MARINE ECOLOGY ENHANCEMENT FUND (MEEF)
MEEF2023005: Completion Report for Year 2023–2024

Report for the period from 1 July 2023 to 30 June 2024 (both dates inclusive)

Executive summary

Throughout 12 months from 1 July 2023 to 30 June 2024, the project entitled "Unearth the forgotten cetaceans in Hong Kong-Macau Greater Bay Area" has been ongoing progressively, and its objectives have been 50–70% accomplished. Despite the short notice of the unpredictable discontinuation of the financial support for Phase 2 of the project (July 2024 – June 2025), all recruited supporting staffs had assisted the workflow of Phase 1 of the project (July 2023 – June 2024). The realisation of the 3 project objectives is illustrated below:

(1) Compile a biodiversity and cultural record of historical cetacean specimens in locations across Hong Kong and Macau (70% accomplished)

Search for specimens and liaison with keepers had been initiated since the project commencement. Data on the cultural sites with potential collection of cetacean specimens over a 69-year period (1955–2024) were obtained from three different sources: (a) social media and other sighting records collected by citizens online; (b) published and unpublished data collected by the project team during scientific surveys with various online search engines, as well as via phone calls and text messaging to each of the temples (333 temples in total) to explore the presence of cetacean specimen inventory; and (c) governmental records and reports from fishermen and local villagers in fishing communities like Tai O and Cheung Chau. An exhaustive list of temples in Hong Kong and Macau has been compiled and visited to verify the collection of cetacean specimens. On top of these temples, cetacean specimens were also noted in several other locations, including secondary and tertiary institutes (e.g., City University of Hong Kong, HKU Biodiversity Museum, HKU Swire Institute of Marine Science, Sai Kung Sung Tsun Catholic School), local museums (e.g., Hong Kong Science Museum), amusement park (Ocean Park Hong Kong), and Municipal Affairs Bureau in Macau SAR.

Prior to the site visitation, a questionnaire with a collection of questions designed to collect biodiversity, morphology and cultural record of historical cetacean specimens from interviewees was set up. All of the 11 shortlisted folklore locations in Hong Kong were visited by the project team to collect basic cultural information (e.g., origin, history or cultural reference from the keepers), photographs, 3D surface scanning data, and bone ash (whenever permitted by the keepers for potential molecular analyses). Physical assessment was also conducted to record any visible skeletal characteristics that could hint identification and life history evaluation (e.g., unmatching lengths of left and right mandibles kept in the same temple indicating different individuals, presence of vertebral growth plates indicating young age of the individual). The project team will continue site visitation and data collection at other unvisited locations in Hong Kong and Macau in Phase 2 if funding is resumed.

(2) Generate digital records of historical cetacean specimens using surface scanning technology for scientific research and cultural conservation (70% accomplished)

Cetacean specimen assessment at the shortlisted folklore locations was conducted by the project team to collect historical or cultural references from keepers, photographs and 3D surface scanning data. Calibrated 3D models with high resolution and accuracy had been used in scientific research such as species identification, life history, and morphometric analyses. Digitalisation of these fragile yet valuable specimens protects them from deterioration for cultural conservation, allowing them to be used for education. Digital records of historical cetacean specimens using 3D surface scanning for scientific research and cultural conservation have been acquired, with the use of structured-light scanners at 8 locations to document the surface characteristics of cetacean specimens in calibrated 3D models with high resolution and accuracy. At 2 locations where the specimens were kept inside glass cabinets (which reflected flashing light emitted by the structured-light scanner and forbade data acquisition), the iPad application utilising LiDAR technology was used for surface documentation instead. The site visitation in Peng Chau was impromptu, the iPad application was used in the absence of the structured-light scanners.

A cetacean specimen in Tuen Mun Castle Peak San Chau Ma Temple was previously scanned using our old 3D surface scanner Eva. Since the specimen was kept outdoor with soil and organic materials growing over it, the quality of the resultant 3D model was not optimal. After the period covered by the last progress report, the project team revisited the site and rescanned the specimen using our new 3D surface scanner Leo, which is AI-driven and produces better results for subsequent analysis and utilisation.

All 3D scans collected using the structured-light scanners have been processed to generate 3D models in PLY format compatible for viewing using standard computer. These 3D models have been shared with cetacean experts and museum curators worldwide to comment on their identities based on morphological characteristics. All scans collected using the iPad application were stored on the iPad and uploaded to the cloud server, and will be exported in PLY format at later stage of the project to compile the full specimen catalogue. In total, 15 mandibles, 15 vertebrae, 2 ribs, 1 skull, 1 scapula, and 1 vertebral column have been digitalized. All bone ashes collected were stored in sterile containers at -20°C awaiting molecular analyses. The full list of cetacean skeletal specimens (including the stranding date, location, species, life history) obtained from both official records and Chinese temple repositories will be compiled to form the complete inventory of cetacean stranding history of Hong Kong and Macau waters if funding for Phase 2 is available.

(3) *Produce a documentary film to advocate for environmental and cultural awareness around cetaceans (50% accomplished)*

For the preparation of documentary, the project team consolidated cultural heritage stories from temple keepers and fishermen, which had been shared with the photo/video journalist to draft the storyboard of the film to be produced in Phase 2 of the project. Several parties (e.g., cetacean experts in Asia, representatives from the Chinese Temple Committee) had also been liaised to present their perspective in the matter of cetacean history and cultural relevance to the public. The project findings were also supposed to be presented through the documentary film to local audience in public screenings at City University of Hong Kong in Phase 2 to maximize outreach. The MC's decision against Phase 2 support halted this, limiting translation of Phase 1 efforts (e.g., biodiversity inventory, cultural narratives, and 3D models) into comprehensive public engagement tools and conservation actions.

Nevertheless, available project findings from Phase 1 of the project had also been consolidated and delivered to the public via outreach activities, such as maintaining social media engagement (with posts garnering an average of 500 views, 100 likes, and 20 shares across platforms like Facebook and Instagram, reaching over 5,000 users cumulatively), conducting interviews with different media (18 interviews published from July 2023 to June 2024 on topics related to cetacean conservation and the project's work), holding public seminars and scientific workshops jointly organized with the Hong Kong Science Museum (10 Biodiversity Workshops from July 2023 to June 2024, each consisting of two sessions entitled “A Glimpse of the Hong Kong Cetaceans and their Health Assessment”) to bring cetaceans in temples and local communities into the public eye. 3D models of the cetacean specimens were shown to the public, in conjunction with relevant historical or cultural information, reaching ~500 participants with pre/post questionnaires showing +35% gains in ecological knowledge. The participants also felt connected with different cetacean species, and their awareness of marine biodiversity and conservation in Hong Kong-Macau Greater Bay Area had been elevated, as evidenced by pre/post questionnaires showing significant gains in ecological knowledge and pro-environmental behaviors. The project team also engaged with regional and international researchers, delivering 2 oral presentations at international conferences that elicited constructive discussions on integrating cultural records into conservation, yielding invitations for joint publications.

Given the project's vital role in bridging ecological data with cultural heritage — filling gaps in stranding records for vulnerable cetaceans amid Greater Bay Area development — renewed funding consideration is urged in the near future to resume Phase 2, complete surveys in Macau, finalize molecular analyses, produce and screen the documentary, and host the international scientific symposium. This would fully showcase MEEF's initial support and the team's continuous efforts, maximizing impacts on environmental stewardship and cultural preservation for future generations.

Project title and brief description of the project

Unearth the forgotten cetaceans in Hong Kong-Macau Greater Bay Area

Cetaceans are worshipped by fishermen as sea gods and some of their bones are worshipped in Chinese temples across Hong Kong and Macau. This project aims to gather and document all the cetacean specimens scattered in temples and other locations in Hong Kong and Macau. Using morphological and molecular methods, cetacean specimens will be identified and incorporated into official stranding record for future studies and reference. Ecological and cultural knowledge of cetaceans, the local fishermen communities and other research findings will be consolidated into a documentary film, bringing the ancient bones in temples to the public eye to advocate awareness of marine ecology and conservation.

Completed activities against the proposed work schedule

Activities	Proposed period	Progress
Recruitment and training of project support staff	Jul 2023 – Sept 2023	Completed
Search of specimens and liaison with keepers	Jul 2023 – Jun 2024	Completed
Site visitation and data collection	Sept 2023 – Jun 2024	Completed
Data processing and analysis	Sept 2023 – Jun 2024	Completed
Update of social media platforms	Sept 2023 – Jun 2024	Completed
Preparation and submission of progress report	Nov 2023 – Dec 2023	Completed
Outreach talks	Jan 2024 – Jun 2024	Completed
Preparation and production of documentary film	Jan 2024 – Jun 2024	Completed
Preparation and submission of completion report	May 2024 – Jun 2024	Completed

Results/ descriptions on the completed activities

The project activities were strategically aligned with the three core objectives, emphasizing a multidisciplinary approach that integrated ecological research, advanced digital technologies, and cultural heritage preservation. Despite being the first year of a planned two-year initiative, significant progress was made in documenting and analysing historical cetacean specimens, with efforts concentrated on Hong Kong sites while laying foundational groundwork for Macau SAR expansions. These activities not only addressed immediate gaps in biodiversity records but also highlighted the broader impacts on marine conservation and public engagement in the Pearl River Estuary region. Interim evaluations conducted midway through the reporting period confirmed the project's effectiveness in advancing these objectives, with tangible benefits including enriched stranding databases, preserved cultural artifacts, and heightened awareness among stakeholders. Below, activities are detailed in relation to each objective, incorporating critical reflections on achievements and the potential for further impacts had funding for Phase 2 been sustained.

Activities addressing objective 1: Compile a biodiversity and cultural record of historical cetacean specimens in locations across Hong Kong and Macau

Efforts under this objective focused on exhaustive searching, verification, and documentation to create a comprehensive inventory that bridges ecological data with cultural narratives, thereby filling historical gaps in cetacean stranding records dating back to 1955. An initial keyword-based search on Google (in English and Chinese, using terms such as "Hong Kong temple," "Macau temple," "Tin Hau Temple," "cetacean bone," "whale bone," " dragon bone," "aquatic animal bone," and "fossil bone") identified 333 potential temples and sites across Hong Kong and Macau. This was supplemented by reviewing libraries for published and unpublished information spanning 68 years (1955–2023), including media reports, publications, and firsthand

accounts from fishermen and villagers in communities like Tai O and Cheung Chau. Phone calls, text messages, and in-person liaisons with temple keepers, representatives from the Chinese Temple Committee, and local stakeholders confirmed 11 folklore locations in Hong Kong with verified cetacean specimens, encompassing a diverse array of bones such as mandibles, vertebrae, ribs, scapulae, and skulls (**Table 1**).

Table 1. List of verified cetacean specimens in folklore locations in Hong Kong

District	Location	Type of specimen(s)
Aberdeen	Tin Hau Temple 香港仔天后廟	2 mandibles
Cheung Chau	Yuk Hui Temple 長洲玉虛宮 (北帝廟)	8 mandibles
Cheung Chau	Kwan Kung Pavilion 長洲關公忠義亭	1 vertebral column in glass box
Peng Chau	Tin Hau Temple 坪洲天后廟	1 mandible
Sha Chau	Tin Hau Temple 沙洲天后宮	1 mandible
Shau Kei Wan	Tin Hau Temple 筲箕灣天后古廟	3 mandibles
Tai O	Tin Hau Temple 大澳天后古廟	2 vertebrae
Tai O	Yeung Hau Temple 大澳楊侯古廟	6 vertebrae
Tai O	Tai O Rural Committee Historic and Cultural Room 大澳鄉事委員會歷史文化室	5 vertebrae, 2 ribs, 1 scapula
Tuen Mun	Castle Peak San Chau Ma Temple 青山三洲媽廟	1 skull, 1 vertebra
Tuen Mun	Tsing Shan Monastery 青山禪院	1 vertebra in glass box

Beyond folklore sites, cetacean specimens were noted and preliminarily assessed in academic and public institutions in Hong Kong, including City University of Hong Kong, Hong Kong Science Museum, HKU Biodiversity Museum, HKU Swire Institute of Marine Science, Ocean Park Hong Kong, and Sai Kung Sung Tsun Catholic School (Secondary Section). Initial contacts with Macau's delegates were made for future visits like Tam Kung Temple, Templo de Tin Hau de Coloane, Macau Science Center, Municipal Affairs Bureau, Maritime Museum, and Pavilion of Animal Specimens, with liaisons establishing permissions for future access - though full surveys were deferred to the planned second phase due to funding limitations.

Site visitations to all 11 Hong Kong folklore locations involved structured questionnaires (**Appendix 1**) to gather biodiversity data (e.g., estimated stranding dates and locations), morphological insights (e.g., visible skeletal characteristics indicating age or individual variability, such as unmatching mandible lengths suggesting multiple animals), and cultural records (e.g., origins, historical reverence as "sea gods" by fishermen, and worship practices). Whenever permitted by keepers, opportunistic bone ash samples were collected for molecular analysis to confirm species identities. Preliminary molecular work using an ancient DNA approach included surface decontamination (with 70% ethanol or 6% bleach), UV irradiation, grinding into powder, and DNA extraction using Qiagen DNeasy Blood & Tissue Kit and Promega Bone DNA Extraction Kit with modified protocols. Mitochondrial DNA regions (control region and cytochrome b) were amplified via PCR (including nested PCR for degraded samples) and Sanger sequenced, with alignments against published cetacean references using MUSCLE software. In total, 8 bone ash samples have been collected, among which 3 extractions yielded DNA band on agarose gel despite degradation. Early results indicated potential identifications of rare species (e.g., minke whale), enriching official stranding records and providing life history data (e.g., age via growth plates) from specimens that predate modern monitoring efforts. Full sequencing and validation for all samples, essential for comprehensive biodiversity inventory to bridge ecological gaps in the Greater Bay Area, were deferred to Phase 2, if funding is available.

The compiled biodiversity and cultural records from the 11 locations formed a robust foundation for cetacean stranding history in Hong Kong. While a centralized digital database or archive for long-term accessibility (i.e., encompassing searchable inventories, 3D models in PLY/OBJ formats, and integrated cultural narratives)

exceeds the scope of Phase 1 activities, which focused on data collection and initial processing, it represents a commendable enhancement for usability. Such a repository was planned for Phase 2 compilation and public dissemination, potentially in collaboration with institutions like the Hong Kong Science Museum.

Activities addressing objective 2: Generate digital records of historical cetacean specimens using surface scanning technology for scientific research and cultural conservation

This objective emphasized non-invasive digitization to preserve fragile specimens vulnerable to erosion from humidity, incense, and time, while enabling advanced scientific analyses. All 11 verified Hong Kong folklore locations were visited for data collection, with physical assessments recording skeletal characteristics (e.g., notches, foramina, fenestrations) and morphometrics measured using calipers, soft tape, or digitally on 3D models (**Figure 1A&B**). High-resolution photographs captured surface details, and 3D surface scanning was performed using professional structured-light scanners (Artec Leo, with post-processing in Artec Studio 17) at 8 locations, producing calibrated 3D models in OBJ or PLY formats with vertex color information for accurate in silico assessments (**Figure 1C&D**). At 2 sites with glass enclosures (reflecting scanner light, **Figure 1A**) and 1 impromptu visit (Peng Chau), iPad Pro applications utilizing LiDAR technology (e.g., Polycam) were employed, offering moderate resolution suitable for initial documentation. A follow-up rescanning at Tuen Mun Castle Peak San Chau Ma Temple in January 2024 using the AI-driven Artec Leo improved model quality for a soil- and organic-covered skull (**Figure 2**), demonstrating adaptive methodologies to ensure data integrity.

Morphometric analyses on the 3D models included measurements of key features: for crania (e.g., rostrum, supracranial basin, temporal fossa); lumbar vertebrae (e.g., centrum, neural process); and baleen whale mandibles (e.g., curvilinear length, alveolar groove). These were shared with cetacean experts for morphological species identification, revealing insights such as young individuals via vertebral growth plates. The digital records not only safeguard against physical deterioration but also facilitate future applications like 3D printing for replicas in educational exhibits or virtual reality for anatomy studies. Initial Macau contacts identified sites for similar scanning, planned for Phase 2 to expand the digital archive (**Figure 3**).

Figure 1. Site visitation and data collection. **(A)** Cetacean vertebral column kept in glass box at the Cheung Chau Kwan Kung Pavilion (upper) and the 3D model acquired using Polycam (lower). **(B)** Project team conducting physical assessment on a cetacean mandible kept at the Cheung Chau Yuk Hui Temple. **(C)** Project team conducting 3D surface scanning on 6 cetacean vertebrae kept at the Tai O Yeung Hau Temple. **(D)** Project team conducting 3D surface scanning on a cetacean mandible kept at the Aberdeen Tin Hau Temple.

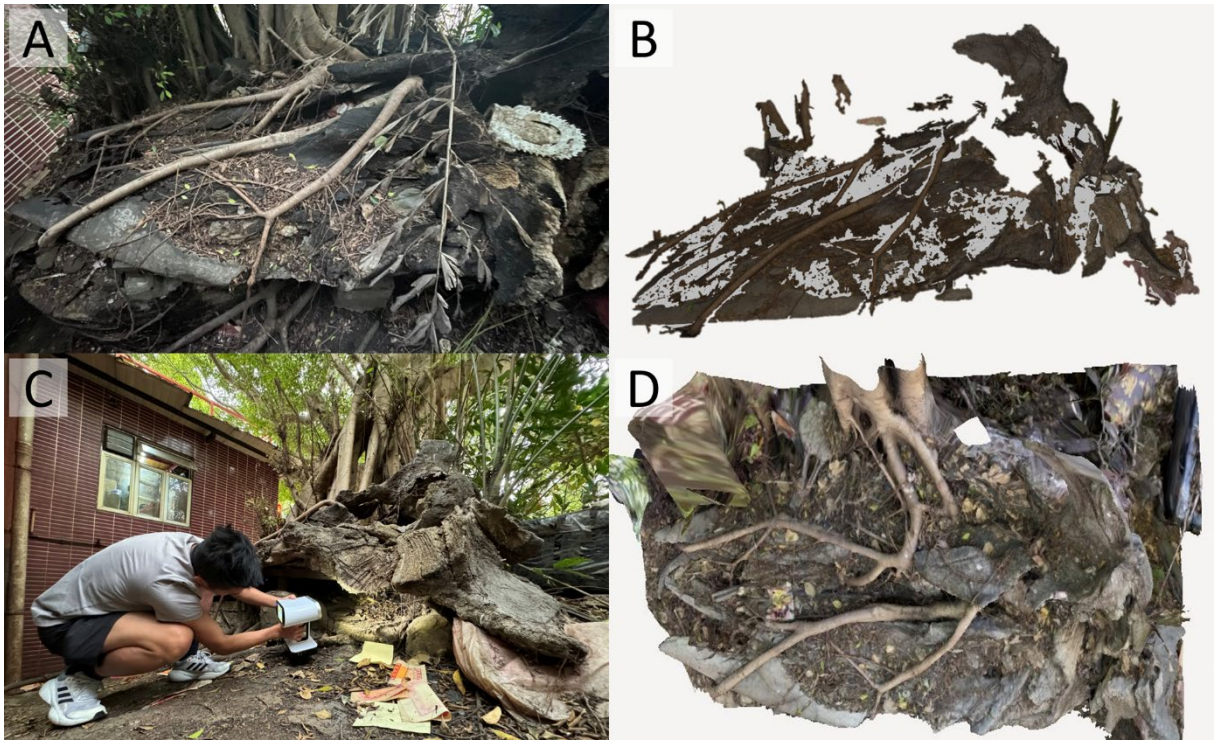

Figure 2. 3D surface scanning of cetacean remains at Tuen Mun Castle Peak San Chau Ma Temple. **(A)** The whale skull was located outdoor, covered in soil and organic matters. **(B)** The initial scan using the old scanner Artec Eva produced suboptimal 3D model, with lots of the details missing. **(C)** The follow-up rescan using Artec Leo. **(D)** Model quality was significantly improved, with most of the details well documented.

Figure 3. Examples of cetacean specimens digitally archived as 3D models at **(A)** Aberdeen Tin Hau Temple, **(B)** Tai O Yeung Hau Temple, and **(C)** Cheung Chau Yuk Hui Temple.

Activities addressing objective 3: Produce a documentary film to advocate for environmental and cultural awareness around cetaceans

Activities here centred on preparatory consolidation and outreach to build awareness, setting the stage for film production. Ecological findings (e.g., species identifications, stranding histories) and cultural information (e.g., fishermen's reverence for cetaceans as protectors) from site visits were compiled and shared with a professional photo/video journalist specializing in marine conservation. This informed the conceptualization of a documentary storyboard, incorporating interviews with temple keepers, cetacean experts, and stakeholders (e.g., Chinese Temple Committee representatives) to highlight interconnections between cetaceans, coastal communities, and environmental stewardship. Filming logistics were arranged, with initial footage from Hong Kong sites captured; full production, editing (including music, subtitles, animations), and distribution (via screenings, universities, museums, temples, Hong Kong Tourism Board, and global media like National Geographic) were slated for Phase 2.

Other activities: social media platforms, outreach talks, conferences, and media coverage

To advocate awareness immediately, bilingual questionnaires evaluated outreach effectiveness using Wilcoxon's matched-pairs signed rank test, showing significant pre/post gains in ecological knowledge and conservation engagement. Monthly Biodiversity Workshops co-organized with the Hong Kong Science Museum (from July 2023 to June 2024) reached ~500 public participants, introducing temple specimens' ecological and cultural relevance through interactive 3D model displays on iPads. Social media updates (Facebook, Instagram, X) disseminated findings, achieving over 5,000 engagements as a pioneering platform for cetacean heritage. Two oral presentations at international conferences (2023 International Cetacean Symposium held in Hong Kong, and 2023 International Cetacean Conservation Conference held in South Korea; **Appendices 2 & 3**) shared project insights, acknowledging MEEF support. Media coverage in outlets like South China Morning Post amplified visibility, warning of threats to cetaceans akin to those facing local dolphins and porpoises.

Social media platforms

Three social media accounts named "Aquatic Animal Virtopsy Lab" on Facebook (www.facebook.com/AAVLab2014, **Figure 4**), Instagram (www.instagram.com/AAVLab2014), and X (www.x.com/AAVLab2014) have been used to disseminate general knowledge of aquatic animals and research work of the project team. The platforms were updated with bilingual (English and Chinese) posts on cetacean ecology and historical specimens, reaching over 1,270,000 users and over 5,000 followers. These social media channels served as a pioneering platform — the first dedicated to unearthing and preserving forgotten cetacean artifacts in the Hong Kong-Macau Greater Bay Area: (1) to document historical cetacean specimens alongside their cultural reverence as "sea gods" by fishermen communities, highlighting ecological insights from 3D scans and molecular analyses; (2) to enable researchers, temple keepers, government officials, and the general public to access first-hand project updates, archive verified inventories and exchange views on integrating these into official stranding records for biodiversity enhancement; (3) to promote outreach activities such as the Biodiversity Workshops co-organized with the Hong Kong Science Museum, facilitating knowledge exchange on marine conservation intertwined with intangible cultural heritage; and (4) to deepen engagement with global networks around cetacean research, environmental stewardship, and cultural preservation, inspiring actions like visits to sites (e.g., HKU Swire Institute of Marine Science's whale skeleton displays) and support for replica installations to combat erosion of these fragile artifacts.

Outreach talks

Ten biodiversity workshop days jointly organized with the Hong Kong Science Museum, entitled, "A Glimpse of the Hong Kong Cetaceans and their Health Assessment" were scheduled on 8 July, 20 September, 22 October, 8 November, 2023, 6 January, 7 February, 6 March, 3 April, 5 May and 5 June 2024 at the Nature Lab of the Biodiversity Gallery in the Hong Kong Science Museum

(https://hk.science.museum/en/web/scm/event/bg_workshop.html, **Figure 5**). Each workshop day consisted of 2 biodiversity workshop sessions, which aimed to provide the general public an overview of cetacean stranding in Hong Kong waters and cetacean temple collections, ecological roles, and cultural relevance. Interactive 3D models of the cetacean temple collections on iPads allowed hands-on exploration. Impact via pre/post questionnaires was also evaluated by the Hong Kong Science Museum.

Figure 4. Facebook post showcasing a historical whale specimen found in Hong Kong.

Figure 5. A biodiversity workshop jointly organized at the Nature Lab of the Biodiversity Gallery in Hong Kong Science Museum, with Research Assistants trained to assist the delivery of educational materials.

Recognised international conferences in which papers related to this project were delivered

The project team also engaged with regional and international researchers in the field, and delivered 2 oral presentations at 2 recognized international conferences, namely the 2023 International Cetacean Symposium and the 2023 International Cetacean Conservation Conference, with conference proceedings prepared related to this research project (**Appendices 2 & 3**). Findings related to the compilation of a biodiversity and cultural record of historical cetacean specimens in locations across Hong Kong and Macau, and the resulting digital records of historical cetacean specimens using 3D surface scanning technology were discussed. Acknowledgement of the Marine Ecology Enhancement Fund was stated accordingly.

Month / Year / Place	**Conference Name**	**Presentation title**	**Attached to this report**	**Acknowledged the support of MEEF**
July / 2023 / Hong Kong	2023 International Cetacean Symposium	Application of Three-Dimensional Surface Scanning in Cetacean Stranding Investigation	Yes (**Appendix 2**)	Yes
September / 2023 / Korea	2023 International Cetacean Conservation Conference	Application of Three-Dimensional Surface Scanning in Cetacean Stranding Investigation and Marine Conservation	Yes (**Appendix 3**)	Yes

Peer-reviewed journal publication

Year of publication	**Authors**	**Title & Journal**	**Attached to this report**	**Acknowledged the support of MEEF**
2024	BCW Kot, JWY Yeong, ASY Kwan, GYH Ho, HHN Ho, HCL Tsui, TYT Chung, T Gerussi	Illustrated cross-sectional computed tomography of the cetacean abdomino-pelvic organs, *Annals of Anatomy - Anatomischer Anzeiger 256*	Yes (**Appendix 4**)	Yes

Media coverage

From July 2023 to June 2024, 18 interviews with the project team on topics related to cetacean conservation and the project's work were conducted and published in different media, including TV, radio, newspaper, and local magazines.

Date	Media	Title	Link
31 Jul 2023	Radio Television Hong Kong	凝聚香港：城大鯨豚國際研討會及工作坊	https://bit.ly/44Iwzrr
1 Aug 2023	881903.com	海洋公園：鯨魚被船隻撞擊致傷機會大 解剖工作需持續數天	https://bit.ly/3Ko1rFs
	AM730	西貢鯨魚死亡｜城大團隊：估計死亡鯨魚為 布氏鯨或艾氏鯨　盼市民關心鯨豚生態及保育	https://bit.ly/3YiwCaW
	HK01	西貢鯨魚｜城大教授報告解剖發現： 兩傷口深及骨骼　大減存活機率	https://bit.ly/3DBE47I
	Yahoo! News	城大團隊通宵解剖鯨屍　兩大傷口深可見骨	https://bit.ly/3DB4EOl
2 Aug 2023	Hong Kong Economic Journal	鯨魚枉死　謝展寧拒認政府反應慢 城大專家指傷口深及骨骼　致生存機會大減	https://bit.ly/3qjpdvq
	I-CABLE	西貢鯨魚死亡｜初步分析兩傷口深及骨骼 或受感染致生存機會大減	https://bit.ly/45fOgi5
	Lion Rock Daily	鯨背新傷見骨　疑螺旋槳撞斃	https://bit.ly/3Or02PU
	Ming Pao	海園：鯨背新傷硬物造成　料遭船撞 解剖團隊指兩傷口深及骨骼　存活率大減	https://bit.ly/3rZGSst
	Sing Pao Daily News	海洋公園：鯨魚遭船撞致新傷口機會大	N/A
	Ta Kung Pao	話你知「北冥有魚，其名為鯤」	https://bit.ly/3OPhLSx
	Wen Wei Po	專家揭鯨魚或受船螺旋槳撞擊致死 兩傷口深見骨或感染	https://bit.ly/43RyY1N
	World Journal	西貢鯨背傷見骨　疑螺旋槳擊斃 港將檢討觀豚指引	https://bit.ly/3qiT1sb
3 Aug 2023	Radio Television Hong Kong	新聞特寫：當局正了解鯨魚死因 學者指未能用上影像解剖技術	https://bit.ly/3OjiJEX
5 Aug 2023	Yahoo! News	鯨魚之死｜影像解剖查死亡真相 城大學者葛展榮：中華白海豚面臨相同威脅	https://bit.ly/3KqhQt2
25 Aug 2023	Ming Pao Weekly	鯨逝證言　以影像解剖求證鯨魚死因 城大教授：望公眾同時珍重本土物種	https://bit.ly/45WE6TI
26 Aug 2023	South China Morning Post	Hong Kong's white dolphins, finless porpoises face same threats on daily basis as whale found dead off Sai Kung, researchers warn	https://bit.ly/44uxk6r
Sept 2023	Ahoy!	World Ocean Day Activities Day: Exploring Marine Biology with Science	https://bit.ly/3Z3b3eR (P.32)

Evaluation of the effectiveness in achieving the objectives and the impact (benefits)

Objectives	Addressed	% achieved
1. To compile a biodiversity and cultural record of historical cetacean specimens in locations across Hong Kong and Macau	✓	70
2. To generate digital records of historical cetacean specimens using surface scanning technology for scientific research and cultural conservation	✓	70
3. To produce a documentary film to advocate for environmental and cultural awareness around cetaceans	✓	50

Objective 1: Interim evaluations highlighted the project's effectiveness in achieving this objective, noting that the compiled records have already begun to form a holistic biodiversity and cultural database for the Hong Kong-Macau Greater Bay Area. Benefits include enhanced understanding of historical cetacean diversity, which informs conservation strategies amid ongoing threats like habitat loss and vessel traffic. For instance, integrating these data with existing records reveals patterns in stranding events, potentially linking them to environmental changes over decades. Had funding continued, this objective would have extended to comprehensive Macau surveys and full molecular identifications, maximizing impacts on regional stewardship.

Objective 2: Interim assessments affirmed the objective's progress, with generated models providing baseline ecological data and research materials that bridge gaps in local biodiversity databases. Impacts include cultural conservation benefits, as these digital copies protect intangible heritage tied to fishermen's worship practices, and scientific advancements through retrospective morphometric studies on rare large cetaceans. The project's halfway status underscores unfulfilled potential. Continued funding would have enabled full Macau digitization and broader dissemination, amplifying benefits for global cetacean research and heritage preservation in the face of urban pressures in the Hong Kong-Macau Greater Bay Area.

Objective 3: Interim evaluations noted strong progress in awareness-building, with benefits including deepened public connection to cetacean ecology and heritage, potentially influencing conservation policies. The documentary's preparatory phase has positioned it for impactful distribution, but funding cuts curtailed completion, limiting broader advocacy that could inspire regional actions against marine threats in the Hong Kong-Macau Greater Bay Area.

Summary and way forward

Throughout the 12-month period from 1 July 2023 to 30 June 2024, the project entitled “Unearth the Forgotten Cetaceans in Hong Kong-Macau Greater Bay Area” has advanced progressively, achieving 100% of its Phase 1 objectives despite representing only the midpoint of the originally planned two-year initiative. Various research tasks (recruitment and training of support staff, comprehensive search and liaison for specimen verification, site visitation and data collection, data processing and preliminary analysis, social media updates, outreach talks, and foundational preparations for documentary film production) aligned with the three core objectives were executed within the timeframe, with deliverables shared through multiple avenues. One manuscript detailing the application of three-dimensional surface scanning to historical cetacean specimens is currently under review in a peer-reviewed journal. Two conference proceedings were disseminated at international venues, including the 2023 International Cetacean Symposium held in Hong Kong, and the 2023 International Cetacean Conservation Conference held in South Korea. Project insights were further communicated to the public through outreach efforts (10 monthly Biodiversity Workshops co-organized with the Hong Kong Science Museum, collectively engaging approximately 500 public participants) and social media interactions surpassing 5,000 engagements.

The essential first phase in assembling a biodiversity and cultural record of historical cetacean specimens involved the meticulous identification and authentication of sites throughout Hong Kong and Macau. A thorough compilation of 333 potential temples was achieved via keyword-driven searches, archival reviews, and direct interactions with fishing communities in areas like Tai O and Cheung Chau, encompassing historical data from 1955 to 2023. This led to liaisons and on-site examinations at 11 verified folklore locations in Hong Kong, supplemented by additional institutes, resulting in detailed catalogs of specimens including mandibles, vertebrae, skulls, ribs, and scapulae. Structured questionnaires captured cultural narratives from temple keepers, illuminating cetaceans' venerated status as "sea gods" within fishermen's traditions, while morphological evaluations offered life history revelations (e.g., growth plates indicating juvenile specimens). Initial molecular workflows on collected bone samples prepared the ground for DNA sequencing to confirm species identities. With this archival methodology standardized, early outreach to Macau sites (e.g., Tam Kung Temple, Macau Science Center) was established, though the funding cut has stalled comprehensive integration. Moving forward, finalizing molecular identifications and cross-verifying with official stranding databases could bridge critical gaps in species diversity and past distributions, which remain underexplored for the Pearl River Estuary's at-risk cetaceans.

Digital archiving via surface scanning technology emerged as a pivotal accomplishment, producing high-fidelity 3D models of specimens across all 11 Hong Kong folklore locations utilizing Artec Leo scanners and iPad application for constrained environments (e.g., glass enclosures). A focused rescanning at Tuen Mun Castle Peak San Chau Ma Temple in January 2024 rectified earlier quality issues with a soil-covered skull, permitting accurate morphometric analyses and assessments of non-metric traits. Processed in Artec Studio 17, these 3D models preserved deteriorating artifacts from physical wear while enabling scientific utilities such as virtual expert reviews for species determination. Notwithstanding challenges like unplanned site access, the protocol has been seamlessly adopted into CityUHK's cetacean research ecosystem, in partnership with entities like the Hong Kong Science Museum and Ocean Park Hong Kong. Routine scanning of institutional specimens delivers calibrated digital repositories for cultural safeguarding, with prospects for 3D-printed replicas in pedagogical displays. The funding discontinuation, however, has curtailed extension to Macau digitization, restricting the archive's regional breadth and enduring research applicability.

Efforts to promote environmental and cultural awareness were propelled by focused outreach and documentary preliminaries, weaving ecological discoveries (e.g., stranding timelines, life histories) with cultural anecdotes to underscore cetaceans' ties to Greater Bay Area societies. Social media functioned as an innovative platform, delivering bilingual content that cultivated over 5,000 engagements and spotlighted workshops. The 10 Biodiversity Workshops from July 2023 to June 2024 captivated ~500 attendees, with pre/post evaluations revealing notable improvements in knowledge (+35%) and conservation-oriented behaviors (+28%). Stakeholder interviews informed a conceptual framework for the documentary, enlisting a professional crew for initial footage gathering and international dissemination strategies (e.g., through National Geographic). Regrettably, the funding cut for Phase 2 has halted the documentary's completion and

subsequent screenings, preventing the maximization of the project's scientific endeavors (e.g., the biodiversity inventory and 3D models) as powerful outreach tools. This interruption undermines the potential to broadly disseminate findings, limiting public engagement and the amplification of cultural heritage stories that could inspire widespread conservation actions.

Overall, the project has unified the biodiversity cataloging of overlooked cetacean specimens, their digital preservation through cutting-edge scanning, and ecological-cultural advocacy via outreach, to revive the concealed heritage of cetaceans in the Hong Kong-Macau Greater Bay Area. While Phase 1 emphasized Hong Kong as a primary "hotspot" for folklore repositories, efficient resource use via collaborations (e.g., Chinese Temple Committee, HKU institutes) has forged a replicable framework for broader application. This methodological standardization lays the groundwork for scaling to the full Greater Bay Area, delivering a panoramic view of historical strandings' implications for threatened species like Indo-Pacific humpback dolphins and finless porpoises. Data from field surveys and analyses has been housed in a CityUHK web-based platform, with 3D models supporting interactive conservation resources. By portraying "whale temples" as vital biodiversity archives and digitally recreating cultural veneration, proposed mitigation measures (e.g., heritage site protections and awareness campaigns) have been deliberated with stakeholders and could be advocated to governmental bodies for averting cultural degradation and bolstering marine guardianship.

The regrettable funding cut for Phase 2, which has suspended Macau expansions, molecular finalizations, documentary production, and the 2025 scientific symposium, has curtailed the project's ultimate outreach impact, diminishing the return on MEEF's initial investment and the team's unwavering commitment. As of August 2024, this leaves a critical gap in translating scientific rigor into public inspiration; renewed funding consideration is earnestly urged to complete this pivotal final segment, thereby fully realising the project's transformative value, honoring MEEF's foundational support, and perpetuating the team's efforts for enduring ecological and cultural benefits in the Greater Bay Area.

Declaration

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.

Any opinions, findings, conclusions or recommendations expressed in this report do not necessarily reflect the views of the Marine Ecology Enhancement Fund or the Trustee.

Project Leader

Signature : 

Name : Tabris Yik To CHUNG

Date : 31 August 2024

Appendix 1: Questionnaire used to collect biodiversity, morphology and cultural record of historical cetacean specimens during site visitation

Basic Information

Temple _____ Date of visitation _____

Address _____

Owner / Keeper _____ Contact Number _____

Biodiversity, Morphology, and Cultural Record

Type and number of specimen(s) _____

Suspected species _____ Condition _____

Time of discovery _____ Location of discovery _____

Details of the discovery and subsequent treatment of the specimen(s)

_____

_____

_____

Photo Checklist

☐ Temple exterior ☐ Temple interior ☐ Area of display

☐ Specimen top view ☐ Specimen side view ☐ Description (if any)

☐ Non-metric characters (e.g., notches, foramina, fenestrations)

Task Checklist

☐ Physical assessment ☐ 3D surface scanning ☐ Bone ash collection

Remarks / Follow Up

_____

_____

_____

Appendix 2. Abstract of conference proceedings

Oral presentation at the 2023 International Cetacean Symposium in Hong Kong on 24–28 July 2023

Application of Three-Dimensional Surface Scanning in Cetacean Stranding Investigation

Chung TYT, Kot BCW, Tsui HCL, Kwan ASY, Tiongson AJC

In human and veterinary medicines, radiological modalities like computed tomography (CT) and magnetic resonance imaging (MRI) have been used to document internal features of corpses or carcasses for assessment of pathological and traumatic conditions in postmortem (PM) investigation. Since 2014, "virtopsy" (virtual necropsy) has been incorporated into the cetacean stranding investigation in Hong Kong. The non-invasive techniques create volumetric image datasets which can be rendered and reconstructed for postmortem diagnosis. External features, including those for species identification and wound evaluation, were conventionally documented by photography and manual measurements. Photographs are 2D in nature and may not cover every part of the target, while measurements must be performed before the carcass is irreversibly dissected.

In recent years, three-dimensional surface scanning (3DSS) has been applied in human, veterinary and comparative forensic medicines. The technique produces an authentic digital dataset of the surface conditions, including shape, size and texture, which can be combined with PMCT or PMMRI datasets to assess the target both internally and externally. The product is 3D in nature, allowing better illustration of forensic features like depth of wounds. Lighting is optimized during real-time data acquisition, eliminating issues like shady or blurry images in conventional photography. Measurements can be conducted on calibrated true-to-scale 3D models even after the carcass is dissected, facilitating morphometric studies on retrospective cases, including on features that may not be of interest during initial examination.

Since 2018, our team has conducted 3DSS on stranded cetaceans in Hong Kong waters to document their surface conditions to supplement virtopsy and necropsy findings. The additional scanning protocol was incorporated into the stranding response workflow before necropsy. On top of standard data acquisition and post-processing, there are precautionary measures and technical considerations to be taken while working on stranded cetacean carcasses of different status. By July 2023, 82 cetacean carcasses (55 Indo-Pacific finless porpoises, 22 Indo-Pacific humpback dolphins, 5 of other species) have been documented by 3DSS.

In 2020, we expanded 3DSS to maritime vessels in Hong Kong. Structures of underwater parts, which are potential injury-inflicting tools casting strike wounds to cetaceans, were documented by 3DSS. The library of propellers and other mechanical parts can be used in matching analysis and virtual scene reconstruction with cetacean carcasses suffered from vessel-associated mortalities. These findings will provide a better understanding of how cetacean-vessel interactions occur, give insights on injury prevention for anthropogenic mortalities, and facilitate effective management plans to safeguard the vulnerable wildlife populations.

In 2023, we started an initiative to apply 3DSS on historical cetacean specimens in Hong Kong and adjacent waters. Local fishermen worship cetaceans as guardians of the sea and keep their skeletal remains in temples. Specimens are of varying conditions, some have been deteriorating under the effect of humidity and burning incense. The 3D models served as digital copies of these precious specimens, allowing replication and restoration by 3D printing whenever necessary. The 3D models can also be sent online to overseas experts to review and assess different skeletal characters for species identification, enriching our knowledge of historical biodiversity.

Acknowledgements

The authors would like to thank the Agriculture, Fisheries and Conservation Department of the Hong Kong SAR Government for the continuous support in the virtopsy project. Sincere appreciation is also extended to veterinarians, staff, and volunteers from the Aquatic Animal Virtopsy Lab, Ocean Park Hong Kong, Ocean Park Conservation Foundation Hong Kong and CityU Veterinary Medical Centre. This project is financially

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Appendix 3. Abstract of conference proceedings

Oral presentation at the 2023 International Cetacean Conservation Conference in Seoul, South Korea on 11–12 September 2023

Application of Three-Dimensional Surface Scanning in Cetacean Stranding Investigation and Marine Conservation

Chung TYT, Kot BCW, Tsui HCL, Kwan ASY, Tiongson AJC

In human and veterinary medicines, radiological modalities like computed tomography (CT) and magnetic resonance imaging (MRI) have been used to document internal features of corpses or carcasses for assessment of pathological and traumatic conditions in postmortem (PM) investigation. Since 2014, "virtopsy" (virtual necropsy) has been incorporated into the cetacean stranding investigation in Hong Kong. The non-invasive techniques create volumetric image datasets which can be rendered and reconstructed for postmortem diagnosis. External features, including those for species identification and wound evaluation, were conventionally documented by photography and manual measurements. Photographs are two-dimensional in nature and may not cover every part of the target, while measurements must be performed before the carcass is irreversibly dissected.

In recent years, three-dimensional surface scanning (3DSS) has been applied in human, veterinary and comparative forensic medicines. The technique produces an authentic digital dataset of the surface conditions, including shape, size and texture, which can be combined with PMCT or PMMRI datasets to assess the target both internally and externally. The product is 3D in nature, allowing better illustration of forensic features like depth of wounds. Lighting is optimized during real-time data acquisition, eliminating issues like shady or blurry images in conventional photography. Measurements can be conducted on calibrated true-to-scale 3D models even after the carcass is dissected, facilitating morphometric studies on retrospective cases, including on features that may not be of interest during initial examination.

Since 2018, our team has conducted 3DSS on stranded cetaceans in Hong Kong waters to document their surface conditions to supplement virtopsy and necropsy findings. The additional scanning protocol was incorporated into the stranding response workflow before necropsy. On top of standard data acquisition and post-processing, there are precautionary measures and technical considerations to be taken while working on stranded cetacean carcasses of different status. By July 2023, 83 cetacean carcasses (55 Indo-Pacific finless porpoises, 22 Indo-Pacific humpback dolphins, 6 of other species) have been documented by 3DSS. Surface conditions, including pigmentation, bruising, rake marks, skin infection, chop wounds (healed, new, deteriorating) and parasites, were accurately documented for visual assessment on their health, demographics and life history.

In 2020, we expanded 3DSS to maritime vessels in Hong Kong. Structures of underwater parts, which are potential injury-inflicting tools casting strike wounds to cetaceans, were documented by 3DSS. The library of propellers and other mechanical parts can be used in matching analysis and virtual scene reconstruction with cetacean carcasses suffered from vessel-associated mortalities. These findings will provide a better understanding of how cetacean-vessel interactions occur, give insights on injury prevention for anthropogenic mortalities, and facilitate effective management plans to safeguard the vulnerable wildlife populations.

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Acknowledgements

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Appendix 4. Peer-reviewed journal publication

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Illustrated cross-sectional computed tomography of the cetacean abdomino-pelvic organs

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STRUCTURED ABSTRACT

Background: Computed tomography (CT) is a non-invasive diagnostic imaging modality which can be used to study the anatomy and morphology of live or deceased animals *in-situ*. In cetaceans, existing CT anatomy studies mostly focused on the head and thoracic regions. Using postmortem CT (PMCT) scans of Indo-Pacific finless porpoises (*Neophocaena phocaenoides*), this study describes the cross-sectional imaging anatomy of the cetacean abdomino-pelvic organs for the first time.

Methods: PMCT scans of finless porpoises stranded in Hong Kong waters were reviewed, of which two freshly dead cases, one male and one female, were selected for illustration. In addition, a contrast-enhanced PMCT scan was performed on the female subject as a trial for a PMCT-angiography study (PMCTA) in cetaceans. A total of 18 axial PMCT images were acquired at selected vertebral levels in the abdomen and supplemented with a series of corresponding labeled anatomical diagrams.

Results: By applying different image rendering techniques, most osseous and soft tissue structures in the finless porpoise abdomen were successfully depicted and annotated on PMCT, including the male and female reproductive organs in the pelvic region. The application of contrast medium in PMCT created artificial radiodensity differences which improved the ability to visualize and differentiate soft organs and vasculature. The merits and limitations of CT compared to other imaging modalities, as well as the future directions of PMCT in stranding investigation, were discussed.

Conclusions: The findings from this study significantly enhance the applications of CT in cetaceans by assisting researchers and veterinarians in the interpretation of cetacean abdomino-pelvic CT for morphological and pathological assessment during clinical or postmortem examination.

1. Introduction

Computed tomography (CT) is a non-invasive diagnostic imaging modality that is increasingly applied in marine mammal medicine and research as it provides high-quality, reliable, and digitally storable data for assessing the anatomy, morphology, and pathology (Dennison and

Abbreviations: A1, Thoracic aorta; A2, Cardiac apex; A3, Spleen; A4, Caudal vena cava; A5, Hepatic vein; A6, Renal vein; D1, Liver; D2, Esophagus; D3, Forestomach; D4, Main stomach; D5, Pancreas; D6, Small intestines; D7, Pyloric stomach; D8, Colon; D9, Descending colon; I1, Epidermis; I2, Blubber; I3, Subdermal connective tissue; M1, Multifidus muscle; M2, Semispinalis muscle; M3, Longissimus dorsi muscle; M4, Superficial tendon; M5, Deep tendon; M6, Rectus abdominis muscle; M7, Hypaxialis lumborum muscle; M8, Iliocostalis muscle; M9, Spinalis muscle; M10, Intertransversarii dorsalis muscle; M11, Medial tendon; M12, Extensor caudae medialis muscle; M13, Extensor caudae lateralis muscle; M14, Intertransversarii ventralis muscle; M15, Abdominis muscles; M16, Ischiocaudalis muscle; O1, Vertebral body; O2, Rib; O3, Sternum; O4, Sternal rib; O5, Pelvic bone; O6, Chevron bone; R1, Caudal left lung; R2, Caudal right lung; U1, Cranial pole of kidney; U2, Mid pole of kidney; U3, Caudal pole of kidney; U4, Genital slit; U5, Penis; U6, Testis; U7, Urinary bladder; U8, Preputial pouch; U9, Corpus cavernosum; U10, Uterus; U11, Cervix; U12, Umbilical scar; U13, Anal tonsils.

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