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28/1/24

Re: Hong Kong boat strike of a Bryde's/Eden's whale in July 2023

I have been asked by Dr NG Wai-chuen on behalf of the Director of Agriculture. Fisheries and Conservation to provide an expert opinion on the necropsy report of a whale boat strike in the waters of Sai Kung, Hong Kong. In preparing this report I have viewed the following:

Formal documents

1 The complete stranding data sheet, Ocean Park Conservation Foundation, Hong Kong, Examination dated 31 July 2023 (19 pages – Appendix II).

2 The complete Baleen whale necropsy form #OT233107M2, Examination occurring between 31/7/23 and 1/8/23 (33 pages - Annex I).

3 These included a series of selected sighting, scene and necropsy photographs.

PROFESSIONAL BACKGROUND

I am currently a Senior Specialist Forensic Pathologist at Forensic Science SA in Adelaide, Australia and held the Marks Chair of Pathology at The University of Adelaide from 2006 to 2023. I was awarded the title of Emeritus Professor by the University of Adelaide Council in 2023 for distinguished and sustained service to the University.

In November 2021 in the Australian National Research Awards I was named a world leader in forensic science and in 2022 was ranked as the top-rated expert (0.0012%) of 83,821 published authors internationally in the forensic sciences 2012-2022. (https://expertscape.com/ex/forensic+science - derived from the US National Library of Medicine "PubMed" database).

In 2013 I became an Officer in the Order of Australia (AO) for distinguished service to medicine in the field of forensic pathology and in 2016 was elected a Fellow of the Australian Academy of Health and Medical Sciences (FAHMS) for distinguished professional achievements and outstanding leadership in a field related to health and medicine. In 2018 I received the John Harbor Phillips Award from ANZPAA/NIFS (National Institute of Forensic Science) for outstanding achievement and excellence in the advancement of the forensic sciences in Australia and New Zealand.

I qualified in medicine in Australia in 1978 (University of Tasmania) and then undertook five years of clinical practice. This included Flying Doctor/Aeromedical work in the Northern Territory, Australia (NE Arnhem Land) and training and qualifying in family practice, as well as studying physical and medical anthropology at McMaster University, Hamilton, Canada. I am an alumnus of 6 universities: the University of Tasmania (Distinguished Alumnus), The University of Adelaide (Distinguished Alumnus), the University of South Australia (Australia), McMaster University, the University of Toronto and the University of Ottawa (Canada).

I have published over 1,000 chapters and papers/short communications/letters in peer-reviewed journals (>650 first authorships) and in 2020 was ranked in the top 2% of scientists worldwide by Stanford University and number two in the field of Legal and Forensic Medicine.
(https://www.researchgate.net/publication/345921476_Worlds_Top_2_Scientists_by_Stanford_University)

I have had more than 900 papers delivered at meetings, invited lectures/chairs and community presentations and have coedited/written 11 professional texts.

I was the Editor-in-Chief/Managing Editor of *Forensic Science Medicine and Pathology* (Springer Publishers, New York) from 2008 to 2021 and have been invited to give educational forensic workshops/presentations in a number of countries including Argentina, Austria, Canada, China, Croatia, Denmark, Finland, France, Germany, Hong Kong, Iceland, India, Indonesia, Israel, Italy, Japan, Kazakhstan, Malaysia, Myanmar, New Guinea, New Zealand, Norway, Portugal, Serbia,

Singapore, South Africa, Spain, Sri Lanka, Saudi Arabia, Switzerland, the Netherlands, the United Kingdom, the United States and Uruguay.

I have attended court or given expert opinion on cases from Australia, New Zealand, Papua New Guinea, Japan, Norway, Fiji, Samoa, Argentina, the United Kingdom and the United States, and have performed autopsies for medicolegal authorities in Australia, Canada, Indonesia, Germany, Samoa, Sri Lanka and Thailand.

In addition to my basic medical and other post graduate qualifications I have three higher doctorates: a Doctor of Philosophy (PhD), a Doctor of Medicine (MD) and a Doctor of Science (DSc). I was nominated in the Australian of the Year Awards for Tasmania for 2024.

My publications can be accessed through google scholar, PubMed and ResearchGate. My current publication parameters are summarised below:

Google Scholar h-index **=** 67 (top 3% globally)
Papers with ≥10 citations = 600 (top 3% globally)
Total citations = 23,497 (top 3% globally)

Research Gate Interest Score: 8,908 with > 525,000 reads (> 99% of all researchers).

SPECIFIC VETERINARY FORENSIC PATHOLOGY ACTIVITIES

I have performed forensic necropsies in conjunction with the South Australian Museum, the Royal Zoological Society of South Australia and the Australian Marine and Wildlife Research and Rescue Organization on a range of animal species including the Sumatran orang-utan (*Pongo abelii*), common chimpanzee (*Pan troglodytes*), Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), New Zealand fur seal (*Arctocephalus forsteri*), southern right whale dolphin (*Lissodelphis peronii*), short-beaked common dolphin (*Delphinus delphis*), pygmy sperm whale (*Kogia breviceps*), green sea turtle (*Chelania mydas*), Australian pelican (*Pelecanus conspicillatus*) and pied cormorant (*Phalacrocroax varius*).

I have also published a number of papers in the international literature on sea mammal injuries including two papers on propeller strikes [1,2]. I also examined the following thesis:

> Mauroo NF. Pathology and demographics of Indo-Pacific humpback dolphins (*Sousa chinensis*) and Indo-Pacific finless porpoises (*Neophocaena phocaenoides*) stranded in Hong Kong. PhD thesis, University of Hong Kong, Hong Kong, (External examiner), 2016

CASE SUMMARY

According to the above reports this immature male Bryde's/Eden's whale (*Balaenoptera edeni edeni*) had been observed swimming in the waters of Sai Kung

from the 13/7/23 until the 31/7/23 when it was found deceased. Two wounds considered likely to be due to propeller strikes were observed on 22/7/23 behind the dorsal fin. The whale had last been seen alive on the morning of 30/7/23. The necropsy was conducted from 2000 to 2400 on 31/7/23 and then from 0800 to 1200 on 1/8/23.

SPECIFIC ISSUES/QUESTIONS

1. Could a clearer understanding of wounds resulting from boat strikes be provided?

2. Is it possible to narrow down the type of vessel or propeller involved?

3. Were the wounds ante or post mortem in nature?

4. Could the time of death be narrowed down?

A very comprehensive necropsy report has been provided by Drs Bradley, Perkins and Li which included PM photographs, relevant measurements and descriptions, microbiology, urinanalysis and post mortem CT (PMCT) imaging. Unfortunately I did not have access to the histology report (Appendix III).

Summary of PM findings:

Length - 815 cm; Approximate weight - 5620 kg.

The necropsy was complicated by putrefactive changes.

The most significant finding was Injury B:

1. Injury B (lethal): A 90 mm wide wound cranial to the dorsal fin associated with comminuted fractures of the dorsal spine penetrating through the lumbar muscles into the peritoneal cavity.

Other injuries:

2. Injury A (possibly lethal): A 56 cm wide wound 37 cm cranial to the blowhole limited to skeletal muscle without any damage to the underlying cervical spine.

3. Injuries C & D (non lethal): Healing superficial propeller wounds.

Other features:

4. No other significant injuries

5. Malnourished

6. No other underlying organic diseases

7. Mixed microbiological growth

8. No significant histological findings (although there was no specific mention of wound findings)

9. Putrefactive changes

Cause of death: Propeller strike to back

1. Could a clearer understanding of wounds resulting from boat strikes be provided?

Propeller strikes in marine animals result from direct impact of the animal with rotating metal propeller blades. Such strikes can result in serious and even lethal injuries to impacted animals with deep wounds exhibiting extensive soft tissue, organ and bone destruction. On occasion, animals such as dolphins may be cut in two [1,2]. The nature of the injuries depends on the speed and size of both the craft and propeller.

Motorboat propellers consist of usually unshielded heavy metal blades that rotate at high speed through water. The repetitive nature of propeller rotation means that multiple closely spaced injuries may be sustained with only one impact. Given the requirement for high speed and considerable torque it has been estimated that a three-blade propeller running at 3200 rpm can inflict 160 impacts per second. An alternative way to look at this is that a 33 mm blade can move from the head to the toes in a human in less than 0.1 of a second inflicting approximately 16 blows [3].

Propellers have a range in speed depending on the craft involved, with speed boats having up to 5000-5550 rotations per minute (rpm), contrasting with sailboats at 850-1650 rpm and large ships at 80-120 rpm. A feature of the impact though also involves not only the sharpness of the blades, but also the size of the vessel, as momentum is dependent on both mass and velocity (momentum = ½ MV^2).

Lesions that may be found after a propeller strike consist of combined blunt and sharp force injuries with sharper blades causing incised wounds and those with blunt edges causing lacerations. Often a hybrid type of wound occurs, termed a chop injury, where the wound is deeply incised but exhibits more contused and ragged margins. This is often associated with the increased momentum of a heavy striking object. These are the types of injuries seen in attacks with axes [4].

Smaller rapidly rotating blades may also cause a series of parallel symmetrical wounds. Thus, multiple closely spaced injuries may occur with only one impact [2]. Internal examination in all forms of significant propeller strikes may reveal organ disruption and crushing injuries with fractures of the skull, vertebrae and the remainder of the extracranial skeleton [1], however the extent of the injuries may be governed by the relative size of the animal compared to the propeller. For example, only relatively superficial injuries might occur in a large whale impacted by a small boat propeller. Thus, for a large sea mammal to sustain significant internal injuries a larger propeller would likely be involved.

The deep cutting nature of the injuries in the current case do not support possible scenarios in which the animal may have crashed into a solid object or been hit by the keel of a boat, as these would be characterised more by pure blunt force injuries such as bruises and lacerations.

2. **Is it possible to narrow down the type of vessel or propeller involved?**

As chop wounds also incorporate blunt trauma there is often no way of associating a wound with a particular weapon/blade, as can sometimes be done with knife wounds. Occasionally a patterned imprint from a blunt object may provide a clue as to its origin but this was not the situation with the current case. This is particularly so given that decomposition had commenced with the likelihood of some post mortem predation by other sea animals, although this was not specifically mentioned.

While the presence of two fresh wounds on the back might suggest a vessel with dual propellers it is also possible that two strikes had arisen in quick succession from the same propeller, as detailed above.

In attempting to determine the features of the propeller blades it would be useful to have measurements of the depths of particularly Injury B as that would give a minimum dimension to the blades. The width is not all that useful as a small blade may cause a wide wound if it is dragged over a body surface.

3. **Were the wounds ante or post mortem in nature?**

As is often the case with bodies retrieved from the sea it is often difficult to determine whether an injury occurred before or after death. Observation of fresh bleeding is often an indication of ante mortem trauma, however this could be best confirmed by the examining veterinarians, in addition to histological examination of tissues from Injuries A and B to check for interstitial haemorrhage. If present this would suggest that the wounds occurred while there was sufficient blood pressure to cause erythrocyte extravasation. Unfortunately I do not have access to either this report or the microscopic slides, however this could again be confirmed by the examining veterinarians.

The absence of any other lethal injury or underlying significant organic illness would support fatal ante mortem injury to the back.

4. **Could the time of death be narrowed down?**

Unfortunately attempting to accurately determine the time of death even under the most ideal of circumstances is one of forensic pathology's most difficult tasks [5]. No parameters exist that I know of for doing this in marine animals and, as well, in this case putrefactive changes have also complicated assessment. All that can be said is that the animal died sometime between the morning of the 30/7/23 and 0930 on the following morning, 31/7/23. This will not be able to be improved upon unless further sightings become available.

Conclusions:

- I believe that death in this animal was due to a propeller strike to the back with fracturing of the spine and significant soft tissue injuries (potentially supported by histologic confirmation of tissue haemorrhage).

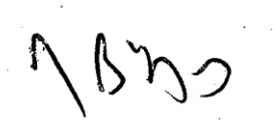
- Estimation of the propeller blade (and therefore vessel) size may be assisted by determining the depth of Injury B.

- In the absence of underlying disease and alternative injuries it is reasonable to believe that the serious propeller injury occurred ante mortem, and was in fact the cause of death.

- Nothing in the necropsy report can be used to more accurately determine the time of death.

I trust that these comments are of use and would be available for further inquiries if required. I can provide a transcript of my full CV if required.

Yours sincerely,



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2. Byard RW, Machado A, Woolford L, Boardman W. Symmetry – the key to diagnosing propeller strike injuries in sea mammals. Forensic Sci Med Pathol 2013; 9: 103-105.

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ADDENDUM REPORT

Re: Hong Kong boat strike of a Bryde's/Eden's whale in July 2023

Since finalising my report I have been provided with additional information to comment on.

1. Although not stated in the necropsy report, the depth of the larger wound (wound B) was estimated to be approximately 50 cm, measured from the body surface to the fractured vertebrae. Could this information provide any indication regarding the size of the propeller/engine that caused the wound or at least the minimum size of the propeller?

   Response As was stated in my original report:' In attempting to determine the features of the propeller blades it would be useful to have measurements of the depths of particularly Injury B as that would give a minimum dimension to the blades.' As the depth is approximately 50 cm this indicates that a minimum measurement for the propeller blade would be 50 cm. This of course does not necessarily give us the overall maximum dimensions. For example, it

is possible to inflict only a 10 cm stab wound from a 70 cm sword if it is not inserted fully – the same applies to propeller chop wounds. It is not possible to assess the size of the engine from inflicted wounds such as these.

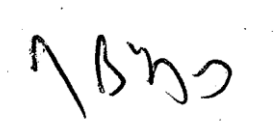
2. The Histopathology Report (Appendix III) from the Veterinary Diagnostic Laboratory College of Veterinary Medicine, Urbana, Illinois, US, dated 27/9/23.
   Response: Unfortunately it is unclear where the tissue sections were taken from with regard to the wounds. While 'very early myofiber degeneration in a section of muscle' is noted I am uncertain as to the significance of this. It may be useful to contact the laboratory and ask whether there was evidence of interstitial haemorrhage in sections taken from Injuries A and B. However, it may not be possible to assess this given loss of tissues from the wounds.

3. In addition, I would appreciate it if you could provide comments on the potential angle of the strike to the whale.

   Response: Determining the relative position of a weapon to a victim is not an easy task as the situation is often quite dynamic with movement of both the weapon and the victim. All that can be reasonably said is that it appears that the whale was struck from above by a blade that was rotating at right angles to the body.

I am not sure whether any of this clarifies the strike, but wish you well in your investigations.

Yours sincerely,



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