

**Marine Ecology Enhancement Fund (MEEF)**  
**Declaration**

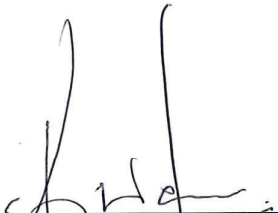
To: The Secretariat of the MEEF

**Reference No.:** MEEF2017014A  
Virtopsy for characterization and documentation of injury and death caused by human interaction, in stranded Indo-Pacific humpbacked dolphins (*Sousa chinensis*) in the Hong Kong waters

**Project Title:** waters

**Name of Project Leader:** Brian Chin Wing Kot

I hereby irrevocably declare to the MEEF Management Committee and the Steering Committee of the relevant Funds including the Top-up Fund, that all the dataset and information included in the completion report has been properly referenced, and necessary authorisation has been obtained in respect of information owned by third parties.

Signature:   
Project Leader, Brian Chin Wing Kot

Date: 22.4.2020

## MARINE ECOLOGY ENHANCEMENT FUND (MEEF)

### Completion Report for Year 2018-2019

Report for the period ending 30 June 2019

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#### **Part A: Executive Summary**

##### **1. Executive Summary**

Throughout 12 months, from 1 July 2018 to 30 June 2019, project entitled “Virtopsy for characterization and documentation of injury and death caused by human interaction, in stranded Indo-Pacific humpbacked dolphins (*Sousa chinensis*) in the Hong Kong waters”, has progressed satisfactorily and its objectives have been 100% accomplished. All supporting staffs (2 research personnel) were recruited to assist the workflow of this project. The realization of the 4 project objectives are illustrated as below:

- a) To characterize virtopsy based markers that aid in the identification and prognosis of injury and death caused by human interaction (HI) in stranded Chinese white dolphins (CWDs) and other stranded cetaceans.
- b) To discern antemortem injury from postmortem injury and to infer such injury characteristics from HIs using virtopsy and conventional necropsy findings in stranded CWDs and other stranded cetaceans.

As of 30 June 2019, 36 out of 45 Hong Kong (HK) stranded cetaceans (80%) were performed virtopsy, including 4 CWDs, 28 Indo-Pacific finless porpoises (NP), 4 other species. All the virtopsy findings were verified by subsequent necropsy, with supplemented information given for the analysis of HI related injury and death of stranded cetaceans. The remaining 9 stranded cetaceans (20%) were recognized to be non-transportable and inappropriate for virtopsy by cetacean stranding response team of the Ocean Park Conservation Foundation Hong Kong (OPCFHK). Onsite necropsy and sample collection were directly performed on these cetacean carcasses by the team of OPCFHK.

In these 36 cases, findings of 11 stranded cetaceans (2 CWDs and 9 NPs) were sufficient to assign the cause of death with confirmed, probable or suspect category associated by HIs (30%), which included evidence of fishery (e.g. fishing gear entanglement/digestion), and vessel interactions (e.g. sharp chopped wound). The rest 25 stranded cetaceans (2 CWDs, 19 NPs, and 4 other species) were likely associated with different causes of death, e.g. respiratory diseases, drowning and natural death. Most virtopsy findings were shared bilingually on the stranded cetacean blog, allowing general public and international experts to obtain first-hand information and share their opinions on local stranding events.

- c) To document and describe the types of HIs taking place using 3-D surface documentation techniques, virtopsy and conventional necropsy findings, leading to injury and death in stranded CWDs and other stranded cetaceans.

In order to undergo corrective virtopsy procedures and interpretation of postmortem radiological images, all supporting staff underwent training by the P.I. in the first month of employment for PMCT/PMMRI imaging techniques and 3-D volume reconstruction and rendering processes, as well as familiarisation of highly specific cetacean anatomy and pathology. Apart from the PMCT/PMMRI imaging techniques, 2 commonly employed 3-D surface documentation techniques i.e. 3-D photogrammetry and 3-D surface scanning, were explored for the documentation of the external conditions, particularly on types of HIs

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taking place in carcass. Trials regarding the applications of 3-D photogrammetry and 3-D surface scanning were performed on dried skeletal specimen and live dolphins in fall 2017 while the procurement of hardware and software for 3-D surface documentation were completed in early December 2017, and subsequent trainings on 3-D surface scanner operation and post-processing technique were performed in December 2017 and January 2018. To date, 7 members in our laboratory were trained and they were all competent in performing 3-D surface documentation on stranded carcass.

Trials of 3-D surface scanning of HK stranded cetacean carcass was conducted in spring 2018. Preliminary results of 3-D models demonstrated an excellent color-texture information, allowing further data postprocessing and measurement in a true-to-scale 3-D model. A standardised protocol on 3-D surface scanning of cetacean carcass was established and its content was subsequently presented by P.I. and his team as a conference proceedings entitled “Three-dimensional surface scanning in postmortem investigation of stranded cetaceans: A step-by-step guide for carcass surface documentation”, in an international conference in May 2018.

Various subprojects with the use of 3-D surface scanning on HK stranded cetacean carcass and the inflicting tools were branched from the core project for final year undergraduate students in Tung Wah College (Forensic science and Basic Medical Sciences major, 2014 cohort) to experience how practical inter-disciplinary research project works with effort contributed from respective expertise. Instead of being merely a school assignment, this provided them an opportunity to demonstrate their work at the international aquatic animal medicine workshop and conference platform and a pathway to enter global research arena.

- d) To compile postmortem findings collected by original notes, 3-D surface documentation techniques, virtopsy and conventional necropsy, and transcribe into virtopsy and postmortem multimedia platform for first time all-in-one real-databased models of the stranded CWDs and other stranded cetaceans for geometric comparison of patterned injuries with the presumed types of HI.

A web-based database named "Cetacean Postmortem Multimedia Analysis Platform (CPMAP)" has been developed since the project commencement. Data compilation of 155 virtopsy cases (from March 2014 to 6 June 2019, included 36 CWDs, 104 NPs and 15 other cetacean species) and respective links between the web server and DICOM viewer were completed. Inclusion of the corresponding stranding information and other multimedia of retrospective cases are in progress.

Five conference proceedings were published regarding a review of the currently available stranding and mortality database and virtopsy findings in this present project. One manuscript would also be submitted to peer-reviewed journal. A number of local and international print media have voiced rising concern on unusual surge of stranding numbers during the project period, with supplemented virtopsy findings reported from P.I. and his team on cetacean stranding blog.

A significant increase in workload of the project team were recognised due to an unexpected surge of cetacean stranding in HK waters since January 2018. From 1 July 2018 to 30 June 2019, 45 stranded cetaceans (5 CWDs, 35 NPs, 5 other species) were recovered in HK waters, which was recognizably higher than the same periods of previous years' records, with 16 carcasses found in average (In 2014: 21 cases; 2015: 19 cases; 2016: 11 cases; 2017: 14 cases). Ten out of 35 stranded cetaceans underwent virtopsy were likely suspected to be associated with HI related injury and death. Although the project was under-resourced due to the unexpected surge of cetacean stranding since 2018, the project team had paid immediate efforts to convey conservative messages via outreach activities, such as conducting interviews with different print media, holding public seminar, talks and workshops, which jointly organised with the Hong Kong Science Museum and universities, to elevate the public awareness on cetacean stranding response program, immediate threats the local cetaceans facing, injury and death of local cetaceans caused by human interaction, and the greater scope: marine conservation and interest in science and technology.

## **Part B: The Project and Investigator(s)**

### **2. Project Title**

Virtopsy for characterization and documentation of injury and death caused by human interaction, in stranded Indo-Pacific humpbacked dolphins (*Sousa chinensis*) in the Hong Kong waters

利用影像解剖識別及紀錄在香港水域擱淺的中華白海豚因人類活動所造成的傷害和死亡的研究

### **3. Project Period**

From 1 July 2018 to 30 June 2019 (both dates inclusive)

### **4. Nature of the Project**

- Marine Habitat & Resource Conservation & Enhancement
- Scientific Research & Studies
- Environmental Education & Eco-tourism

### **5. Brief description of the Purpose of the Project**

Evaluating marine mammals for signs of human interaction requires consistent, objective, thorough examinations by experts in various disciplines. This project is meant to apply virtopsy on characterization and documentation of human interaction related injuries and death in stranded Chinese white dolphin, and provide supplementary information to aid conventional necropsy, for determination of human activities contributed to the stranding event. World first all-in-one real-databased models of the stranded cetaceans for geometric comparison of patterned injuries with the presumed types of human interaction will also be established, thus providing a sound scientific basis for policy and management decisions in the Hong Kong waters.

一直以來，如欲評估及證實人類活動在海洋哺乳類動物身上所留下的痕跡，均需不同界別的專家進行一致及客觀的測試。本項目將利用影像解剖技術識別及紀錄擱淺的中華白海豚因人類活動而造成的損傷及死亡，並以這些額外的資訊為傳統解剖提供協助，從而判斷人類活動對擱淺所造成的影響。此外，本項目亦會建立全球首個一站式鯨豚類擱淺數據資料庫，有系統地比較擱淺鯨豚身上的損傷及人類活動，為管理香港水域及制定相關政策提供科學根據和基礎。

### **6. Investigator(s) and Academic Department/Units Involved**

<b>Research Team</b>	<b>Name / Post</b>	<b>Unit / Department / Institution</b>
Principal Investigator	Dr. Brian Chin Wing KOT, Research Fellow/Visiting Assistant Professor	State Key Laboratory of Marine Pollution/Department of Infectious Diseases and Public Health, Jockey Club College of Veterinary Medicine and Life Sciences, City University of Hong Kong
Co-investigator	Dr. Paolo MARTELLI, Chief Veterinarian	Department of Zoological Operations and Education, Ocean Park Corporation
Co-investigator	Prof. Hock Gan HENG,	Department of Veterinary Clinical Sciences, Purdue University, West

	Clinical Professor & Section Head, Diagnostic Imaging	Lafayette, Indiana, USA
Co-investigator	Prof. Michael J. THALI, Director	Institute of Forensic Medicine, University of Zurich
Co-investigator	Dr. Chiou Ju YAO, Assistant Curator	National Museum of Natural Science
Supporting bodies	Ms. Gendron SUZANNE Foundation Director	Ocean Park Conservation Foundation Hong Kong
Supporting bodies	Dr. Wai Chuen NG, Marine Conservation Officer	Agriculture, Fisheries and Conservation Department, The Government of the Hong Kong SAR
Supporting bodies	Mr. Victor HUNG	TeraMed Ltd.
Supporting bodies	Dr. Richard BROWN, Associate Director (Production Animal Programmes)	College of Veterinary Medicine and Life Sciences, City University of Hong Kong
Supporting body	Dr. Jonathan P. SPEELMAN	Peace Avenue Veterinary Clinic, City University of Hong Kong

## 7. Timetable of Completed Activities against the Proposed Work Schedule

Activities	Original Period	Progress
Recruitment of support staff	July 2018	Completed
Training of support staff	July – September 2018	Completed
Compilation of retrospective cases and prospective data collection	July 2017 – now	Completed
Stranded cetacean blog	October 2017 – now	Completed
Press release/media tea reception	Fall 2018	Completed 26 April 2019
HK SciFest 2019 Public seminar and workshop	Spring 2019	Completed 28 April 2019
Public seminar (Symposium)	2018 – 2019	Completed 13 -14 April 2019
Exhibition	2018 – 2019	Completed 26 April to 29 May 2019
Public talks – Biodiversity workshops	2018 – 2019	Completed 18 July 2018, 15 August 2018, 21 November 2018, 2 January 2019, 27 February 2019, 10 April 2019, 8 May 2019, 11 May 2019
Data consolidation and write up publications	Summer 2019 onwards	Completed
Handbook of virtopsy for stranded cetacean	Summer 2019	Preparation of related publications in progress

## **8. Project Expenditure**

**Project expenditure details are not disclosed due to confidentiality reason.**

## **Part C: Completion Report on Year 2018-2019 Project Progress**

### **9. Project Objectives**

#### **9.1 Objectives as per Original Application**

- a) To characterize virtopsy based markers that aid in the identification and prognosis of injury and death caused by human interaction (HI) in stranded Chinese white dolphins (CWDs) and other stranded cetaceans.
- b) To discern antemortem injury from postmortem injury and to infer such injury characteristics from HIs using virtopsy and conventional necropsy findings in stranded CWDs and other stranded cetaceans.
- c) To document and describe the types of HIs taking place using 3-D surface documentation techniques, virtopsy and conventional necropsy findings, leading to injury and death in stranded CWDs and other stranded cetaceans.
- d) To compile postmortem findings collected by original notes, 3-D surface documentation techniques, virtopsy and conventional necropsy, and transcribe into virtopsy and postmortem multimedia platform for first time all-in-one real-databased models of the stranded CWDs and other stranded cetaceans for geometric comparison of patterned injuries with the presumed types of HI.

#### **9.2 Revised Objectives**

N/A

### **10. Research Activities**

*(Results / descriptions on the completed activities with appropriate analysis, with the support of photos, videos, social media platform, etc.)*

#### **10.1 Areas addressed in relation to the project objectives that were carried out during this reporting period**

##### **A. Change of recipient organisation**

P.I. had received a notice of job offer from the City University of Hong Kong (CityU) by mid September 2018, with the first day of duty on 2 October 2018. P.I. had applied a project transfer to CityU on 27 September 2018 and subsequently, the request was approved by the MEEF Management Committee, subject to the agreement with the conditions as stated in the Novation Agreement by the authorized representative(s) of Integrated Medimaging Institute Limited and CityU on 15 October 2018. The Novation Agreement were prepared and co-signed by Marine Ecology & Fisheries Enhancement Funds Trustee Limited, Integrated Medimaging Institute Limited and CityU, effective from 24 October 2018.

Meanwhile, since July 2018, the outstanding Completion Report and related Statement of Accounts (2017-2018) had been provided by Research Office of Tung Wah College (TWC), and had been under MEEF management committee's review. In order to avoid any conflict of interest with TWC, to date, no expenditure was used in the first instalment of MEEF funded budget (2018-2019, i.e. HK\$233,032). A note of satisfaction on Completion Report and the Statement of Accounts (2017-2018) was received on 16 October 2018.

P.I. had received full support and endorsement from his unit heads to continue the captioned MEEF project as the project P.I. in CityU, with the intention of support and duty nature of all the co-organising/supporting bodies in the captioned MEEF project remained the same unaffectedly.

## **B. Recruitment of the supporting staff (2018-2019)**

Two research personnel were recruited in November 2018 respectively for a period of around 8 months, once after the project transfer to CityU. One RA takes up the role as a project manager to assist P.I. to oversee project logistics arrangement, liaison and coordination among other team members, departments and collaborators, data collection and management (i.e. and data gathering and archiving) and publication preparation. Another RA takes up the role as a project assistant to respond virtopsy of the increased stranded cetaceans and assist the project operation timely for the development, information validation, maintenance of web-based database, stranding response, on-site examinations for virtopsy, and other administrative works (e.g. creating the stranded cetacean blog for public outreach). The team members remained unchanged during the period of reporting.

## **C. Training of the supporting staff**

All supporting staff underwent training by the P.I. in the first month of employment for PMCT/PMMRI imaging techniques, 3-D surface documentation techniques, and 3-D volume reconstruction and rendering processes, as well as familiarization of highly specific cetacean anatomy and pathology. They were also advised the project should be executed according to timelines, with proper documentation maintained throughout the project. Following the initial training period, the supporting staff understood the stranding procedures, assisted all postmortem imaging procedures, stranded cetacean carcass logistics and liaison, and data gathering and archiving.

## **D. Establishment of a stranded cetacean blog and media coverage**

Diverse social media accounts regarding this project were developed, including Facebook, Instagram and YouTube channel. Both Facebook page ("Cetacean Virtopsy Lab", <https://www.facebook.com/cetavirtolab/>; Fig. 1) and Instagram ("dolphin\_cvlab", [https://www.instagram.com/dolphin\\_cvlab/](https://www.instagram.com/dolphin_cvlab/)) were officially launched in middle of August 2017, with prior notification to the secretariat of the MEEF management committee and Agriculture, Fisheries and Conservation Department (AFCD), the government of the HK Special Administrative Region (HKSAR). These social media accounts acted as a world-first stranded cetacean social platform 1) to document stranding incidents (highlight HI related injury and death) with virtopsy-driven stranding response effort in HK waters; 2) to allow clinicians, scientists, researchers, governmental officials and general public to archive first-hand information and share their views on HK local cetacean stranding cases; 3) to promote regional seminar and workshop to facilitate knowledge exchange on stranded cetacean postmortem investigation with HI related injury and death; and 4) to deepen engagement with social networks around marine ecology, conservation and related research interests. Up to 30 June 2019, the Facebook page has reached over 60,000 users with 537 followers and 83 posts were published.



Fig. 1. Stranded cetacean blog, Facebook page of Cetacean Virtopsy Lab, providing diverse information regarding virtopsy of stranding cetacean in HK waters.

The renowned Japan national public broadcasting organization, NHK (Japan Broadcasting Corporation) conducted an interview with P.I. and his team on 29 November 2018 in preparing a TV



documentary on the threats of CWDs in the Pearl River Estuary (Fig. 2). The captioned interview emphasized the applications of virtopsy and its significant contribution made to understand the biological health and profile in stranded cetaceans, as well as the identification and prognosis of injury and death caused by HI in stranded cetaceans. The TV documentary was on screen on 20 January 2019.



Fig. 2. A TV documentary interview by NHK (Japan Broadcasting Corporation) on 29 November 2018.

Apart from the promotion of cetacean stranding blog, Initium Media (one of the highest shares Hong Kong-based digital media outlets), published a news article on 16 August 2018, entitled “丈量死亡之狀，他們重新接近海豚擱淺真相”，with in-depth interviews to P.I. and his team regarding the virtopsy and postmortem investigation on local stranded cetaceans. The news article also highlighted the applications of virtopsy on documentation of incidence of injury and death caused by HI, including fishery and vessels interactions, in local stranded cetaceans from the middle of 2017 to August 2018. Common pathologies observed were also noted including atlanto-occipital dissociation (<https://goo.gl/Md6Skg>).

A total of 21 local and international media have reported the virtopsy and our outreach events (e.g. public seminar, talk, workshop and exhibition, please refer to Part D below) from July 2018 to 30 June 2019, with supplemented virtopsy findings reported from P.I. and his team on cetacean stranding blog. All the related articles were listed as below:

Newspaper	Title	Date	URL Link
Cityu NewsCentre	城大合辦本港首個鯨豚主題公眾展覽	26 <sup>th</sup> April 2019	<a href="http://bit.ly/2xzh47r">http://bit.ly/2xzh47r</a>
HK01	揭開海豚死亡真相：撞船斷背 胃藏魚鈎魚絲	12 <sup>nd</sup> February 2019	<a href="https://bit.ly/2U6dEBX">https://bit.ly/2U6dEBX</a>
	【鯨豚法醫】本港首辦鯨豚展 影像解剖技術拆解擱淺之謎	26 <sup>th</sup> April 2019	<a href="http://bit.ly/2LxotMG">http://bit.ly/2LxotMG</a>
NHK	これでわかった世界のいま	20 <sup>th</sup> January 2019	
Radio Television Hong Kong	For local CSI team, beach deaths are the battle	26 <sup>th</sup> April 2019	<a href="http://bit.ly/2FMdVp3">http://bit.ly/2FMdVp3</a>
TOPick hket.com	中華白海豚疑被船撞爛肉見骨 獲遙距注射抗生素堅強活下	21 <sup>st</sup> September 2018	<a href="https://goo.gl/3PGqu3">https://goo.gl/3PGqu3</a>
	本港首個鯨豚展覽 影像解剖分析擱淺鯨豚致命原因	26 <sup>th</sup> April 2019	<a href="http://bit.ly/309STZv">http://bit.ly/309STZv</a>
TVB News	科學館展出香港擱淺鯨豚標本 推廣保育海洋生物意識	26 <sup>th</sup> April 2019	<a href="http://bit.ly/2Jj3Kte">http://bit.ly/2Jj3Kte</a>

大公網	鯨豚展香港開幕 提升市民保育意識	26 <sup>th</sup> April 2019	<a href="http://bit.ly/2XjpABI">http://bit.ly/2XjpABI</a>
中國新聞網	香港城市大學辦全港首個鯨豚展 提升市民保育意識	26 <sup>th</sup> April 2019	<a href="http://bit.ly/2XgmH4H">http://bit.ly/2XgmH4H</a>
文匯快訊	鯨豚展香港開幕 提升市民保育意識	26 <sup>th</sup> April 2019	<a href="http://bit.ly/2KTYyWi">http://bit.ly/2KTYyWi</a>
民視新聞網	近年多遭觀光船撞死 香港白海豚列「易危」	13 <sup>rd</sup> February 2019	<a href="https://bit.ly/2UEoTph">https://bit.ly/2UEoTph</a>
成報	城大與科學館合辦展覽剖析鯨豚	27 <sup>th</sup> April 2019	<a href="http://bit.ly/2KVGdYS">http://bit.ly/2KVGdYS</a>
東方日報	鯨豚骨骼標本展覽 宣揚保護海洋	27 <sup>th</sup> April 2019	<a href="http://bit.ly/2Yqqxth">http://bit.ly/2Yqqxth</a>
明報	白海豚疑遭螺旋槳重創 海洋公園遙距注射抗生素試圖治療	21 <sup>st</sup> September 2018	<a href="https://goo.gl/bKfA4y">https://goo.gl/bKfA4y</a>
果燃台	《果燃台》紀錄片《白海豚失樂園》專家座談	22 <sup>th</sup> April 2019	<a href="http://bit.ly/36ikF8A">http://bit.ly/36ikF8A</a>
星島日報	鯨豚法醫「影像解剖」尋死因	27 <sup>th</sup> April 2019	<a href="http://bit.ly/2FGS1Uj">http://bit.ly/2FGS1Uj</a>
星島頭條網	城大科學館聯辦首個鯨豚展覽 影像解剖技術拆解鯨豚死因	26 <sup>th</sup> April 2019	<a href="http://bit.ly/2YqHCn1">http://bit.ly/2YqHCn1</a>
信報財經	化身鯨豚 感受海洋污染	15 <sup>th</sup> May 2019	<a href="http://bit.ly/2YuZcpW">http://bit.ly/2YuZcpW</a>
香港經濟日報	法醫「港」鯨豚 培育同理心	27 <sup>th</sup> April 2019	<a href="http://bit.ly/327ndFF">http://bit.ly/327ndFF</a>
雷霆881 端傳媒	大玩派 丈量死亡之狀 他們重新接近海豚擱淺真相	13 <sup>rd</sup> May 2019 16 <sup>th</sup> August 2018	<a href="https://youtu.be/CbNoySgVd2I?t=1">https://youtu.be/CbNoySgVd2I?t=1</a> <a href="https://goo.gl/Md6Skg">https://goo.gl/Md6Skg</a>
蘋果日報	【生態災難】珠三角基建處處 白海豚面臨滅絕危機	20 <sup>th</sup> October 2018	<a href="https://goo.gl/3Ff3cR">https://goo.gl/3Ff3cR</a>
	鯨豚法醫展解構死因	27 <sup>th</sup> April 2019	<a href="http://bit.ly/2Nm4vGX">http://bit.ly/2Nm4vGX</a>

#### **D. Public seminar, talk, workshop and exhibition**

Outreach workshops jointly organised with the HK Science Museum, entitled, “Bloodless Necropsy – Local Cetaceans: Anatomy and Threats” and “Virtopsy: Threats to Hong Kong's Cetaceans” was held on 18 July 2018, 15 August 2018, 21 November 2018, 2 January 2019, 27 February 2019, 10 April 2019, 8 May 2019, 11 May 2019 respectively at the Nature Lab of the HK Science Museum (<http://hk.science.museum/ms/bdg/eworkshop.html>). Each aforesaid workshop date consisted of 2 biodiversity workshop sessions, which aimed to provide 1) an overview of cetacean stranding in HK waters, and 2) implementation of virtopsy into the local stranding response program, to the general public (Fig. 3). Throughout 16 workshop sessions in 8 days, over 480 participants were recorded.



Fig. 3. Biodiversity workshop held at the Nature Lab of the HK Science Museum.

In addition, highlighted public seminar and workshop entitled, “CSI of the Cetaceans: Virtopsy and One Ocean One Health” (<http://bit.ly/2XFk0Od>) and “CSI of Cetaceans: 3D Modelling Techniques” (<http://bit.ly/2J2O1ld>) respectively, were conducted on 28 April 2019, in the HK SciFest 2019 (Fig. 4) – the annual large-scale event in HK to provide interesting scientific activities to elevate the public awareness and interest in science and technology, hosted by HK Science Museum (<http://bit.ly/302F3la>). Over 130 participants attended the public seminar and workshop. This participation was jointly organised among the HK Science Museum and CityU and was aimed to promote the modern non-invasive imaging techniques, i.e. virtopsy and 3-D surface scanning, in assisting the investigation of injury and death caused by HIs in stranded cetaceans. Acknowledgement of MEEF's support was included in the captioned event links, as well as all the presentation materials.



Fig. 4. Public seminar (Left) and workshop (Right) conducted in the HK SciFest 2019 on 28 April 2019.

Furthermore, an exhibition entitled, “CSI of the Cetaceans: Hope of Solutions” (<http://bit.ly/2ZXqIga>) was co-organized with the HK Science Museum and another CityU project team from 26 April to 29 May 2019 (Fig. 5). This exhibition was held in the HK Science Museum, and was the first cetacean-themed public special exhibition ever in HK. Such works include specimens prepared by our team from skeleton of CWD and NP stranded in HK waters, and how our team used advanced virtopsy and conventional necropsy evidence to help identify the threats faced by cetaceans. The exhibition also presents the 3D printed specimen of Omura’s whale skeleton, a mobile app and virtual reality (VR) games produced by CityU students under another CityU project team. The mobile app and VR games could help users identify different species of cetaceans and understand the threats the local cetaceans facing in HK waters.

During the exhibition period, 12 school tours were organized to provide in-depth interpretation of the exhibition content for these local schools. Through visiting the exhibition, the students and general public could learn more about the investigations undertaken on stranded cetaceans and the importance

of virtopsy in such investigations. This event was also one of the most publicized outreach activities in the project. We received 15 local media new reports and 1 radio broadcast interview. Over 110,000 visitors enjoyed our exhibition over a 1-month time period.

Relevant disclosure and acknowledgement of MEEF's support were included in the captioned event link, as well as on the exhibition boards.



Fig. 5. Opening ceremony of the exhibition conducted in the HK Science Museum on 26 April 2019, which was officiated by Prof. Matthew Lee Kwok-on, Vice-President (Development and External Relations) of CityU and Project Leader of the “Jockey Club Enhancing Youth Empathy Project through Immersive Visualisation”, Ms. Paulina Chan Shuk-man, Director of the HK Science Museum, Dr. Brian Kot Chin-wing (P.I. of the project), Research Fellow of the State Key Laboratory of Marine Pollution and Visiting Assistant Professor of CityU’s Department of Infectious Diseases and Public Health, and Mr. Peter Lee, General Manager (Environment) of the Airport Authority HK.

## 10.2 Research activities in relation to the project objectives that were carried out during this reporting period

### A. Cetacean virtopsy web-based database

A web-based database named "Cetacean Postmortem Multimedia Analysis Platform (CPMAP)" has been developed since the project commencement. Data compilation of 155 virtopsy cases (from March 2014 to 6 June 2019, included 36 CWDs, 104 NPs and 15 other cetacean species) and respective links between the web server and DICOM viewer were completed. Inclusion of the corresponding stranding information and other multimedia of retrospective cases are in progress.

Prior to the official online launch of our web-based database implemented into the new CityU network, a demonstration of CPMAP prototype was conducted on 26 October 2018 to IT officials from Computing Services Centre and Jockey Club College of Veterinary Medicine and Life Sciences, which provided affirmative supports and constructive comments to the functions and applications of this database. Demonstration and training sessions to rest of the project team units are anticipated in spring 2019.

### B. 2019 International Cetacean Symposium

An international symposium was organized in the CityU from 13 to 14 April 2019 to introduce the threats and technology afforded to the cetaceans in the HK and adjacent waters (Fig. 6). In this symposium, 9 speakers from 7 countries were invited. Together with local speakers, a total of 20 talks were presented on Cetacean related topics. In total our symposium attracted 252 participants. P.I. also give an oral presentation entitled as, “The Virtopsy Approach: Bridging Radiological and Necroscopic Data for Postmortem Investigation of Stranded Cetaceans” (Appendix 1) in the symposium. Relevant disclosure and acknowledgement of MEEF's support were listed in presentation slides.



Fig. 6. International Cetacean Symposium 2019 was held in the CityU from 13 to 14 April 2019

### **C. Virtopsy cases performed**

As of 30 June 2019, 36 out of 45 stranded cetaceans (80%) in HK waters were performed virtopsy, including 4 CWDs, 28 NPs, 4 other species (Fig. 7). All the virtopsy findings were verified by subsequent necropsy, with supplemented information given for the analysis of HI related injury and death of stranded cetaceans. The remaining 10 stranded cetaceans (20%) were recognized to be non-transportable and inappropriate for virtopsy by cetacean stranding response team of the Ocean Park Conservation Foundation Hong Kong (OPCFHK). Onsite necropsy and sample collection were directly performed on these cetacean carcasses by the team of OPCFHK.



Fig. 7. Performing virtopsy (postmortem computed tomography) to HK stranded cetaceans at the Peace Avenue Veterinary Clinic, CityU.

In these 36 cases, findings of 11 stranded cetaceans (2 CWDs and 9 NPs) were sufficient to assign the cause of death with confirmed, probable or suspect category associated by HIs (30%), which included evidence of fishery (e.g. fishing gear entanglement/digestion), and vessel interactions (e.g. sharp chopped wound) (Fig. 8). The rest 25 stranded cetaceans (2 CWDs, 19 NPs, and 4 other species) were likely associated with different causes of death, e.g. respiratory diseases, drowning and natural death. Most virtopsy findings were shared bilingually on the stranded cetacean blog, allowing general public and international experts to obtain first-hand information and share their opinions on local stranding events. Most virtopsy findings were shared bilingually on our stranded cetacean blog (Facebook page: "Cetacean Virtopsy Lab", <https://www.facebook.com/cetavirtolab/>).

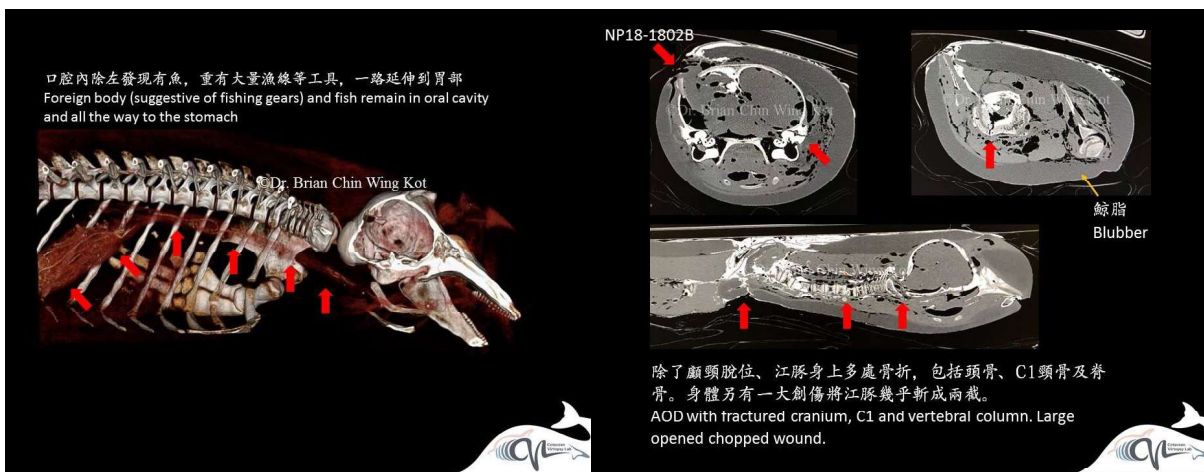


Fig. 8. Example on Virtopsy (postmortem computed tomography) findings of stranded cetaceans in HK waters, associated with HIs, included fishery (Left) and vessel interactions (Right).

#### **D. Publications**

Publication related to this current MEEF-funded project entitled, “Morphological analysis of the foramen magnum in finless porpoise (genus *Neophocaena*) using postmortem computed tomography 3D volume rendered images” was accepted by Marine Mammal Science (MMS 2018 early view abstract: <https://onlinelibrary.wiley.com/doi/abs/10.1111/mms.12512>) on 12 March 2018. This serves as an important baseline for the morphometric and typology of cranial characters in both finless porpoise species. These results may aid corrective diagnosis, classification, and treatment of diseases related to the foramen magnum in stranded or injured cetaceans in our project. Acknowledgement of MEEF's support was listed in the accepted manuscript. The manuscript is scheduled for publication in the upcoming (January 2019) issue of Marine Mammal Science, and P.I. and his co-authors were invited to submit a project photograph for potential use as a cover illustration.

P.I. had received invitations by Prof. Wenhua Liu, Dean of College of Science, Shantou University to attend a Chinese White Dolphin Forum and the 1st Asian-Pacific Biennial Conference of Marine Endangered Species Research and Conservation at Shantou University on 13 August and 12-16 November 2018 respectively. P.I. orally presented the current MEEF-funded project findings entitled, “Diagnostic imaging on cetacean as sentinel species for ocean health: from captive to free-ranging population” and “Application of interactive digital technology in cetacean and marine conservation” (Appendix 2 & 3). Relevant disclosure and acknowledgement of MEEF's support were listed in presentation slides.

Conference proceedings related to this current MEEF-funded project entitled, “Fatal Café Coronary in Stranded Cetaceans: The Virtopsy Approach to Diagnose Asphyxiation” was presented at the 50<sup>th</sup> Annual International Association for Aquatic Animal Medicine (IAAAM) Meeting and Conference, May 18 - 22, 2019, Durban, South Africa (Appendix 4). Relevant disclosure and acknowledgement of MEEF's support were listed in presentation slides. Meanwhile, the P.I. also received a peer-reviewer invitation by the President-Elect of the IAAAM to score submitted abstracts on quality, scientific importance/impact, originality, subject matter, and presentation format. Scores were then used by the scientific program chair and committee to determine which abstracts to award presentation slots or poster slots in the captioned conference in May 2019.

Besides, P.I. had also received invitation from the National Museum of Nature and Science to be the speaker in the 30<sup>th</sup> Annual Meeting of Cetology Study Group of Japan from 8 to 9 June 2019. P.I. had an oral presentation entitled as, “Virtopsy-driven stranding response program for the assessment of cetacean biological health and profiles in Hong Kong waters: Achievements, challenges and way forward” (Appendix 5). Relevant disclosure and acknowledgement of MEEF's support were listed in presentation slides.

Fourth publication related to this current MEEF-funded project entitled, "Image Rendering Techniques in Postmortem Computed Tomography (PMCT): Evaluation of Biological Health and Profile in Stranded Cetaceans", will be submitted to Journal of Visualized Experiments at the end of December 2019 (Appendix 6). The scientific video article aims to assess different image rendering techniques in PMCT for the evaluation of biological health and profile in stranded cetaceans in the Hong Kong waters. This helps guide radiologists, clinicians and veterinarians through the often difficult and complicated realm of PMCT image rendering and review. Descriptions of 8 image rendering techniques, in both 2D and 3D, mainly provided in the 3D workstations will be revealed. Practical examples for each image rendering techniques applied in the biological health and profile investigation of stranded cetaceans will be also provided. Relevant disclosure and acknowledgement of MEEF's support will be listed in the manuscript.

### 11. Evaluation of the project effectiveness in achieving the proposed objectives addressed to date

<b>Objectives</b> <i>(as per 9.1/9.2 above)</i>	<b>Addressed</b> <i>(please tick)</i>	<b>Percentage achieved</b> <i>(please estimate)</i>
1. To characterize virtopsy based markers that aid in the identification and prognosis of injury and death caused by human interaction (HI) in stranded Chinese white dolphins (CWDs) and other stranded cetaceans.	√	100
2. To discern antemortem injury from postmortem injury and to infer such injury characteristics from HIs using virtopsy and conventional necropsy findings in stranded CWDs and other stranded cetaceans.	√	100
3. To document and describe the types of HIs taking place using 3-D surface documentation techniques, virtopsy and conventional necropsy findings, leading to injury and death in stranded CWDs and other stranded cetaceans.	√	100
4. To compile postmortem findings collected by original notes, 3-D surface documentation techniques, virtopsy and conventional necropsy, and transcribe into virtopsy and postmortem multimedia platform for first time all-in-one real-databased models of the stranded CWDs and other stranded cetaceans for geometric comparison of patterned injuries with the presumed types of HI.	√	100

## **Part D: Research Output**

### **12. Peer-reviewed journal publication(s) arising directly from this research project**

The Latest Status of Publications				Author(s) (denote the corresponding author with an asterisk*)	Title and Journal/Book (with the volume, pages and other necessary publishing details specified)	Attached to this report (Yes or No)	Acknowledged the support of MEEF (Yes or No)
Year of publication	Year of Acceptance (For paper accepted but not yet published)	Under Review	Under Preparation (optional)				
			Dec 2019	*Brian C.W. Kot, Derek K.P. Chan, Henry C.L. Tsui	Image Rendering Techniques in Postmortem Computed Tomography: Evaluation of Biological Health and Profile in Stranded Cetaceans. Journal of Visualized Experiments.	Yes (Appendix 6)	Yes

### **13. Recognized international conference(s) in which paper(s) related to this research project was / were delivered (Please attach a copy of each conference abstract)**

Month / Year / Place	Title	Conference Name	Attached to this report (Yes or No)	Acknowledged the support of MEEF (Yes or No)
November 2018, Shantou, China	Diagnostic imaging on cetacean as sentinel species for ocean health: from captive to free-ranging population	Chinese White Dolphin Forum and the 1st Asian-Pacific Biennial Conference of Marine Endangered Species Research and Conservation	Yes (Appendix 2)	Yes
November 2018, Shantou, China	Application of interactive digital technology in cetacean and marine conservation	Chinese White Dolphin Forum and the 1st Asian-Pacific Biennial Conference of Marine Endangered Species Research and Conservation	Yes (Appendix 3)	Yes
April 2019, Hong Kong, China	The Virtopsy Approach: Bridging Radiological and Necroscopic Data for Postmortem Investigation of Stranded Cetaceans	International Cetacean Symposium 2019	Yes (Appendix 1)	Yes
May 2019, Durban, South Africa	Fatal Café Coronary in Stranded Cetaceans: The Virtopsy Approach to Diagnose Asphyxiation	International Association for Aquatic Animal Medicine Meeting and Conference	Yes (Appendix 4)	Yes



June 2019, Tokyo, Japan	Virtopsy-driven stranding response program for the assessment of cetacean biological health and profiles in Hong Kong waters: Achievements, challenges and way forward	International Symposium-Workshop 2019 Scientific Studies of Marine Mammals in Asia and the 30th Annual Meeting of Cetology Study Group of Japan	Yes (Appendix 5)	Yes
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#### 14. Other impact

(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, Teaching enhancement, etc.)

N/A

### **Part E: Summary and Way Forward**

#### 15. Summary and Way Forward

Throughout 12 months, from 1 July 2018 to 30 June 2019, project entitled “Virtopsy for characterization and documentation of injury and death caused by human interaction, in stranded Indo-Pacific humpbacked dolphins (*Sousa chinensis*) in the Hong Kong waters”, has progressed satisfactorily and its objectives have been 100% accomplished. Various research tasks (e.g. virtopsy, 3-D surface documentation techniques) and outreach activities (e.g. 1 public seminar, 17 workshops, 1 exhibition and 1 symposium) targeted to fulfill the captioned 4 objectives in this project were completed within the 12-month timeframe. Five conference proceedings were published regarding a review of the currently available stranding and mortality database and virtopsy findings in this present project. One manuscript would also be submitted to a peer-reviewed journal. A number of local and international print media have demonstrated rising concern on unusual surge of stranding numbers during the project period, with supplemented virtopsy findings reported from P.I. and his team on cetacean stranding blog.

For future prospect of the captioned project, there is an urging need to upgrade our established web-based database, CPMAP. At the inception stage of database development, the design of database (i.e. user interface) might not be user-friendly enough, and only provided some general and basic functions, such as import, export, searching. To make it more comprehensive and user-friendly, additional commercial web template would be expanded. Featured functions would be built, and focused on the development of display data tools, i.e. data filtering, statistical presentation and mapping. The statistical presentation would be included the tendency chart filtered by days, months and years, while the mapping would display the high-density stranding location. In addition to the user interface, new featured function, and additional license and image loading capacity could be upgraded in the AqNET client-viewer. A larger number of images that user allowed to attempt concurrently (up to 6,000 images) and more diverse 3-D reconstruction template setting and tool would be available in the upgraded version of CPMAP, which could facilitate a better presentation of injured and death findings.


With this, a consistent platform for collecting, collating, and visualizing cetacean biological health data would be provided, which could enhance visual identification of “hot spots” of cetacean injury and death, disease and health for better management decisions and evaluations through a dynamic and user-friendly tool. The updated CPMAP could also aid emergency management responses to natural and anthropogenic emergencies by assessing changes in cetacean health before, during, and following the event and enhance communication and collaboration amongst cetacean health scientists and veterinarians, resulting in better understanding of the relationship between health and environmental factors.

**Part F: Complete statement of accounts**

I hereby irrevocably declare, warrant and undertake to the MEEF Management Committee and the Steering Committee of the relevant Funds including the Top-up Fund, that I myself, and the Organisation:-

1. *do not deal with, and are not in any way associated with, any country or organisation or activity which is or may potentially be relevant to, or targeted by, sanctions administered by the United Nations Security Council, the European Union, Her Majesty's Treasury-United Kingdom, the United States Department of the Treasury's Office of Foreign Assets Control, or the Hong Kong Monetary Authority, or any sanctions law applicable;*
2. *have not used any money obtained from the Marine Ecology Enhancement Fund or the related Top-up Fund (and any derived surplus), in any unlawful manner, whether involving bribery, money-laundering, terrorism or infringement of any international or local law; and*
3. *have used the funds received (and any derived surplus) solely for the studies or projects which further the MEEF Objectives and have not distributed any portion of such funds (including any derived surplus) to members of the recipient organisation or the public.*

**Principal Investigator**

Signature : 

Name of Project Leader : Brian Chin Wing Kot

Date : 2 July 2019

Official Chop : 

## Appendix 1: Abstract of conference proceedings

Oral presentation at the 2019 International Cetacean Symposium in City University of Hong Kong from 13 to 14 April 2019

The Virtopsy Approach: Bridging Radiological and Necroscopic Data for Postmortem Investigation of Stranded Cetaceans

Brian CW Kot<sup>1,2</sup>

<sup>1</sup>State Key Laboratory of Marine Pollution, City University of Hong Kong

<sup>2</sup>Department of Infectious Diseases and Public Health, Jockey Club College of Veterinary Medicine and Life Sciences, City University of Hong Kong

### Abstract

In the course of the pioneering virtopsy-driven stranding response program in Hong Kong and adjacent waters, virtopsy using computed tomography (CT), magnetic resonance imaging (MRI) and ultrasonography have been implemented to provide supplementary or complementary information to conventional necropsy. From January 2014 to November 2019, a total of 235 stranded cetaceans were recovered in the Hong Kong waters, including 52 Indo-Pacific humpback dolphins (*Sousa chinensis*) (SC: 16 males, 24 females, 12 undetermined sex; calf to adult; 78-272.5 cm in body length of whole-body carcass), 162 Indo-Pacific finless porpoises (*Neophocaena phocaenoides*) (NP: 60 males, 63 females, 39 undetermined sex; calf to adult; 50-181 cm in body length of whole-body carcass) and 22 other species of cetaceans (OT: 9 males, 5 females, 8 undetermined sex; juvenile to adult; 127-1080 cm in body length of whole-body carcass). Approximately 73% (172 out of 235 recovered local stranded cetaceans) were performed PMCT prior to necropsy, in which 40 SC (14 males, 22 females, 4 undetermined sex; calf to adult; 91-272.5 cm in body length of whole-body carcass) and 116 NP (47 males, 46 females, 23 undetermined sex; calf to adult; 50-181 cm in body length of whole-body carcass) and 16 OT (7 males, 5 females, 4 undetermined sex; juvenile to adult; 127-365 cm in body length of whole-body carcass). The OT included 2 pygmy sperm whales (*Kogia breviceps*), a short-finned pilot whale (*Globicephala macrorhynchus*), a dwarf sperm whale (*Kogia sima*), 2 pantropical spotted dolphin (*Stenella attenuata*), a false killer whale (*Pseudorca crassidens*), a common bottlenose dolphin (*Tursiops truncatus*), 2 short-beaked common dolphin (*Delphinus delphis*), an Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), and 5 undetermined species. In the 172 PMCT scans, 116 were scanned whole-body carcass (67%) while the rest of 56 scanned on the skull and flippers (33%). All the stranded cetaceans were examined, and findings were compared by subsequent necropsy.

CT was performed on a 16-slice multi-detector row Toshiba Alexion™ CT system or a Somatom Definition 64 slices Dual Energy CT system. The MRI examination of brain, thorax and spine (sequences: T1-weighted, T2-weighted) was performed on a Siemens MRI Magnetom Trio 3.0 Tesla unit or a 0.25 Tesla Esaote Vet MRI Grande scanner. Post processing was performed with the built-in software and/or TeraRecon Aquarius workstation. Radiological findings were compared with subsequent necropsy findings.

Most of the radiological findings, pertaining to head and neck, heart and vascular, thorax, abdomen, vertebral column and pectoral limbs, corresponded to necroscopic findings. CT was useful in diagnosing fatal hemorrhage, organ herniation, and pathological gas collection, as well as determining the number, shapes and characteristics of the fractures sites and the direction of external force. MRI was effective in evaluating soft tissue lesions, musculoskeletal injuries, integrity of spinal cord and brain herniation. Radiological assessment of the degree of epiphyseal fusion/ossification at postcranial skeleton allowed individual age-at-death estimation, supplementing the data obtained by dental growth layer group pattern. Gradual increment of postmortem gas accumulation in the brain, pleural cavity, mediastinum, esophagus, cardiac chambers, subcutaneous tissue, gastrointestinal tract, liver, spleen, kidney, blood vessels and musculatures could be quantified with CT, which might gain invaluable insight to the individual death interval.

This long-term study demonstrated virtopsy is a potentially powerful tool, providing non-invasive and objective measurements to supplement the necroscopic findings for cetacean biological health and profiles investigation. Virtopsy could also facilitate veterinary personnel to perform image-guided target specimen

necropsy and sampling for histology and toxicology. The calibrated 3-D documentation and analysis of virtopsy findings would lead to qualitative improvements in conventional necropsy.

### **Acknowledgements**

The authors would like to thank Agriculture, Fisheries and Conservation Department of the Hong Kong Special Administrative Region Government for the continuous support in this project. Sincere appreciation is also extended to veterinarians, staff and volunteers from Ocean Park Hong Kong, Ocean Park Conservation Foundation Hong Kong, City University of Hong Kong and Aquatic Animal Virtopsy Lab, for paying great effort on the stranding response, conventional necropsy and logistic arrangements in this project. Special gratitude is owed to technicians in CityU Veterinary Medical Centre for operating the CT units in the present study. Special thanks to Dr. Michael Bradley for English editing of this manuscript. This project was financially supported by the Marine Ecology Enhancement Fund (grant number: MEEF2017014/MEEF2017014A), Marine Ecology Enhancement Fund, Marine Ecology & Fisheries Enhancement Funds Trustee Limited. Any opinions, findings, conclusions or recommendations expressed herein do not necessarily reflect the views of the Marine Ecology Enhancement Fund or the Trustee. The pioneer stranded cetacean virtopsy project received financial support from the Hong Kong Research Grants Council (Grant number: UGC/FDS17/M07/14).

## **Appendix 2: Abstract of conference proceedings**

Oral presentation at the Chinese White Dolphin Forum and the 1st Asian-Pacific Biennial Conference of Marine Endangered Species Research and Conservation at Shantou University on 13 August and 12-16 November 2018 respectively

### **Diagnostic imaging on cetaceans as sentinel species for ocean health: from captive to free-ranging population**

Brian CW Kot<sup>1,2</sup>, Henry CL Tsui<sup>3</sup>,

<sup>1</sup>State Key Laboratory of Marine Pollution, City University of Hong Kong

<sup>2</sup>Department of Infectious Diseases and Public Health, Jockey Club College of Veterinary Medicine and Life Sciences, City University of Hong Kong

<sup>3</sup>Office of the Vice-President (Development and External Relations), City University of Hong Kong

#### **Abstract**

Different diagnostic imaging modalities are used individually or in combination for the ante- and post-mortem diagnosis of diseases and life stages and events evaluation in captive to free-ranging cetacean population. Adoption of digital imaging has led to significant efficiencies in imaging workflow. The shift from hardcopy images printed on film to digital archives has streamlined radiology file room processes, significantly reduced the problems caused by misplaced radiographs, and trimmed the capital costs of film development and storage. With the use of advanced imaging (computed tomography (CT), magnetic resonance imaging (MRI) and ultrasound) and 3-D reconstruction techniques, imaging can aid in the implications of lesions diagnosis and prognosis, the planning of corrective treatment or intervention, as well as the understanding of anatomy and biological profiles.

The unique ability of CT and MRI studies to overcome the limitations of tissue superimposition is invaluable. However, the need for familiarization with species-specific anatomy is critically essential, but without fundamental understanding of appropriate CT and MR image acquisition, image display parameters, and modality indications and contraindications, a study could be resulted incomplete at best or non-diagnostic at worst. Thus, thorough and comprehensive consultation and reporting from specialists with human/veterinary radiology, cetacean medicine and forensic medicine background should always be adopted, and meaningful consideration should be given to this approach.

Most abdominal, neck and vascular structures are able to be examined by ultrasound for clinical and research purposes. A comprehensive understanding on animal species, physiological status and nutritional conditions should be made for the preparation of and during ultrasound examinations, for accurate diagnosis. Equipment selection, scanning techniques and normal sonographic anatomy should be well-addressed, along with illustrations of cetacean pathologies identified using ultrasound. Limitations included machine inaccessibility, animal uncooperativeness, large body size, thick integument and blubber layers, which prohibited examination of some structures. Ultrasound is useful in various aspects of cetacean medicine, and should be incorporated as a tool for controlled natural breeding and artificial insemination, and routine health surveys in a preventive medicine program, as it enables the monitoring of reproductive and maternity cycles, the diagnosis of diseases and the course of therapy.

Virtopsy, using post-mortem CT and post-mortem MRI, provides a virtual alternative to the conventional autopsy for death investigations. Our team is the first worldwide to apply virtopsy on stranded cetaceans routinely in the Hong Kong waters, augmenting conventional necropsy protocols. These volumetric image datasets provide invaluable initial or supplementary information of the cause of death in the stranded cetaceans prior to a conventional necropsy. With the advantages of being observer-independent, non-subjective, non-invasive, digitally storable and transferable, thereby facilitating a second opinion, virtopsy has become a valuable alternative technique to provide new insights of findings in stranded carcasses. For example, atlanto-occipital dissociation was among the recognizable findings commonly observed in virtopsy of the stranded cetaceans in Hong Kong and adjacent waters, which could be difficult to recognize via necropsy.

To enhance the use of radiology in cetacean medicine, we introduce our team website that has been developed as a centralized source to those working in the field of cetacean medicine. The goals of the website are to provide examples of normal diagnostic imaging studies, to showcase cases of interest to the cetacean professional community, and to provide information on the appropriate application of different diagnostic imaging modalities for the ante- and post-mortem diagnosis of diseases and life stages and events evaluation for corrective therapy and conservation measures. A centralized web-accessed database named "Cetacean Postmortem Multimedia Analysis Platform" has also been developed, which may eventually support the conservation and policy decision for the Hong Kong waters, leading to a 'One Ocean–One Health' paradigm using cetaceans as sentinels of potential emerging hazards.

### **Acknowledgements**

Sincere appreciation is extended to veterinarians, staff and volunteers from Ocean Park Hong Kong, Ocean Park Conservation Foundation Hong Kong for their great efforts with the stranding response program in Hong Kong. The authors would also like to thank the Agriculture, Fisheries and Conservation Department of the Hong Kong Special Administrative Region Government for the continuous support in the pioneer cetacean virtopsy project. Special thanks to Dr. Michael Bradley for English editing of this manuscript.

This project was financially supported by the Marine Ecology Enhancement Fund [Grant number: MEEF2017014/MEEF2017014A], Marine Ecology Enhancement Fund, Marine Ecology & Fisheries Enhancement Funds Trustee Limited. Any opinions, findings, conclusions or recommendations expressed herein do not necessarily reflect the views of the Marine Ecology Enhancement Fund or the Trustee.

### **Appendix 3: Abstract of conference proceedings**

Oral presentation at the Chinese White Dolphin Forum and the 1st Asian-Pacific Biennial Conference of Marine Endangered Species Research and Conservation at Shantou University on 13 August and 12-16 November 2018 respectively

#### **Application of interactive digital technology in cetacean and marine conservation**

Henry CL Tsui<sup>1</sup>, Brian CW Kot<sup>2,3</sup>

<sup>1</sup>Office of the Vice-President (Development and External Relations), City University of Hong Kong

<sup>2</sup>State Key Laboratory of Marine Pollution, City University of Hong Kong

<sup>3</sup>Department of Infectious Diseases and Public Health, Jockey Club College of Veterinary Medicine and Life Sciences, City University of Hong Kong

#### **Abstract**

Education on cetacean and marine conservation is challenging, as most of the ocean is invisible to the human eye and marine species and processes are spread over large temporal and spatial scales. Interactive digital technologies have the potential to support learning about the ocean, as, virtually, they can take the learners into the depth of the ocean and help them visualise complex interactions between different marine species over time and space.

In 2014, a 10.8-metre long Omura's whale (*Balaenoptera omurai*) stranded in the Hong Kong waters, with evidence of fishery entanglement. Omura's whale is a newly-discovered species of whale, which was confirmed to be a separate species after a detailed genetic analysis had been done in 2003. In this regard, delegates from the Jockey Club College of Veterinary Medicine and Life Sciences and students from various departments of the City University of Hong Kong (CityU) had taken the lead to deflesh the whole skeleton and preserve it into a specimen. Together with the cooperation with the pioneer cetacean virtopsy project, aiming to provide supplementary or complementary information to conventional necropsy for the biological health and profile investigation of stranded cetaceans, CityU is one of the first institutions worldwide to apply interactive digital technology to create various multimedia products in cetacean and marine conservation, namely photogrammetry and 3D printing, motion graphic, immersive virtual reality, and mobile application.

These technologies require different levels of knowledge, manpower and production time. The use of these interactive digital technologies in cetacean and marine conservation can make the invisible visible, allowing engagement with and manipulation of the abstract features of the ocean, as well as human interactions and threats to marine species. These technologies provide a field of action where users can experiment, make mistakes, get feedback and try again in ways that are different from paper-based learning activities, and would be demonstrated and displayed in various outreach visits and exhibitions, in order to increase public empathy for nature and arouse public awareness in conservation and nature. The present talk offers an overview of the range of impacts that interactive digital technologies can have on the development of cetacean and marine conservation, their pros and cons, as well as illustrating how technologies open up new ways of learning about marine environmental issues both inside and outside of school. It also provides an account of why ocean literacy is such an important skill for 21<sup>st</sup> century citizens living in a rapidly changing world with significant challenges to the environment and our own habitats.

#### **Acknowledgements**

Sincere appreciation is extended to veterinarians, staff and volunteers from Ocean Park Hong Kong, Ocean Park Conservation Foundation Hong Kong for their great efforts with the stranding response program in Hong Kong. The authors would also like to thank the Agriculture, Fisheries and Conservation Department of the Hong Kong Special Administrative Region Government for the continuous support in the pioneer cetacean virtopsy project. Special thanks to Dr. Michael Bradley for English editing of this manuscript.

This project was financially supported by the Marine Ecology Enhancement Fund [Grant number: MEEF2017014/MEEF2017014A], Marine Ecology Enhancement Fund, Marine Ecology & Fisheries

Enhancement Funds Trustee Limited. Any opinions, findings, conclusions or recommendations expressed herein do not necessarily reflect the views of the Marine Ecology Enhancement Fund or the Trustee.



## **Appendix 4: Abstract of conference proceedings**

Oral presentation at the the 50<sup>th</sup> Annual International Association for Aquatic Animal Medicine Meeting and Conference from 18 to 22 May, 2019 in Durban, South Africa

### **Fatal Café Coronary in Stranded Cetaceans: The Virtopsy Approach to Diagnose Asphyxiation**

Brian C.W. Kot,<sup>1,2\*</sup> and Henry C.L. Tsui.<sup>3</sup>

<sup>1</sup>*Department of Infectious Diseases and Public Health, Jockey Club College of Veterinary Medicine and Life Sciences, City University of Hong Kong, Kowloon, Hong Kong SAR, China;* <sup>2</sup>*State Key Laboratory of Marine Pollution, City University of Hong Kong, Kowloon, Hong Kong SAR, China;* <sup>3</sup>*Office of the Vice-President (Development and External Relations), City University of Hong Kong, Kowloon, Hong Kong SAR, China*

#### **Abstract**

Café Coronary is a condition to describe accidental asphyxiation resulting from food impaction in the upper aerodigestive tract. Fatal asphyxiation in cetaceans resulting from laryngeal displacement and suffocation by intended prey impaction has been reported in previous studies. The interpretation on fatal asphyxiation requires definitive and compelling evidence from the postmortem examination, death scene, and/or history, which is often hindered by the carcass condition in stranded cetaceans. Location of food bolus need not necessarily be the same at necropsy as at the time of death and foreign material can be dislodged during organ removal.

In humans, virtopsy techniques like postmortem computed tomography (PMCT) could localize food bolus and visualise aerodigestive tract in multiple reformatted planes, with small haemorrhages in the laryngeal muscles easily assessable prior to autopsy. PMCT can confirm the diagnosis of laryngeal obstruction by food bolus. To the best of our knowledge, the formal literature is devoid of any reference to the applicability of virtopsy in the diagnosis of fatal asphyxiation in stranded cetaceans. This study aimed to evaluate the practicality of virtopsy techniques in stranded cetaceans and compared the findings obtained by conventional necropsy.

Retrospective analysis of stranding cases with food bolus aerodigestive tract obstruction as the defined cause of death were undertaken, with both PMCT and conventional necropsy performed. PMCT was useful in identifying position and direction of the food bolus, orientation of goosbeak, haemorrhage in the adjacent muscle and blubber layers, and distribution and discharge characteristics of trachea and bronchi. PMCT postprocessing techniques virtual bronchoscopy and gastroscopy allowed planning and assisting in minimally invasive bronchoscopic and gastroscopic interventions during the conventional necropsy.

This study demonstrated virtopsy is a potentially powerful tool, providing non-invasive and objective measurements to supplement the necroscopic findings for diagnosis of fatal asphyxiation in stranded cetaceans. PMCT should be proposed in the cases of suspected asphyxiation, as the screening procedure of first instance to produce preliminary information useful to rapidly develop the successive necropsy performance.

#### **Acknowledgements**

The authors would like to thank the Agriculture, Fisheries and Conservation Department of the Hong Kong SAR Government for the support in the virtopsy project. Sincere appreciation is also extended to veterinarians, staff and volunteers from Ocean Park Hong Kong, Ocean Park Conservation Foundation Hong Kong for paying great effort on the stranding response and necropsy in this project. Special gratitude is owed to technicians from Peace Avenue Veterinary Clinic, City University of Hong Kong for operating the CT units to collect volumetric data in the present study. This project was financially supported by the Marine Ecology Enhancement Fund (Grant number: MEEF2017014/MEEF2017014A). Any opinions, findings, conclusions or recommendations expressed herein do not necessarily reflect the views of the Marine Ecology Enhancement Fund or the Trustee.

## **Appendix 5: Abstract of conference proceedings**

Oral presentation at the International Symposium-Workshop 2019 Scientific Studies of Marine Mammals in Asia and the 30<sup>th</sup> Annual Meeting of Cetology Study Group of Japan from 8 to 9 June 2019 in Japan

### **Virtopsy-driven stranding response program for the assessment of cetacean biological health and profiles in Hong Kong waters: Achievements, challenges and way forward**

Necropsy records and mortality data provide concrete information for monitoring morbidity in animal population. While conventional necropsy is considered the gold standard in postmortem investigation, it has several clear limitations. Conventional necropsy on cetaceans is invasive, requiring the body to be opened for examination which may induce unnecessary tissue destruction. Inspection, palpation and tissue incision during conventional necropsy may entail potential risks of disease contraction for veterinary personnel. These reasons illustrate the dire need for a review of the ways of handling carcasses with measures to complement the conventional necropsy.

In the course of the pioneering virtopsy-driven stranding response program in Hong Kong and adjacent waters, virtopsy using computed tomography (CT), magnetic resonance imaging (MRI) and ultrasonography have been implemented to provide supplementary or complementary information to conventional necropsy. Since March 2014, a total of 192 deceased cetaceans were confirmed in the Hong Kong waters. Whole body or regional virtopsy of 153 carcasses were performed and analyzed for pathologic findings, as well as characterized and documented the related injuries and death caused by human interaction. Two common stranded cetacean species, *Sousa chinensis* and *Neophocaena phocaenoides* (56 males, 65 females, 32 unknown sex; calf to adult; 50–365 cm in length; weight 5.9–386 kg), together with 16 more cetacean species, were included, with the carcass code ranging from 1–5. CT was performed on a 16-slice multi-detector row Toshiba Alexion™ CT system or a Somatom Definition 64 slices Dual Energy CT system. The MRI examination of brain, thorax and spine (sequences: T1-weighted, T2-weighted) was performed on a Siemens MRI Magnetom Trio 3.0 Tesla unit or a 0.25 Tesla Esaote Vet MRI Grande scanner. Post-processing was performed with the built-in software and/or TeraRecon Aquarius workstation. Radiological findings were compared with subsequent necropsy findings.

Most of the radiological findings, pertaining to head and neck, heart and vascular, thorax, abdomen, vertebral column and pectoral limbs, corresponded to necroscopic findings. CT was useful in diagnosing fatal hemorrhage, organ herniation, and pathological gas collection, as well as determining the number, shapes and characteristics of the fractures sites and the direction of external force. MRI was effective in evaluating soft tissue lesions, musculoskeletal injuries, integrity of spinal cord and brain herniation. Radiological assessment of the degree of epiphyseal fusion/ossification at postcranial skeleton allowed individual age-at-death estimation, supplementing the data obtained by dental growth layer group pattern. Approximately half of the cases were sufficient to assign the cause of death with confirmed, probable or suspect category associated by human interactions, which included fishery and vessel interactions.

A thoughtful management in a cetacean stranding response program with virtopsy as an integral part would yield valuable supplementary information prior to the conventional necropsy for biological health and profiles investigation of stranded cetaceans. This long-term study demonstrates virtopsy is a potentially powerful tool, providing non-invasive and objective measurements to document and analyze postmortem findings, leading to qualitative improvements in conventional necropsy, which eventually aids precise conservation planning and management for the vulnerable local resident cetacean populations.

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## Appendix 6: Abstract of publication

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### **Image Rendering Techniques in Postmortem Computed Tomography: Evaluation of Biological Health and Profile in Stranded Cetaceans**

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#### **Abstract**

With 5-year experience of implementing virtopsy routinely into Hong Kong cetacean stranding response program, a standardized virtopsy procedure, postmortem computed tomography (PMCT) acquisition, postprocessing and evaluation were successfully established. In this cetacean virtopsy-driven stranding response program (CVDSRP), 118 out of 167 recovered local stranded cetaceans (71%) were performed PMCT, providing supplementary information of the cause of death (COD) in the stranded marine animals prior to necropsy. The present study aimed to assess 8 image rendering techniques in PMCT for the evaluation of biological health and profile in stranded cetaceans in the Hong Kong waters, including multiplanar reconstruction (MPR), curved planar reformation (CPR), maximum intensity projection (MIP), minimum intensity projection (MinIP), DVR, segmentation, transfer function (TF) and perspective volume rendering (PVR). This helps guide radiologists, clinicians and veterinarians through the often difficult and complicated realm of PMCT image rendering and review. Descriptions of 8 image rendering techniques, in both 2D and 3D, mainly provided in the 3D workstations are revealed. Practical examples for each image rendering techniques applied in the biological health and profile investigation of stranded cetaceans were also provided.

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