real time in the 10Hz to 22.5 kHz frequency range and of a single broad band 10Hz to 100 kHz band.

2.11 The recorded data will be analyzed over the minimum frequency range from 10 Hz to 100 kHz to provide RMS sound pressure levels averaged over 1 second intervals, as well as broadband pressure spectral density (PSD) re 1 $\mu Pa^2/Hz$, and the data will also be used to produce spectrograms (level vs. frequency vs. time). These spectral densities can be used to provide an indication of changes in level at frequencies from 10 Hz to 100 kHz, particularly between times when the piling changes mode.

2.12 Basically, for a baseline monitoring duration of 28 days, the recorded data will be averaged over 28 days into 24 nos. of hourly averaged PSD for each frequency from 1Hz to 100kHz and the PSD data will be plotted against frequency and the range of PSD at each frequency will be determined for comparison with similar data during the piling.

Impact Phase (March, April, July, 2013)

2.13 During the impact phase, the system will transmit data in real time to a laptop computer on which noise levels will be displayed in near real time. The near real time data will enable operation decisions to be made in the event of noise levels exceeding some Action Level and Limit Level.

2.14 The data will also be analyzed into PSD against frequency and these will be overlaid onto the plot for the baseline data so as to determine at what frequency range(s) the piling noise exceeded the baseline level, if any, and by how much.

2.15 We will analyse the monitor data to assess whether the noise generated by the activities, which typically have a frequency range of 100 Hz - 1 kHz, would be within the audiological range of frequencies of a CWD (500Hz to 24.9kHz).

2.16 The EIA report predicted that bored piling will generate lower noise level than percussive piling. Since no percussive piling is involved in this project nor did the EIA have any underwater noise modeling, this prediction in the EIA cannot be verified. The collected data will be used as a reference as recommended in the EM&A Manual Section 10.3.3.

3 EVENT AND ACTION PLAN

3.1 Based on the literature search as shown in **Appendix C**, it is proposed that the Action Level is set at 170 dB re 1μPa, RMS Sound Pressure Level over 1 second between 70 Hz and 125kHz, measured at 100m from the piling site. Limit level is taken as 180 dB re 1μPa, RMS Sound Pressure Level over 1 second between 70 Hz and 125kHz at the same distance from the site, or when the underwater noise level cannot be reduced to 170 dB or below after triggering the action level for half an hour.

3.2 The measured data will be analyzed in real time. In the event that:

(a) If the 1 second RMS sound pressure level re 1μPa exceeds the Action Level, the ET will give signals to the Contractor to review the piling sequence or method in order to reduce the underwater noise levels to no higher than 170 dB. At the same time, a protection zone of 50m radius will be set if the underwater noise level measured is between 171 to 174 dB. The zone will be enlarged to 100m radius if the underwater noise level is between 175 to 179 dB. If dolphin is found within the protection zone, the construction work will stop and can only commence after confirming that no dolphin is present for 30 minutes. A scanning staff from the Contractor will scan the surrounding area near the bored piling site.

(b) If the measured underwater noise level cannot be reduced to below 170 dB within half an hour, the ET will give signals to the Contractor to stop the activities. The Contractor should not be allowed to resume the works unless the Contractor can come up with an alternative method or sequence agreeable to the Engineer that would generate noise no higher than 170 dB.

(c) If the measured noise level exceeds 180 dB, the ET will give signals to the Contractor to stop the activities immediately. Again, the Contractor should not be allowed to resume the works unless the Contractor can come up with an alternative method or sequence agreeable to the Engineer that would generate noise no higher than 170 dB.

3.3 Detailed explanation of the setting of action and limit level can be found in **Appendix C**.

3.4 The Event Action Plan is summarized as follows:

Event	Action			
	ET Leader	**IEC**	**ER**	**Contractor**
Action level triggered	1. Inform the IEC, ER and Contractor; 2. Advise Contractor of dolphin protection zone coverage. 3. Continue to monitor underwater noise level.	1. Check monitoring data submitted by ET.	1. Inform Contractor.	1. Review the piling sequence or method; 2. Implement the mitigation measure to lower the underwater noise level to below action limit within 30 minutes; 3. Implement protection zone. 4. Closely liaise with the ET on the progress.
Limit level triggered	1. Instruct the Contractor to stop construction work; 2. Inform the IEC and ER; 3. Discuss with IEC, ER and Contractor on noise reduction proposal; 4. Assess effectiveness of Contractor's proposal and keep IEC and ER informed.	1. Check monitoring data submitted by ET. 2. Discuss amongst ER, ET and Contractor on the potential remedial actions.	1. Review the proposal by Contractor; 2. Make agreement on the measures to be implemented.	1. Stop construction work 2. Inform the ER 3. Review the piling sequence or method in order to reduce the underwater noise levels to no higher than 170 dB. 4. Submit noise reduction proposal to the ER for endorsement. 5. Implement the agreed measures. 6. Re-submit proposals if problem still not under control; 7. Stop the relevant portion of works as determined by the ER until the exceedance is abated

4 PROPOSED KEY STAFFING

Requirements under the EM&A Manual

4.1 According to the EM&A Manual, clause 10.3.7, the construction-phase underwater noise monitoring shall be undertaken by qualified dolphin specialist and bio-acoustician, who have sufficient (at least 5-10 years) relevant post-graduate experience and publication in the respective aspects. Approval on the specialist responsible for construction-phase underwater noise monitoring shall be sought from AFCD and EPD.

Proposed Key Staffing

4.2 The underwater monitoring will be supervised by Dr HF Chan and supported technically by Dr Douglas Gillespie and Dr Lindsay Porter. Mr. KS Lee and Mr. Mark Cheng will operate the system in the field. Dr. Douglas Gillespie is the nominated specialist and bio-acoustician responsible for underwater noise monitoring and supported by KS Lee.

4.3 Dr Chan is the ETL of this Contract. He has over 30 years of extensive experience in the environmental including noise field, with his career spanning over 5 years in the Hong Kong Environmental Protection Agency and over 25 years in noise/environmental consultancy.

4.4 Dr Gillespie is a Senior Research Fellow of SMRU. He has more than 20 years of experience developing automatic detection systems for marine mammals and for other applications. He has logged considerable sea hours on a research vessel dedicated to collecting and analyzing marine mammal vocalizations.

4.5 Dr Porter is a Senior Research Scientist of SMRU who runs the SMRU Ltd's office in the Asia Pacific Region. Lindsay has spent the last 17 years in Asia primarily in the South China Sea, studying populations of Indo-Pacific humpback dolphins and other tropical delphinids. Her PhD research focused on aspects of the ecology of the Hong Kong population of Indo-Pacific humpback dolphins.

4.6 Mr. Graham Weatherup is a Systems Engineer of SMRU. He is specialized in the passive acoustic monitoring and will provide technical support on PAMBuoy.

4.7 Mr. KS Lee is the Principal Environmental Consultant of Cinotech with over 17 years in environmental including noise assessment and measurement. KS has been the chief operator of the underwater noise system during the Deep Cement Mix trial commissioned by Airport Authority Hong Kong in early 2012. KS will be assisted by Mark Cheng who was his deputy in the DCM trial underwater noise test.

4.8 Detailed CV of the staff can be found in **Appendix B**.

5 REPORTING

5.1 According to EM&A Manual Section 16.2, the 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 ET Leader shall liaise with the relevant parties on the exact number of copies they require. The report format and baseline monitoring data format shall be agreed with the EPD prior to submission.

5.2 The baseline monitoring report shall include at least the following:

(i) up to half a page executive summary;

(ii) brief project background information;

(iii) drawings showing locations of the baseline monitoring stations;

(iv) monitoring results (in both hard and diskette copies) together with the following information:

- monitoring methodology;
- name of laboratory and types of equipment used and calibration details;
- parameters monitored;
- monitoring locations;
- monitoring date, time, frequency and duration; and
- quality assurance (QA) / quality control (QC) results and detection limits;

(v) 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 results;

(vi) determination of the Action and Limit Levels for each monitoring parameter and statistical analysis of the baseline data;

(vii) revisions for inclusion in the EM&A Manual; and

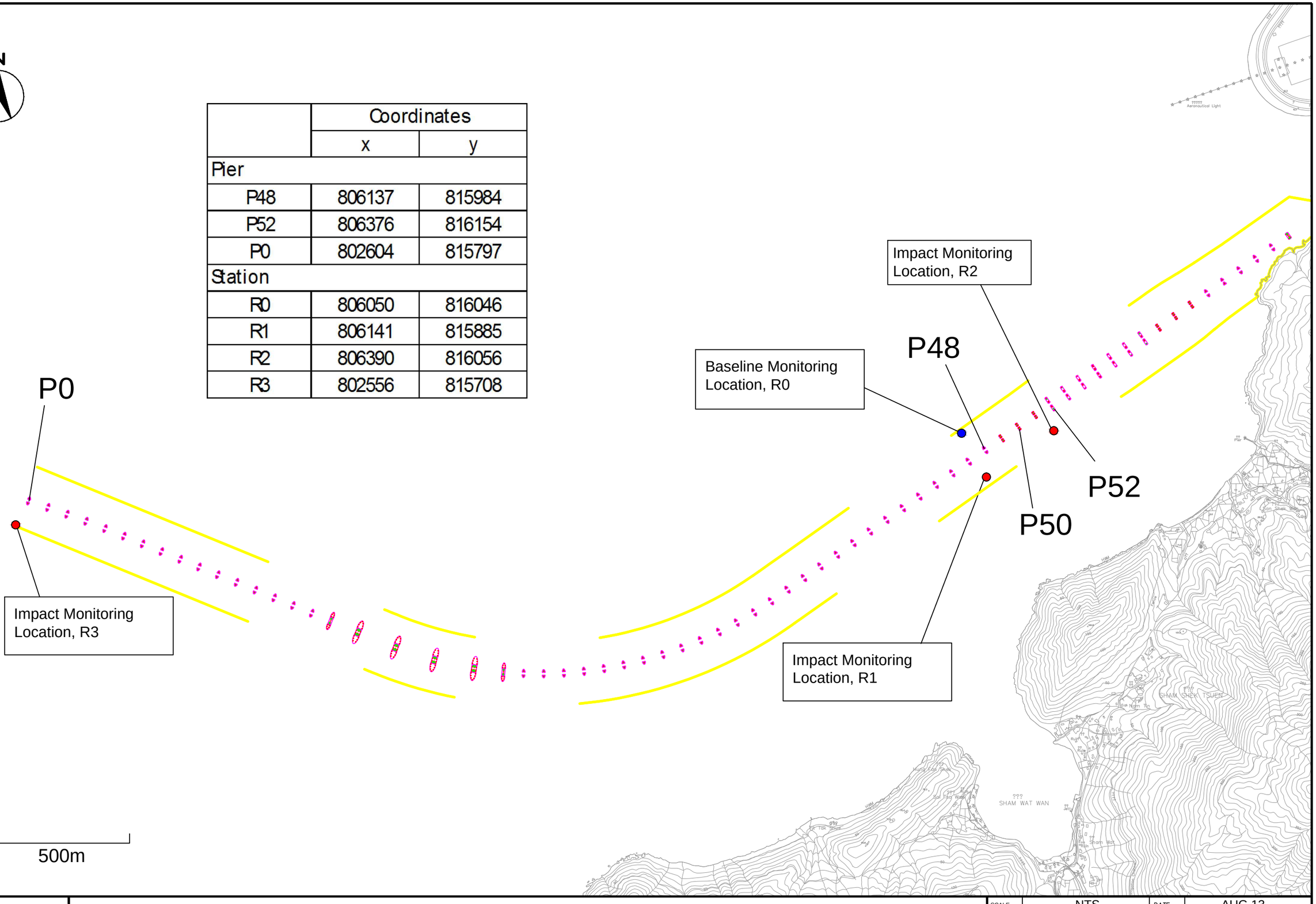
(viii) comments, recommendations and conclusions.

5.3 According to Section 16.3 of the EM&A Manual, the results and findings of all EM&A work required in the Manual shall be recorded in the monthly EM&A reports prepared by the ET Leader. According to Section 4.3 of the EP, Baseline Monitoring Report shall be submitted to the Director at least two weeks before commencement of construction of the Project. The submission shall be verified by the IEC. Each monthly EM&A report shall be submitted to the following parties: the Contractor, the IEC, the ER and EPD. The reporting format shall follow Section 16.3.3 and 16.3.4.

FIGURES

N

	Coordinates	
	x	y
Pier		
P48	806137	815984
P52	806376	816154
P0	802604	815797
Station		
R0	806050	816046
R1	806141	815885
R2	806390	816056
R3	802556	815708



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Contract No. HY/2011/09 Hong Kong Link Road - Section between HKSAR Boundary & Scenic Hill

Proposed Baseline and Impact Monitoring Locations

SCALE	NTS	DATE	AUG 13
CHECK	KW	DRAWN	BC
JOB No.	MA12014	DRAWING No. 1	REV -

APPENDIX A
Technical Specification of PAMBuoy

PAMBuoy®

marine mammal monitoring

Real-time marine mammal detection and noise level measurement

A revolution in marine mammal science.

PAMBuoy™ is a cutting edge autonomous marine mammal detection and noise level passive acoustic monitoring system. It operates 24/7 to automatically detect and classify vocalising marine mammals (whales, dolphins, porpoises), providing high resolution data that can be used to identify species present and determine temporal patterns in use.

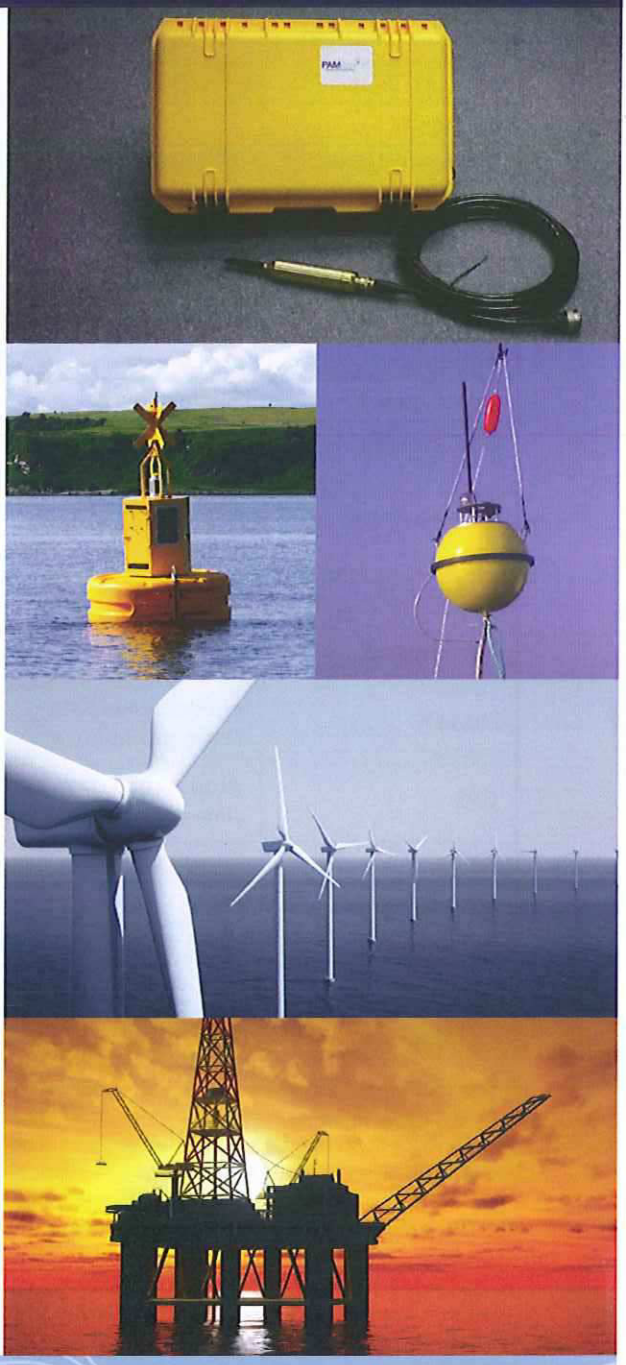
The benefits of using **PAMBuoy™** are:

- **Risk Reduction**
  - Real time data transmission
- **Cost saving**
  - Autonomous and remotely controlled – minimising service and data download visits
- **Time saving**
  - On board data processing and management.

PAMBuoy™ provides a cutting edge solution to monitoring marine mammals. It is used in support of environmental assessments, mitigation measures and scientific research, with applications for marine renewable energy developers, oil and gas companies, marine civil engineering, Government agencies, harbour authorities, regulators, defence contractors and academic researchers.

PAMBuoy™ has been designed with the customer in mind. It minimises risk by returning data to you on a real time (or less frequent, if required) basis, giving confidence that project timelines can be met.

PAMBuoy™ requires little attention to maintain. It can be upgraded and adjusted remotely saving you time and money. The cost of putting vessels and personnel on the water can be prohibitive – the whole point of **PAMBuoy™** is to minimise the cost and maximise quality of data obtained.



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PAMBuoy®
marine mammal monitoring

Technical specifications

Parameter	Description	Min	Typical	Max	Unit
Environmental					
Ambient Temp	-	-10	-	60	°C
DC Supply	-	-	12	-	V
Average Power*	Of complete system	-	3	<5	W
Technical					
Channels	Sampling channels	0	1/2	4	-
Sampling rate**	Channel sampling rate	-	500	1250	kHz
Bit depth	Channel data word width	-	16	-	bits
Anti-aliasing***	Single pole LP	-	200	-	kHz
Channel Gain	Applied per channel, SW selectable	-	0/10/20/30	-	dB
Channel filters	Channel signal filters(2 pole), SW selectable	-	Butterworth HP:10/100/2000/20000	-	Hz
Memory****	Micro SD(SDHC)	0	32	32	GB
Hardware					
Modem	Bi-directional data communications	-	3G/Iridium	-	-
GPS	Auto escape detection/ time provision	-	-	-	-
AIS	Vessel movement data	-	-	-	-
Solar module		24	60	150	W
Hydrophone	Linear frequency range (+3dB)	-	0.02-250	-	kHz
	Sensitivity	-	-186±3	-	dBre1V/µPa
	Preamplifier gain	-	26	-	dB
	Cable length	10	10	100	m

*Dependent on number of channels and sampling rate.
**It is not recommended to sample all four channels at 1250KHz.
***Note each channel is oversampled at a x16 rate allowing for a single pole anti-alias filter, with additional filtering inside the ADC.
****Can be extended with additional USB drives at a power consumption cost.

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APPENDIX B
CV of Key Staff for Underwater Noise Monitoring

APPENDIX C
Basis for Setting Action and Limit Levels

APPENDIX C: BASIS FOR SETTING ACTION AND LIMIT LEVELS

Auditory Injury

At high enough sound levels, (generally taken to be in excess of 180 dB re. 1 µPa) and particularly where there are repeated high level exposures from activities such as impact pile driving, seismic operations, or for continuous wave sound such as sonar, underwater sound has the potential to cause hearing impairment in marine species. This can take the form of a temporary loss in hearing sensitivity, known as a Temporary Threshold Shift (TTS), or a permanent loss of hearing sensitivity, known as a Permanent Threshold Shift (PTS).

There is data concerning hearing damage in fish, including TTS measurements on goldfish (Cox *et al*. 1986, 1987), cod (Enger 1981), and Oscar fish (Hastings *et al*. 1986), and hearing damage in marine mammals from Schlundt *et al*. (2000) and Nachtigall *et al*. (2004) that indicate auditory damage in marine species may occur following exposure to high level underwater noise. The conservative limit proposed by the US National Marine Fisheries Service (NMFS) of 180 dB re. 1 µPa Sound Pressure Level limit has been considered in this respect.

There is no adopted or recommended Action Level elsewhere for marine mammals, e.g. Dolphins. An appropriate Action Level could be set at 170 dB re. 1 uPa since the sound energy at 170 dB is one tenth of that at 180 dB. Furthermore, the subjective loudness as perceived by a human at 170 dB is half as much as at 180 dB, though, of course, there is no research data to show that humans and dolphins have the same subjective response to noise. Nevertheless, this is a useful reference in view of the lack of a universally adopted Action Level for Dolphins.

Another reason for setting a 170 dB action limit at 100m from the bored piling site is for executing protection zone for dolphins that swim close to the piling site. During the underwater noise monitoring period, a 25m work zone around the piling site will be kept free of dolphins by a scanning staff. Outside this work area, there is no restriction on the area that the dolphin can swim.

By calculation, when 170 dB is recorded at the underwater noise monitoring station 100m away from the piling site, the noise level outside the 25m work area will be less than 180 dB. As the noise level increases, the 180 dB noise will cover area outside of the work zone, putting dolphins at risk of auditory damage.

Distance from Piling Site (m)	Distance correction from 100m (dB)	RMS SPL (dB) for		
		170 dB at 100m	174 dB at 100m	179 dB at 100m
10	15.0	185.0	189.0	194.0
20	10.5	180.5	184.5	189.5
25	9.0	179.0	183.0	188.0
30	7.8	177.8	181.8	186.8
40	6.0	176.0	180.0	185.0
50	4.5	174.5	178.5	183.5
60	3.3	173.3	177.3	182.3
70	2.3	172.3	176.3	181.3
80	1.5	171.5	175.5	180.5
90	0.7	170.7	174.7	179.7
100	0.0	170.0	174.0	179.0

When the noise level measured is between 171 and 174 dB, the equivalent noise level within 40m from the piling site will reach 180 dB. Therefore, a protection zone of 50m radius from the piling site will be set up.

Similarly, when the noise level measured is between 175 to 179 dB, the equivalent noise level within 90m from the piling site will reach 180 dB. The protection zone will extend to 100m from the piling site.

A scanning staff from the Contractor will scan the protection zone. Construction work will stop if dolphin is found within this zone. The work can only commence after confirming that the zone is free of dolphin for 30 minutes.

If 180 dB is measured at 100m from the piling site, limit level is triggered and the construction work must stop no irrespective of any presence of dolphin. This can ensure that no dolphins will experience 180 dB underwater noise level.

Based on our experience with the underwater noise measurement as part of the Deep Cement Mixing Trial for the Third Runway, the underwater noise at 50~100 m from the boring machine was no higher than 130~140 dB re. 1 uPa. Hence, setting 170 dB at 100m as the Action Level is sufficient to protect Dolphins.

Audiological Range of Chinese White Dolphin

A literature review has been carried out on the hearing of the native Chinese White Dolphin (*Sousa chinensis*). A Scottish study compared the audiograms of ten marine mammals and fish and found that they had different audio frequencies (Gordon & Northridge 2002). Bottlenose Dolphins have similar body sizes as the local Chinese White Dolphins. Its hearing sensitivity ranges from around 70Hz at 130 dB re 1µPa to 270kHz at 136 dB re 1µPa (Gordon & Northridge 2002). While there is no audiogram produced from Chinese White Dolphins, there are studies on their vocalization. It is reasonable to assume that they can hear the frequency that they produce. A local research showed that their vocalization ranges from 4.1 to 24.9kHz (Sims *et. al.* 2011). A similar study on the same species in Australian waters recorded 0.5 to over 22kHz (Van Parijs *et.*

al. 2001). The Hong Kong dolphins have a larger minimum frequency possibly due to limitation of the hydrophone, masking effect from the background or individual variation (Sims *et. al.* 2011). Based on the most available information, the audiological range of Chinese White Dolphin is 500Hz to 24.9kHz.

References

1. Cox M, Rogers P H, Popper A N and Saidel W M. (1986). *Anatomical Effects of Intense Tone Simulation in the Ear of Bony Fish.* Journal of the Acoustical Society of America, Suppl 1, 80: S75.
2. Cox M, Rogers P H, Popper A N, Saidel W M and Fay R R. (1987). *Anatomical Effects of Intense Tone Simulation in the Goldfish Ear: Dependence on Sound Pressure Level and Frequency.* Journal of the Acoustical Society of America, Suppl 1, 89: S7.
3. Enger P S. (1981) *Frequency Discrimination in Teleosts – Central or Peripheral.* In Tavaloga W N, Popper A N and Fay R R (eds), Hearing and Sound Communication in Fish.
4. Hastings M C, Popper A N, Finneran J J and Lanford P J. (1986). *Effects of Low-Frequency Underwater Sound on Hair Cells of the Inner Ear and Lateral Line of the Teleost Fish (Astronotus ocellatus).* Journal of the Acoustical Society of America, 99:1759-1766.
5. Nachtigall P E, Supin A Y, Pawloski J and Au W W L. (2004). *Temporary Threshold Shifts after Noise Exposure in the Bottlenose Dolphin (Tursiops truncatus) Measured Using Evoked Auditory Potentials.* Marine Mammal Science 20(4): 673-687.
6. National Marine Fisheries Service (NMFS). (1998). *Small takes of marine mammals incidental to specified activities; seismic hazards investigations in Puget Sound / Notice of issuance of an Incidental Harassment Authorisation.* Federal Register Vol.63, No.9, January 14, 1998, pp2213-2216.
7. Schlundt C E, Finneran J J, Carder D A and Ridgway S H. (2000). *Temporary Shift in Masked Hearing Thresholds of Bottlenose Dolphins (Tursiops truncatus) and White Whale (Delphinapterus leucas) after Exposure to Intense Tones.* Journal of the Acoustical Society of America, 107(6): 3496-3508.
8. Li S., Wang D. et. Al. (2012). *Evoked-potential audiogram of an Indo-Pacific humpback dolphin (Sousa chinensis)*. The Journal of Experimental Biology, vol. 215, no. 17, pp. 3055–3063.