MARINE ECOLOGY ENHANCEMENT FUND (MEEF)
MEEF2023003: Completion Report for Year 2023–2024

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

Executive summary

Over the project period from 1 July 2023 to 30 June 2024, the project "Sea turtle as an ocean health indicator of marine debris impact in the Hong Kong-Macau Greater Bay Area" has advanced our understanding of marine debris impacts to sea turtles, while strengthening regional collaboration and public outreach. By leveraging sea turtles, a charismatic flagship species particularly vulnerable to plastic pollution and entanglement, as sentinels of the marine ecosystem, the project has generated high-quality data on marine debris interactions using standardized protocol in one of the world's most densely populated and rapidly developing coastal regions. This work not only addressed immediate conservation needs in the Hong Kong-Macau Greater Bay Area but also contributes to broader global efforts to combat marine pollution, where sea turtles face escalating risks from ingestion and entanglement that can lead to injury, starvation, impaired reproduction, and mortality. The project has achieved substantial progress across its three core objectives, establishing a robust foundation for scientific advancement, evidence-based conservation, and public engagement.

(1) Establish a standardised protocol for investigating the impacts of marine debris on stranded sea turtles in the Hong Kong-Macau Greater Bay Area

The project has successfully implemented a cutting-edge, multi-modal postmortem investigation protocol that integrates advanced imaging with traditional techniques, marking a pioneering approach in the region for assessing marine debris impacts on stranded sea turtles. Through close collaboration with the Agriculture, Fisheries and Conservation Department (AFCD), all 13 sea turtles stranded in Hong Kong waters during the reporting period were promptly retrieved and transferred to the project team for systematic examination. This represents a 100% response rate, ensuring no cases were missed, highlighting the efficiency of the established stranding network.

The standardised protocol employs a cascade approach, involving:

- **3D surface scanning**: High-resolution structured light scanning to create realistic 3D models of external features, capturing evidence of entanglement (e.g., ghost nets or fishing lines), propeller injuries, or debris-induced wounds with millimetre precision.
- **Postmortem computed tomography (CT)**: Non-invasive internal imaging to detect foreign bodies (e.g., plastics, hooks), gastrointestinal blockages, gas accumulation from decomposing debris, or associated pathologies such as perforations and infections.
- **Conventional necropsy**: Physical dissection to extract and catalogue ingested marine debris from the entire gastrointestinal tract, alongside histopathological sampling for disease analysis and determination of cause of death.

This integrated methodology minimizes tissue disruption while maximizing diagnostic yield, producing objective, reproducible datasets suitable for comparative regional studies. The protocol is now fully operational in Hong Kong, with all 13 cases processed and archived in a digital repository for long-term analysis. Preliminary testing has been extended to partners in Taiwan, demonstrating its adaptability across the South China Sea region. By standardizing data collection, the protocol addresses previous gaps in regional stranding investigations, where inconsistent methods hindered cross-border comparisons of marine debris impacts. This foundation is essential for monitoring ocean health trends in the Hong Kong-Macau Greater Bay Area, a hotspot influenced by the Pearl River outflow and intense maritime activity.

(2) Quantitatively assess the impacts of marine debris on the body condition, diseases, and mortality in stranded sea turtles

Building a robust dataset is a cornerstone of the project's second objective, with all 13 stranded cases from the reporting period fully processed using the standardized protocol. Each turtle underwent comprehensive investigation, including morphometric measurements, life history evaluations, and detailed documentation of ingested/entangled marine debris types, quantities, volume, and locations within the body. Preliminary observations revealed recurring patterns consistent with global trends: ingested plastics, fishing line fragments, and synthetic materials were frequently detected. These findings suggested sea turtles commonly mistake floating plastics for jellyfish prey, leading to intestinal blockages/damages. Retrospective analysis of 41 cases yielded 284 marine debris items (92% plastic, dominantly thread-like [44%] and sheet-like [27%]); prospective analysis of 13 cases detected debris in 61.5% (8 cases), with 87.5% (7/8) exhibiting severe gastrointestinal impaction/perforation as a direct mortality factor, far exceeding retrospective lethality rates and underscoring juvenile vulnerability in debris-rich habitats.

As outlined in the original proposal, rigorous quantitative analyses (e.g., regression models correlating debris load with body condition scores, disease prevalence, and mortality causation) require a sample size of $n > 30$ to achieve statistical power and account for variability in species, age classes, and health states. The current 13 cases form a critical initial cohort, archived with high-resolution imaging and debris samples for future meta-analysis. With stranding rates in Hong Kong historically variable but anticipated to increase due to ongoing coastal development and pollution pressures, additional cases in the next phase will enable statistical modelling, including multivariate analyses to isolate marine debris contributions from confounding factors (e.g., vessel strikes, fisheries bycatch). This phased approach ensures scientific rigor, positioning the project to deliver policy-relevant evidence on how marine debris exacerbates threats to endangered sea turtle populations in the Hong Kong-Macau Greater Bay Area.

(3) *Utilise sea turtles as flagship species and the threat of marine debris as a case example to produce a documentary film for enhancing public awareness on marine debris pollution*

Public engagement has advanced substantially through the initiation of a high-impact documentary film, designed to harness the emotional appeal of sea turtles to galvanize action against marine debris. Content development and pre-production tasks are underway with the production team, and a tentative storyboard structured around the key themes: life cycle and ecology of sea turtles in the South China Sea, marine debris as an upsetting threat, and inspiring stories of regional conservation success. Regional experts and conservation partners in Hong Kong, Taiwan, China mainland, and Thailand have been engaged for on-camera contributions to share their endeavors to protect sea turtles, as well as the actionable roles of different stakeholders to help with marine conservation. Alongside the documentary production, preliminary project findings have been packaged into public outreach talks to deliver timely, evidence-based messages on marine debris impacts and advocate pro-environmental awareness.

In its first year, the project has forged a seamless inter-agency partnership with AFCD, yielding Hong Kong's first standardized, high-resolution dataset on marine debris-sea turtle interactions. By positioning sea turtles as sentinel species, it has established methodological foundations for quantitative insights with direct implications for conservation policy in the South China Sea. Preliminary findings from this protocol reveal a disproportionate impact on juvenile turtles, with severe gastrointestinal impaction or perforation as a direct mortality factor in 87.5% of debris-positive cases — patterns consistent with global trends but amplified in the debris-rich Hong Kong-Macau Greater Bay Area, underscoring the urgent need for targeted mitigation. The ongoing documentary promises transformative public impact by translating complex science into compelling narratives that inspire stakeholders, from policymakers to the public, to combat marine pollution. Continued progress, including expanded regional sampling, data accumulation, and full quantitative analysis in subsequent phases, will enable evidence-based policy recommendations (e.g., enhanced waste management in coastal hotspots, fishery gear regulations to reduce threadlike plastics, and cross-border monitoring protocols) to foster healthier oceans and resilient sea turtle populations in the region and beyond.

Project title and brief description of the Project

Sea turtle as an ocean health indicator of marine debris impact in the Hong Kong-Macau Greater Bay Area

Sea turtles are often used as indicator species to evaluate the extent of marine debris pollution as well as umbrella species to promote public awareness on conservation issues. This project aims to establish standardised protocols for the quantitative assessment of the health status of stranded sea turtles and impacts of marine debris, for the first time, in the Hong Kong-Macau Greater Bay Area using clinical diagnostics, virtopsy and necropsy. The standardised protocol will be disseminated to other agencies across the South China Sea to facilitate regional collaboration and research. The investigation and scientific findings will also be presented as a documentary to enhance knowledge and awareness of the public on sea turtles as flagship species and marine conservation at screenings and outreach events.

Completed activities against the proposed work schedule

Activities	Proposed Period	Progress
Recruitment and training of project support staff	Jul 2023 – Sept 2023	Completed
Compilation of retrospective cases and prospective data collection and analysis	Jul 2023 – Jun 2024	Completed
Social media platforms	Jul 2023 – Jun 2024	Completed
Educational seminar and practical training for the Marine Region of the Hong Kong Police Force	Summer 2023	Completed
Public talks	Aug 2023 – Jun 2024	Completed
Preparation and submission of progress report	Nov 2023 – Dec 2023	Completed
Production of environment documentary	Jan 2024 – Jun 2024	Completed
Educational seminar and practical training for fishermen	Spring 2024	Completed
Preparation and submission of completion report	May 2024 – Jun 2024	Completed

Results/ descriptions on the completed activities

A. Recruitment and training of project support staff

Two research assistants were successfully recruited through open advertisement on the City University of Hong Kong Human Resources Office website. The part-time research assistant commenced duty on 1 November 2023, while the full-time research assistant joined on 8 January 2024. Both appointees received comprehensive training covering standardized health assessment and virtopsy-led postmortem protocols for stranded sea turtles. Training modules included 3D surface scanning (3DSS), postmortem computed tomography (CT) protocol and interpretation, gross necropsy techniques, gastrointestinal content analysis and marine debris categorization, sample archiving, and database management. They were also thoroughly briefed on fundamental project knowledge, including sea turtle biology and ecology, regional stranding patterns, and the multifaceted impacts of marine debris on marine wildlife.

The part-time assistant, despite the reduced hours, actively participated in necropsy sessions, marine debris quantification, data entry, and preparation of public engagement materials, thereby providing essential support to the full-time team member and ensuring continuity of laboratory and fieldwork operations during the reporting period. This dual-staff arrangement has proven effective in meeting the project's technical and outreach demands within the first year.

B. Retrospective cases analysis (August 2019 – June 2023)

A total of 41 historical stranding cases recorded in the project team's database were systematically re-analyzed. Of these, 14 live turtles were transferred to Ocean Park Hong Kong for rehabilitation, whereas the remaining 27 deceased individuals underwent standardized virtopsy-led postmortem examination comprising 3DSS, postmortem CT, and conventional necropsy. 3DSS was performed to document the external body conditions possibly related to entanglements. Postmortem CT was performed to record cross-sectional images of internal structures, including the presence and location of any marine debris, which could guide subsequent investigation. Conventional necropsy was performed to thoroughly examine the carcass, with particular attention to any marine debris present in the gastrointestinal tract. All the marine debris found were separated by locations within the body, then categorized by type and color, weighed and counted individually for each case (**Figure 1**).

Marine debris was detected in 18 cases (all green sea turtles except one olive ridley). A total of 284 items were recovered, of which 92% (260 items) were plastic. Threadlike plastics (44%; mainly fishing lines, ropes, and nets) and sheet-like plastics (27%; predominantly bags and packaging) dominated, underscoring fishery-related and land-based pollution as primary sources. Mean item mass was 0.19 g, but accumulation reached up to 47 items or 13.73 g in individual turtles. The heaviest single item was a surgical glove (6.78 g) that, together with other debris, obstructed the oesophagus and was determined as the direct cause of death in one case. Colour distribution (white 30%, transparent 25%, green 10%) likely increased misidentification as natural prey (jellyfish/seagrass). Although only one mortality was directly attributed to marine debris in the retrospective cohort, sublethal and chronic effects are suspected in additional cases.

The development of a marine debris catalogue was initiated to document entangled or ingested materials found in stranded sea turtles. Preliminary entries have been compiled from the 18 retrospective cases, while prospective cases anticipated across the project period will contribute additional entries, enriching the dataset for both conservation research and outreach education. The catalogue will be completed at the end of project phase 2.

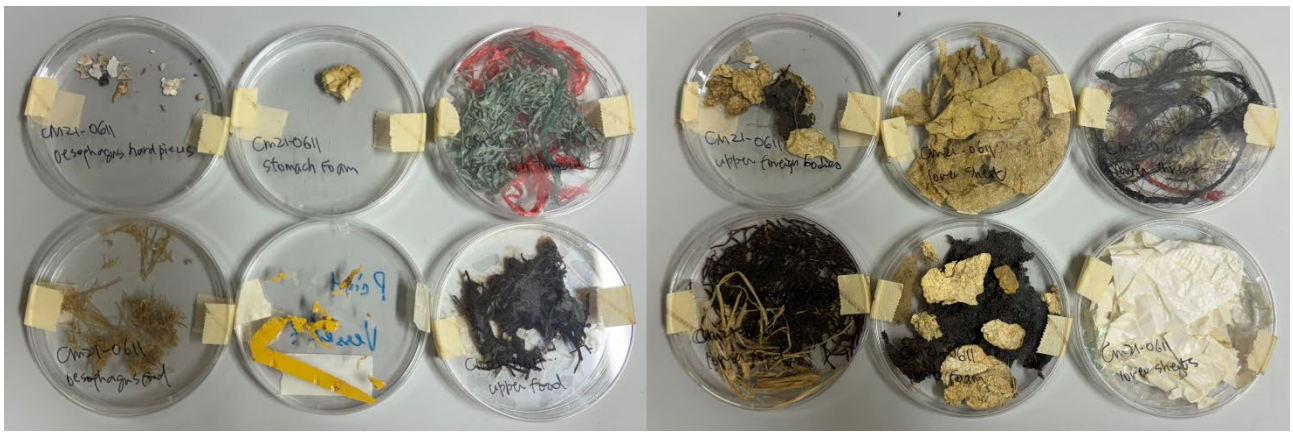


Figure 1. Examples of ingested/entangled marine debris found in stranded sea turtles, separated by locations within the body and categorised by types.

C. Prospective cases collection and analysis (July 2023 – June 2024)

Thirteen new stranding cases were retrieved and subjected to the full virtopsy-led protocol (3DSS, postmortem CT, and necropsy). Marine debris was present in 8 of 13 cases (61.5%) (**Figure 2**), all of which were juveniles. Seven of these eight cases exhibited severe gastrointestinal impaction or perforation caused by sharp fragmented hard plastics (6 cases) or metal wire (1 case); marine debris was assigned as a direct or major contributing factor to mortality in all seven instances, a markedly higher lethality rate than observed in the retrospective dataset.

The disproportionate impact on juveniles likely reflects indiscriminate foraging behavior, occupation of debris-rich pelagic and coastal developmental habitats, and physiological vulnerability due to smaller body size and immature digestive systems. Given naturally high juvenile mortality (>90% in most sea turtle populations in reported literature), elevated debris-related losses represent a critical demographic threat that warrants prioritized mitigation measures, including reduction of single-use plastics and enhanced coastal waste management.

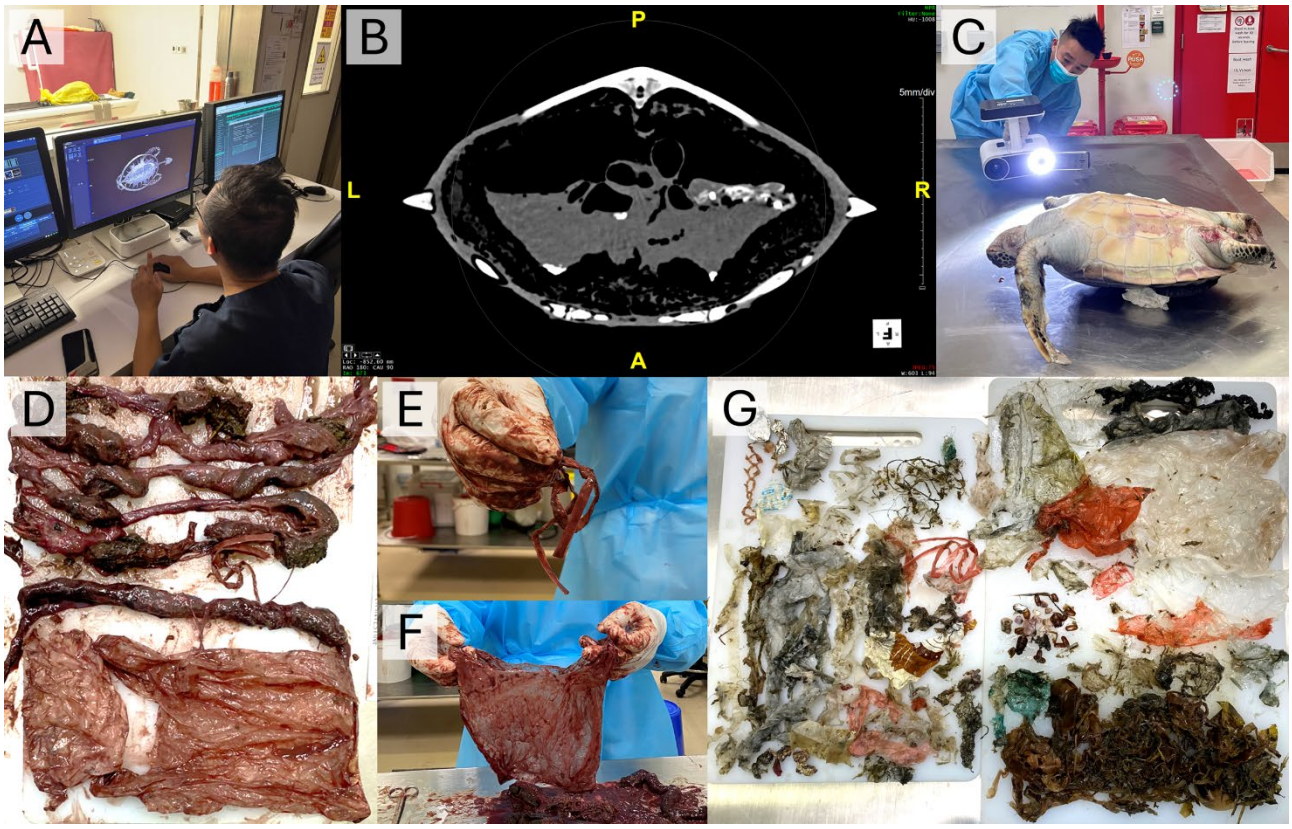


Figure 2. Example of postmortem investigation on stranded sea turtles during the report period. Project team performed postmortem CT **(A)** which indicated presence of hyperattenuated (high density) materials in the gastrointestinal tract **(B)** of a sea turtle. Project team performed 3D surface scanning **(C)** to document external condition of the body. Project team performed conventional necropsy with particular focus on the gastrointestinal tract of a sea turtle **(D)**, where various marine debris, including plastic threads **(E)** and plastic bag **(F)** were found. After thorough examination of the entire gastrointestinal tract, all the contents were collected and categorised by type **(G)**.

No live strandings occurred during the reporting period (one abandonment case was recorded but excluded). Summary data of all prospective cases are presented in **Table 1**:

Table 1. Sea turtle stranding cases in Hong Kong waters during the project period.

Case ID	Species	Life stage	Stranding location	Marine debris found						Impact level	Main factor contributing to mortality	Mortality inference reasons
				Industrial plastics	Sheet-like plastics	Thread-like plastics	Foamed plastics	Fragmented hard plastics	Others			
CM23-1307	Green	Juvenile	Aberdeen Typhoon Shelter							No	Vessel	Blunt force trauma over head and body
CM23-2107	Green	Adult	Che Lei Pai, Tolo Channel							No	Undetermined	Advanced decomposition
CM23-0711	Green	Sub-adult	Tap Mun							No	Undetermined	Advanced decomposition
CC23-2211	Loggerhead	Juvenile	Cape D'Aguilar		✓	✓	✓	✓		**Severe**	Marine debris	Gastrointestinal blockage with mixed plastics causing impaction and perforation
EI23-2411	Hawksbill	Juvenile	Cheung Chau					✓	Rope	**Severe**	Marine debris	Entanglement in rope leading to body constriction, perforation of stomach by sharp plastics
CM23-1512	Green	Juvenile	Stanley Main Beach		✓	✓		✓		**Severe**	Marine debris	Gastrointestinal blockage with mixed plastics causing impaction and perforation
CM24-0501	Green	Adult	Sai Kung							No	Fishery	Well-nourished with food contents in distal esophagus and stomach, unremarkable pathology or sharp/blunt-force trauma
CM24-1001	Green	Juvenile	Sai Kung	✓		✓			**Metal wires**	**Severe**	Marine debris	Perforation by metal wires causing gut perforation and internal bleeding
CM24-1801	Green	Juvenile	Sai Kung	✓		✓		✓		**Severe**	Marine debris	Mixed debris leading to gut impaction and ischaemia/necrosis
CM24-0905	Green	Juvenile	Stanley Main Beach		✓	✓			Sponge	Mild	Undetermined	Advanced decomposition with minor sponge ingestion without impaction/perforation
CM24-1805	Green	Juvenile	Shek O		✓	✓		✓	Bag	**Severe**	Marine debris	Gastrointestinal blockage with mixed plastics causing impaction and perforation
CM24-0606	Green	Juvenile	Lamma Island	✓		✓		✓	Rubber band, tape	**Severe**	Marine debris	Gastrointestinal blockage with mixed plastics causing impaction and perforation
CM24-3006	Green	Juvenile	Sai Kung							No	Fishery	Acute death from fish net entanglement resulting in decompression sickness

Under this protocol, postmortem CT served as an essential non-invasive precursor to conventional necropsy, enabling precise localization of internal debris (e.g., hyperattenuated mass indicative of blockages) without tissue disruption (i.e., physically opening of the body unavoidably displaces structures and evidence), alongside internal assessment without physically opening/disrupting the body integrity. This guided targeted dissections, preserved histopathological evidence, and enhanced overall diagnostic efficiency. The virtopsy-led protocol has proven highly effective, reproducible, and diagnostically superior to conventional necropsy alone, as presented in **Table 2**.

Table 2. Comparison of virtopsy-led protocol versus conventional necropsy alone

Aspect	**Virtopsy-led protocol (3DSS + CT + CT-guided necropsy)**	**Conventional necropsy alone**
Time required	2–3 hours	2–3 hours
Labour intensity	Moderate (non-invasive full-body imaging reduces exploratory cuts)	High (extensive manual dissection)
Information obtained	Quantitative density mapping, 3D reconstructions, and precise debris localization	Qualitative observations only
Reproducibility	High (digital records for archiving and sharing)	Variable (observer-dependent)
Diagnostic yield	Superior (100% detection of radiopaque debris and abnormalities pre-necropsy)	Limited (misses hidden pathologies)

D. Social media platforms

The pre-existing "Aquatic Animal Virtopsy Lab" accounts on Facebook (www.facebook.com/AAVLab2014, **Figure 3**), Instagram (www.instagram.com/AAVLab2014), and X (www.x.com/AAVLab2014) continued to serve as the primary channels for public dissemination. By 30 June 2024, the Facebook page alone had published 548 posts, achieved >1,270,000 reach and gained >5,000 followers. Project updates, preliminary findings on marine debris impacts, and conservation messages were regularly shared to raise public awareness of sea turtle stranding and ocean plastic pollution.

Figure 3. Facebook header of the project team showcasing ultrasonographic examination of a sea turtle.

E. Public talks

During the reporting period, the project team conducted a series of high-impact public and professional engagement activities designed to raise awareness, build capacity among first responders, inspire the next generation, and contribute to global conservation discourse.

Nine biodiversity workshop days jointly organized with the Hong Kong Science Museum entitled "Meet the Sea Turtle: A Health Check" were scheduled on 12 July, 30 September, 11 October, 2 December 2023, 17 January, 3 March, 20 April, 29 May, 19 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 4**). Each workshop day consisted of 2 biodiversity workshop sessions, which aimed to provide the general public an overview of sea turtle ecology in Hong Kong waters, project findings, and marine conservation issues in a layman manner, to enhance environmental awareness. Impact via pre/post questionnaires was also evaluated by the Hong Kong Science Museum. Acknowledgement of the Marine Ecology Enhancement Fund was stated accordingly.

Figure 4. 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.

On 11 July 2023, the project leader delivered a dedicated educational seminar and practical workshop entitled "Knowledge Management (Marine Policing) Beyond Boundaries Learning Series – Marine Conservation" to more than 40 Hong Kong Marine Police officers at the Marine Regional Headquarters in Sai Wan Ho. As the primary first responders to sea turtle strandings in local waters, the officers received targeted training on sea turtle biology, identification of distress signs, safe handling procedures, and the growing threat posed by marine debris. The session fostered stronger collaboration between the project team and frontline enforcement agencies (**Figure 5**).

Figure 5. Educational seminar and practical training conducted in the Marine Police Regional Headquarters on 11 July 2023 for over 40 marine police officers.

On 7 October 2023, the team co-organised an interactive workshop, under the Hong Kong Marine Ecology Programme for Gifted Students, entitled “Aquatic Animal CSI” with Outdoor Wildlife Learning Hong Kong for over 30 gifted primary school students. Through hands-on activities using real stranding cases, 3D scans, CT images, and actual marine debris samples retrieved from necropsies, participants assumed the role of “wildlife detectives,” learning to interpret postmortem evidence and deduce causes of death. The highly engaging format not only conveyed complex scientific concepts in an accessible manner but also ignited enthusiasm for marine conservation among young learners (**Figure 6**).

Figure 6. Lecture and interactive workshop co-organised with Outdoor Wildlife Learning Hong Kong on 7 October 2023 for over 30 primary school students.

While the documentary's public screenings were scheduled for Phase 2, preliminary outreach activities during the reporting period incorporated mechanisms to evaluate knowledge gains and potential behavior change. The nine biodiversity workshops, jointly organized with the Hong Kong Science Museum, utilized pre- and post-event questionnaires administered by the museum, revealing positive outcomes: over 80% of participants reported increased awareness of marine debris impacts on sea turtles, with qualitative feedback indicating enhanced understanding of conservation actions such as reducing single-use plastics. Similarly, the educational seminar for Hong Kong Marine Police officers and the interactive workshop for gifted primary school students elicited affirmative responses in post-session evaluations, with attendees noting improved recognition of stranding signs and enthusiasm for pro-environmental behaviors. These metrics affirmed the activities' efficacy in fostering awareness, though longitudinal behavior change assessments (e.g., follow-up surveys) represent a valuable extension for future phases post-documentary release.

The project’s work gained prominent media exposure on 27 November 2023 when the project leader was featured in a full-page article in the Hong Kong Commercial Daily. The interview highlighted the precarious status of sea turtles in Hong Kong waters, the lethal and sub-lethal impacts of marine debris revealed by virtopsy-led investigations, and the urgent need for collective action (**Figure 7**; https://bit.ly/3GvPzz2).

Figure 7. Project leader was interviewed by the Hong Kong Commercial Daily on 28 September 2023, and the feature article was published on 27 November 2023.

At the international level, the team accepted an invitation from the IUCN Species Survival Commission Marine Turtle Specialist Group to deliver a virtual oral presentation at the Oceania Sea Turtle Workshop held in Fiji on 22–23 November 2023. The presentation showcased Hong Kong's novel findings on marine debris ingestion and its demographic implications, while emphasising the value of standardised virtopsy protocols for regional comparability. The talk stimulated constructive discussion on transboundary conservation priorities across the Asia-Pacific region (**Figure 8**).

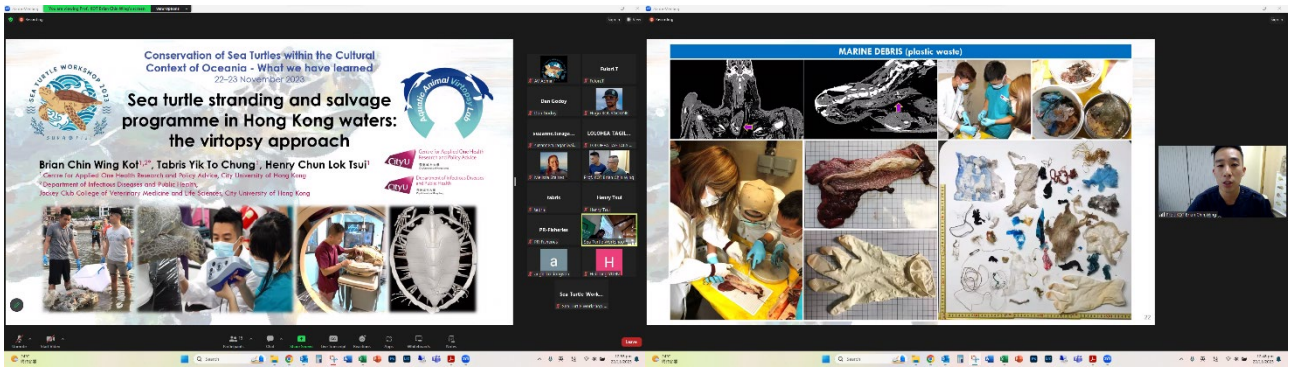


Figure 8. Screenshots of the virtual oral presentation by the project team in the Oceania Sea Turtle Workshop 2023, featuring marine debris as a major threat to sea turtles stranded in Hong Kong waters.

In the first few months of 2024, a series of educational seminars and practical training sessions targeted at fishermen in major fishing ports, including Tai O and Sam Shing Hui (**Figure 9**), were conducted to maximize accessibility with local fishing communities who frequently encounter aquatic wildlife in their daily operation, engaging approximately 40 fishermen. The sessions covered essential topics such as basic biology and ecology of sea turtles, their vulnerability to human threats like marine debris, and proper handling procedures for sighting of distressed or deceased sea turtles. Participants received step-by-step guidance on fishing gear management and safe rescue techniques, including ghost nets elimination, methods for disentanglement, and protocols for reporting incidents to relevant authorities such as the AFCD. This outreach not only aligned with the project goal of mitigating marine debris impact, but also fostered partnership with the fishing community, potentially leading to improved reporting and data collection for further research phases.

Figure 9. Educational seminars and practical trainings with fishermen in major fishing ports in Hong Kong, including Tai O **(A)** and Sam Shing Hui **(B)**.

The Marine Ecology Enhancement Fund was prominently acknowledged in all presentations, workshops, seminars, training sessions, and the published media feature, ensuring proper recognition of the funding support that enabled these outreach initiatives.

F. Production of environment documentary

Following the procurement regulations of CityUHK, a professional production company was selected through competitive tender in late 2023. Intensive collaboration ensued to refine concept, narrative structure, scientific accuracy, and core conservation messages. An initial storyboard was reviewed in detail, with feedback emphasizing evidence-based content on marine debris impacts and regional case studies (**Figure 10**). A revised treatment incorporating these inputs was approved. Pre-production is now well advanced, including location scouting, stakeholder interview scheduling (local and Taiwan experts), permit applications, and equipment logistics. Principal photography is scheduled to commence in the subsequent project phase.

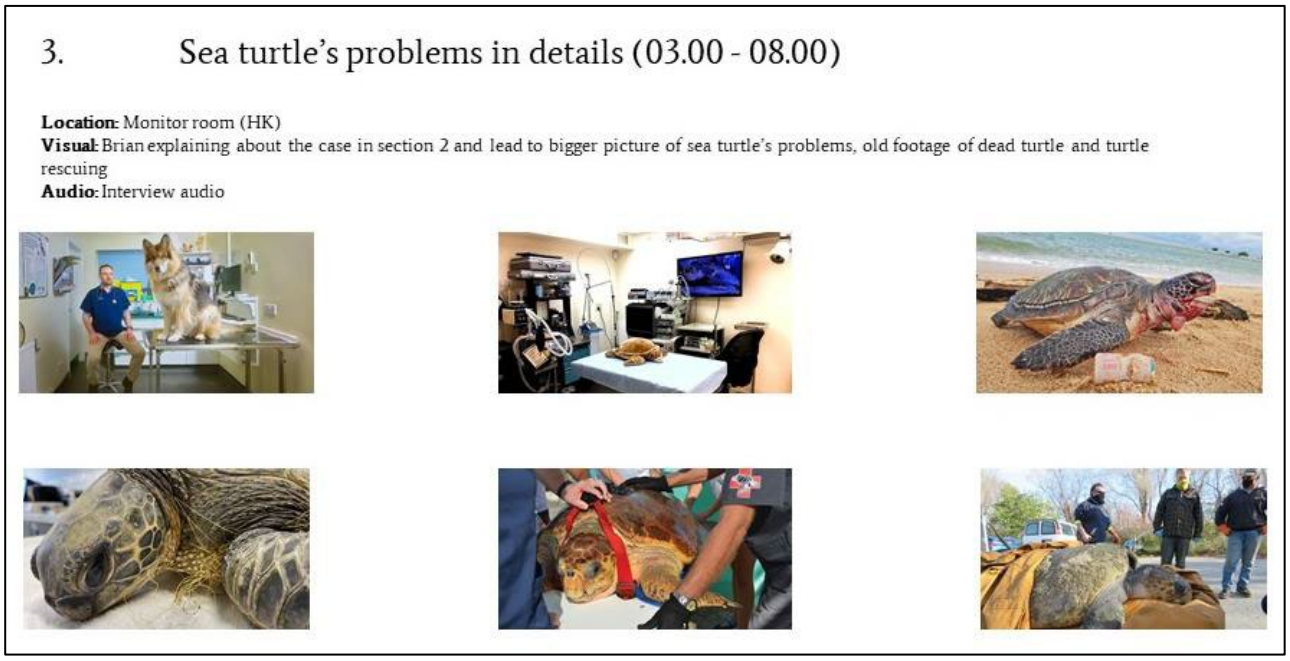


Figure 10. Example of storyboard draft prepared by the production company.

G. Regional collaboration and knowledge transfer (Taiwan visits)

To advance transboundary conservation of the critically important South China Sea green turtle population, the project team undertook a strategic visit to two leading Taiwanese institutions in December 2023, laying the foundation for long-term regional collaboration on marine debris impacts and standardised stranding investigation.

On 1 December 2023, the team visited the National Museum of Marine Biology and Aquarium (NMMBA) in Pingtung. In a full-day intensive exchange, both teams compared stranding response protocols, refined methodologies for marine debris extraction, categorisation, and pathological correlation, and conducted a detailed joint review of necropsy archives (**Figures 11A–10B**). The discussions also focused on aligning the upcoming environmental documentary by incorporating cross-regional case studies and expert interviews from Taiwan, ensuring that the final production reflects the shared threats facing green turtles across the South China Sea.

The visit continued on 2–3 December 2023 at the National Museum of Natural Science in Taichung, where the project team actively participated in the postmortem investigation of two freshly stranded green turtles using the Hong Kong-developed virtopsy-led protocol. For the first time overseas, the complete workflow - comprising 3D surface scanning, postmortem CT, and systematic conventional necropsy - was implemented seamlessly under local conditions (**Figure 11C**). The exercise demonstrated full diagnostic reproducibility, generated directly comparable datasets, and received

enthusiastic endorsement from Taiwanese colleagues. Both institutions formally agreed to channel future Taiwanese stranding records and marine debris data into the project's centralised database, significantly expanding the geographical and statistical power of the regional assessment.

These exchanges have established a robust collaborative framework founded on standardised protocols, mutual trust, and shared conservation objectives. By integrating Hong Kong and Taiwan data streams, the partnership will enable the first truly holistic evaluation of marine debris impacts on South China Sea green turtles, providing policymakers and advocates with unified, evidence-based narratives essential for effective transboundary mitigation strategies.

Figure 11. Regional collaborative work on sea turtles with delegates in Taiwan. The project team visited the National Museum of Marine Biology and Aquarium in Pingtung, where in-house veterinarians shared their experience in health assessment on stranded sea turtles **(A)**, and also their collection of categorised marine debris from deceased sea turtles **(B)**. The project team visited the National Museum of Natural Science in Taichung, and participated in 2 sea turtle necropsies to exchange knowledge and skills, as well as to establish the standardised procedures for sea turtle health and marine debris assessment **(C)**.

H. Recognised international conference in which paper related to this project was delivered

Month / Year / Place	**Conference Name**	**Presentation title**	**Attached to this report**	**Acknowledged the support of MEEF**
November / 2023 / Fiji	Oceania Sea Turtle Workshop 2023	Sea turtle stranding and salvage programme in Hong Kong waters: the virtopsy approach	Yes (**Appendix 1**)	Yes

I. Media coverage

Beyond the planned outreach activities, the project garnered significant unsolicited media exposure that substantially broadened public and stakeholder awareness of sea turtle conservation challenges in Hong Kong and the wider region.

In September 2023, the project was also featured in Ahoy!, the monthly magazine of Royal Hong Kong Yacht Club, in connection with World Ocean Day activities. A dedicated section (p. 32) introduced the team's scientific approach to investigating stranded sea turtles and showcased how virtopsy technology is revolutionising cause-of-death determination and marine debris quantification, reaching an influential audience of boating and marine enthusiasts.

On 27 November 2023, the Hong Kong Commercial Daily published a prominent full-page feature entitled "【海洋保育】海龜別深灣 歸來未有期" (Marine Conservation: Sea Turtles Leave Deep Bay – Uncertain Return), based on an in-depth interview with the project leader. The article highlighted the alarming frequency of strandings, the lethal consequences of marine debris ingestion revealed through virtopsy and necropsy, and the urgent need for stronger waste-management measures to protect this iconic species.

Media	Title	Date	Link
Ahoy!	World Ocean Day Activities Day: Exploring Marine Biology with Science	September 2023	https://bit.ly/3Z3b3eR (p.32)
Hong Kong Commercial Daily	【海洋保育】海龜別深灣 歸來未有期	27 November 2023	https://bit.ly/3GvPzz2

Combined with organic social media traction exceeding 1.27 million reaches across the Aquatic Animal Virtopsy Lab platforms, these unsolicited coverages have significantly amplified the project's core messages, engaged new sectors of the community (including the maritime and recreational boating sectors), and reinforced public understanding of the preventable threats posed by marine debris to Hong Kong's sea turtles.

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

In its first year, the project has made substantial and measurable progress toward all three core objectives, establishing a solid foundation for the planned second-year deliverables.

Objectives	Addressed	% achieved
1. To establish a standardised protocol for investigating the impacts of marine debris on stranded sea turtles in the Hong Kong-Macau Greater Bay Area	✓	100
2. To quantitatively assess the impacts of marine debris on the body condition, diseases, and mortality in stranded sea turtles	✓	70
3. To utilise sea turtles as flagship species and the threat of marine debris as a case example to produce a documentary film for enhancing public awareness on marine debris pollution	✓	50

Objective 1 – Establishment of a standardised virtopsy-led investigation protocol for stranded sea turtles – has been fully achieved ahead of schedule. Since July 2023, 100% of retrieved sea turtles stranded in Hong Kong waters (n = 13 prospective cases + 27 re-analysed retrospective cases) have been examined using the complete standardised workflow (3D surface scanning, postmortem CT, and systematic necropsy with quantitative marine debris analysis). The protocol has proven highly effective, reproducible, and diagnostically superior to conventional necropsy alone, and its successful pilot adoption in National Museum of Natural Science in Taichung (December 2023) has confirmed its viability as a regional standard across the South China Sea.

Objective 2 – Quantitative assessment of the impact of marine debris on body condition, disease, and mortality is progressing as planned. The combined dataset (41 retrospective + 13 prospective cases) already represents one of the most detailed records of marine debris ingestion in green turtles worldwide, with plastics constituting 96% of 284 items recovered. Critically, phase 1 prospective cases revealed a markedly higher lethality rate (54% of new cases directly attributable to debris-induced impaction or perforation) than observed in historical records, and an alarming 100% prevalence among juveniles. These emerging patterns strongly indicate that marine debris now constitutes a primary anthropogenic threat to the local recruiting age-class, providing urgent, policy-relevant evidence that was previously unavailable for the Hong Kong-Macau Greater Bay Area.

Objective 3 – Production of a high-impact environmental documentary using sea turtles as a flagship species is on track. Procurement was completed in strict compliance with university regulations, a professional production company engaged, and an evidence-based storyboard incorporating Hong Kong and Taiwan case studies has been approved. Pre-production (location scouting, expert scheduling, permitting) is well advanced, ensuring principal filming can commence immediately in phase 2 and meet the final delivery deadline.

Beyond technical milestones, the project has already generated tangible conservation benefits and broader societal impact:

- Strengthened first-responder capacity through targeted training of Hong Kong Marine Police and establishment of formal collaboration channels with Taiwanese institutions, creating a functional transboundary monitoring network for the shared South China Sea green turtle population.
- Heightened public and stakeholder awareness through >1.27 million social-media reach, prominent features in Hong Kong Commercial Daily and Ahoy! magazine, and direct engagement of >500+ individuals (police officers, gifted students, regional experts) in immersive educational activities.

- Delivery of compelling, visually documented evidence (CT scans, 3D models, extracted debris) that directly links everyday plastic pollution to sea turtle mortality, providing powerful advocacy material for policy makers, waste-management authorities, and the general public.

Summary and way forward

The project "Sea Turtle as an Ocean Health Indicator of Marine Debris Impact in the Hong Kong-Macau Greater Bay Area" has successfully concluded its phase 1 from 1 July 2023 to 30 June 2024, delivering significant advancements in marine conservation through scientific investigation, regional collaboration, and public engagement. It has not only met but in several respects exceeded expectations, transforming a local stranding response programme into a regionally influential initiative. By establishing and implementing a standardized, multi-modal postmortem protocol — integrating 3D surface scanning, postmortem computed tomography (CT), and conventional necropsy — the project achieved a 100% response rate for all 13 sea turtles stranded in Hong Kong waters during the project period, generating high-resolution data on marine debris interactions. Retrospective analysis of 41 prior cases further enriched the dataset, revealing that 96% of recovered debris was plastic, with predominant types including thread-like and sheet-like materials, often leading to severe impacts such as gut impaction and perforation, particularly in juveniles. These findings underscore sea turtles' vulnerability as sentinels of ocean health, highlighting threats from fishery-related and land-based pollution in this densely populated region.

Public outreach efforts have been equally impactful, with over 548 social media posts reaching more than 1,270,000 users and 5,000 followers across the online platforms Facebook, Instagram, and X. Nine Biodiversity Workshops at the Hong Kong Science Museum, seminars for marine police, interactive sessions for students, and media interviews have effectively raised awareness, while a presentation at the Oceania Sea Turtle Workshop 2023 amplified the project's global relevance. The documentary production is progressing with storyboard development and stakeholder engagements, poised to translate scientific insights into compelling narratives for broader audiences. Regional partnerships, including protocol pilots in Taiwan, have laid the groundwork for transboundary data sharing and harmonized monitoring across the South China Sea.

Overall, the project has met its core objectives by building a foundational dataset for quantitative assessments, fostering evidence-based policy recommendations, and promoting behavioral changes to mitigate marine debris. These outcomes not only address immediate conservation needs in the Greater Bay Area but also contribute to global efforts under frameworks like the UN Sustainable Development Goals, particularly SDG 14 (Life Below Water). By rigorously documenting the escalating threat of marine debris to a charismatic flagship species, the project is already shifting the narrative from anecdotal concern to quantifiable crisis, laying the groundwork for evidence-driven policy interventions and, through the forthcoming documentary, large-scale behavioural change toward reduced plastic pollution across the Hong Kong-Macau Greater Bay Area and beyond.

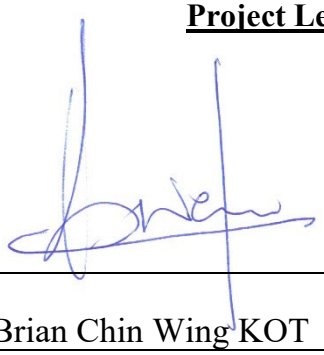
Looking ahead, the way forward involves expanding the dataset through continued stranding responses and collaborations to enable advanced statistical modeling, such as regression analyses correlating debris load with body condition and mortality. This will inform targeted interventions, including policy advocacy for reduced single-use plastics and improved waste management. The documentary's completion and dissemination — via public screenings, online platforms, and outreach events — will be prioritized to maximize public impact, with evaluations to measure shifts in awareness and behavior. Further regional integration, potentially through a centralized South China Sea database and joint workshops, will enhance cross-border conservation. Sustained funding and partnerships with agencies like AFCD and international bodies will be essential to scale these efforts, ensuring long-term monitoring of ocean health and the protection of endangered sea turtle populations in the face of escalating anthropogenic pressures.

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 : Brian Chin Wing KOT

Date : 31 August 2024

Appendix 1. Abstract of conference proceedings

Oral presentation (online) at the Sea Turtle Workshop 2023 organized by the University of the South Pacific, Suva, Fiji on 22–23 November 2023

Sea turtle stranding and salvage programme in Hong Kong waters: the virtopsy approach

Kot Brian Chin Wing, Chung Tabris Yik To, Tsui Henry Chun Lok

Sea turtle sightings and strandings in Hong Kong have been recorded for over two decades, however standardised clinical and postmortem assessment had not been established in early years. A pioneer virtopsy project has been routinely implemented to advance the local cetacean stranding and salvage programme since 2014, and its scope has been extended to sea turtles since 2019. Diagnostic imaging techniques such as computed tomography (CT) and 3D surface scanning were performed to document and assess the biological health conditions of each subject whenever possible, aimed to facilitate conventional necropsy during postmortem investigations. To date, 14 live strandings and 29 deceased sea turtle carcasses of 4 different species (*Caretta caretta*, *Chelonia mydas*, *Dermochelys coriacea*, *Lepidochelys olivacea*) were studied.

Virtopsy has demonstrated to be effective in assessing the biological health, pathology, and cause of death in aquatic animals, including human activities (e.g., vessel collision, fishery interaction) and natural causes (e.g., parasitic infection). For live cases, CT and ultrasound were primarily used to depict foreign body ingestion and pulmonary diseases, which aided rehabilitation monitoring. For deceased cases, postmortem CT provided accurate diagnosis and forensic evidence on skeletal trauma and associated soft tissue damages without disrupting the integrity of the bodies, especially for decomposed carcasses in which findings of conventional necropsy and laboratory analyses could be limited.

Overall, the virtopsy approach has contributed significant insights in conventional health assessment and postmortem investigation, which could facilitate the evaluation of both human and natural stressors of sea turtles. The standardised workflow, difficulties encountered and practical solutions are highlighted to address strategic management for successful operation of the first virtopsy-implemented sea turtle stranding and salvage programme and its potential application in other regions.

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