Case Review: Dead floating immature juvenile Bryde´s whale

Review Report by request:

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Summary

As Veterinary Pathologist, I have been requested to review the results from the postmortem investigation of a dead floating Bryde´s whale found in Hong Kong. The present report is done, based on a scientific collaboration with the Hong Kong Government, who requested my scientific professional opinion. I have therefore written the following personal opinions and comments on the present case:

- The information about the logistics, necropsy, additional data, and pictures included in the report, which I have access to, provides a very comprehensive and professional work carried out to approach the diagnosis of cause of death of a young immature Bryde´s whale found floating.
- The conclusion reached as ("propelled") ship-strike, as cause of death, in the report is strongly supported by the information, data and findings provided before and after the finding of the dead whale floating as well as during the necropsy and complementary data.
- The participants performed an almost complete necropsy (including thoracic and abdominal cavities) as soon as possible, avoiding as much as possible postmortem decomposition effects as well as artefacts due to carcass handling. Brain was not investigated.
- The time of death could be established within a 12hour period (the day before, from late evening or during the night) and more than 2-3 hours before being found early in the morning, based on no bloody water around the body and no signs of predation by fishes or other animals (I speculate here based on the few pictures of the floating carcass at sea). More pictures and / or information could help to do a better approach.

- **How** the injuries were produced may have different options, in my opinion:

    - A single boat with twin propellers, separated by around 3 meters from one another, which is also the distance between the borders of the two lesions (as it is reported in the postmortem report). The whale could have been hit (strike) laterally, at the same time by the two propellers, when the boat passed perpendicular through the dorsal part of the whale, when the animal was either resting or diving superficially (as in the picture). This would be option (**A**).
    - The propeller (of a single propeller boat) or a propeller of a two propellers boat could hit the frontal part of the animal first (injury), then the second (injury) when the animal try to escape diving deeper. This option (**B**) should be also considered.

- It is difficult to believe or to propose about the possibility that propellers of two different boats could have hit the whale at the same time. Or the involvement of aquatic bikes. But we are still learning on this increasing problem in many places of the world.
- Regarding the angle, the option **A** is more likely (in my opinion). But I also want to keep option **B** (frontal) open, as a possibility too.
- Attending the morphology of the lesions. Both lesions are very similar morphologically. An inverted triangle, with a larger base superficially (A=66cm) (B=90cm). Both lesions are very pleomorphic destructive injuries (from the front to back and from up to down) to a depth (50 cm). Therefore, in my opinion, the size of the blades could be of 40-50 cm (minimum) or more (to get such deep lesions). The speed of rotation of the propeller had to be fast to cause such a type of muscular destruction versus a more linear cut seen in other types of ship-strike.

- Histological results are missing so far. Theys would help to understand better the individual health status of the whale, as well as it may contribute to add agonal / perimortem tissular changes (vital reactions, i.e. heart) which could be indicative of the proposed mechanism/cause of death (trauma and hemorrhagic hypovolemic shock).
- An important organ to rule out any individual important health problem would have been the investigation of the brain, which was not investigated grossly or histologically. No neurotrophic virus has been investigated.
- To ensure the most an "in vivo" lethal trauma, laboratory analysis based on histochemical analysis looking for tissue-thrombo-embolism and or fat embolism in the lung vessels is highly recommended. Complementary histological analysis of the dorsal closed muscles to severe body wounds, would also contribute to ensure the "in vivo" trauma (see bibliography for these techniques).

Comments and suggestions

I would like to stress positively the work done by participants in the report in different aspects:

1) Logistics (I want to stress especially how the whale was picked up, horizontally, and placed on the carrier boat avoiding to cause PM (post mortem) artefacts during handling, especially for joins, vertebrae, ribs, and internal organs).
2) The necropsy report is very useful with comprehensive diagrams and pictures.
    a. Severe local extensive and deep injuries affecting skin (inc. blubber), fascia and dorsal muscles as well as arteriovenous vessels and neurological structures as well shown in the pictures, as well as the progressive autolysis of the tissues involved.
    b. Vertebral column affection is more comprehensive using CT scan than during necropsy (see later).

c. For a reviewer, it would be a good complement a of a larger set of pictures from internal organs. Special attention to cardiovascular system within the abdominal cavity (abdominal aorta, mesenteric aorta, renal arteries, cava, and portal, etc.) would be very welcome as well as brain. Adrenal glands would have been of interest for gross observations of hemorrhages (frequent in case of severe trauma).
d. Brain would have helped to rule out possible encephalic pathology.
e. How much urine was taking from the urinary bladder? It seems that the urinary bladder was not distended, and the urine did not contain blood? Just, we have seen distended urinary bladder with urine in spinal cord affected cetaceans.

3) Histology:
   a. Histology would help to complete this report:
      i. Histology of the heart and muscles (**see literature annexed here**).
      ii. Histology of the lungs (HxE) as well as histochemical for detection of fat lung emboli (for intra-vital trauma) (**see literature annexed here**). And lung lymph nodes (same techniques).
      iii. Histology of other organs, like kidney, liver as well as brain.
      iv. We would be very happy to have a look at histological slides.
4) CT Scan to Whale samples:
      i. Excellent CT scan pictures with especial value to contribute to gross observations and findings in hard body structures (especially bones and vertebrae).

Attending to data, pictures taking at sea as well as during transportation and before the necropsy, the whale showed a code 2 (very fresh carcass, as reported), and although autolysis of the internal organs are reported, all evidence indicate that the whale died during the period proposed (from last sight till early morning). According to my experience, this whale suffered of severe trauma with a severe loss of dorsal muscle affecting arteriovenous and nervous system involved in the affected area during a period that could be established from late evening and during the night. But few hours before the animal was found floating in the day light morning.

All evidence points to a severe and fatal trauma with great loss of tissues (including skin, dorsal diving muscles, and the corresponding arterial-venous vessels and involved nervous tissue in the two areas of impact. Based on the morphology of the two massive extensive destructive lesions, blades of a rotating propeller are the most consistent “mechanical physical cause” involved in these severe lesions provoked in seconds. The consequent effects of these serious injuries were a massive hemorrhage with severe neuromuscular body effects. Fat, muscle and bone thromboembolism is expected to be found out in venous system and specially in the lung vasculature. The whale died shortly after such a trauma due to a lethal hemorrhagic hypovolemic shock. To a better confirmation about an "in vivo" ship strike in this case, histological analyses looking for thromboembolism in the lung would support definitively the "in vivo" trauma.

The deep, perpendicular cuts indicate a collision on the dorsal linear area of an animal that was resting or swimming superficially. While the whale was traumatized by two propellers at the same time is an option, other options should also be considered such as a frontal first injury followed by a second injury by the same propeller when the animal tried to escape by diving deeper. Or the propeller of a one propeller boat could cause the injuries when passing laterally close to the animal.

If the animal had been dead before collision, they body would have been floating laterally, and a postmortem impact by propeller would have shown cuts in the lateral walls of the body and not in dorsal parts as they are shown here. The fact that the whale was found early in morning with no apparent sings of depredation (based on pictures) as well as no hemorrhages around would speaks up for hours after dead.

Wounds C and D are not shown in document with pictures; therefore, I am not able to give an opinion about these lesions and likely causes.

Important scientific references for DIAGNOSIS

1. Ship strike articles and forensic histological technique:https://www.frontiersin.org/articles/10.3389/fmars.2019.00379/full
2. Sierra, E., Fernández, A., Espinosa De Los Monteros, A., Arbelo, M., Díaz-Delgado, J., Andrada, M., et al. (2014). Histopathological muscle findings may be essential for a definitive diagnosis of suspected sharp trauma associated with ship strikes in stranded cetaceans. *PLoS One* 9:e88780. doi: 10.1371/journal.pone.0088780 https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0088780

Additional information

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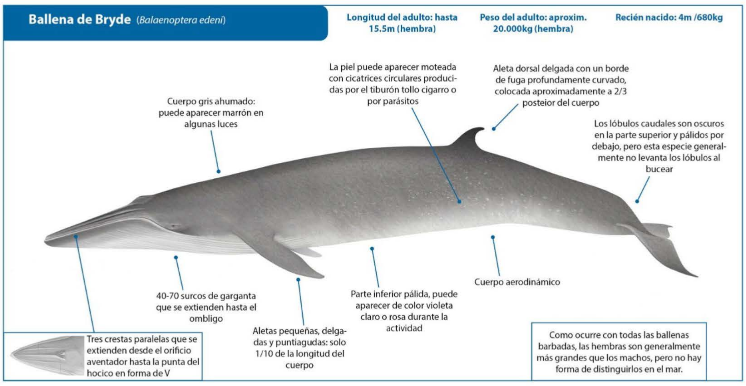

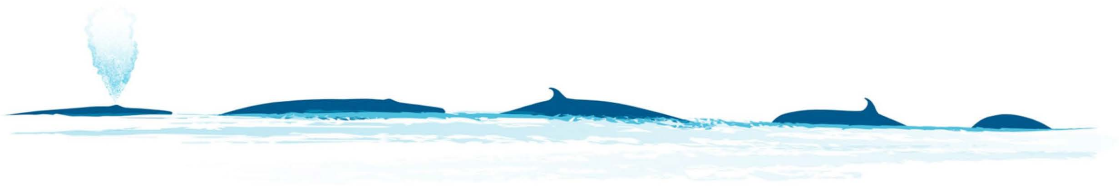

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Resting and Surface Diving profile

Just possibilties of strike and examples of propollers

Whale resting

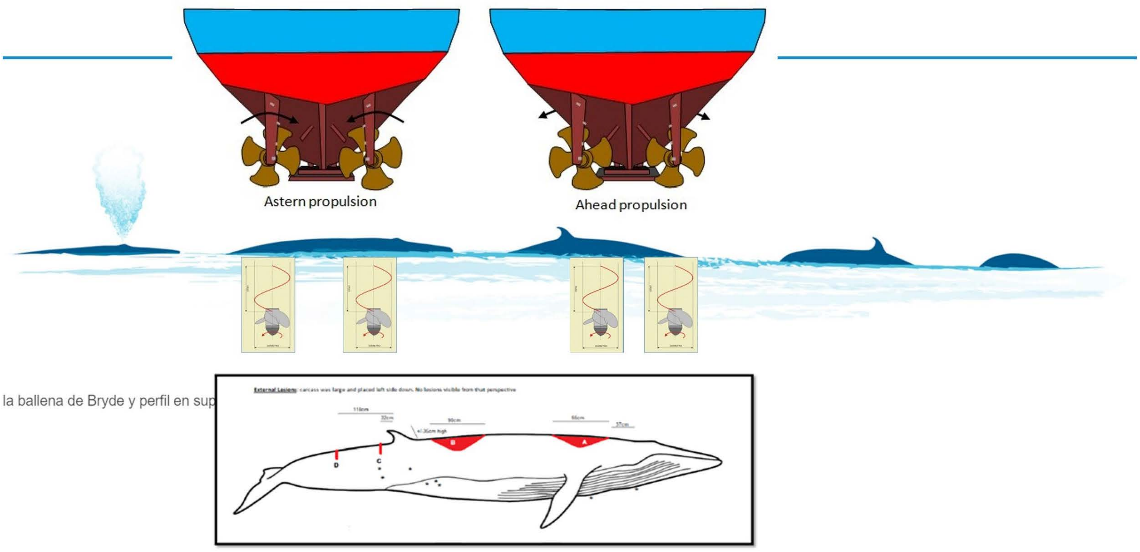
Whale diving superficially

Twin propellers

One propeller

Lateral collision

From Frontal



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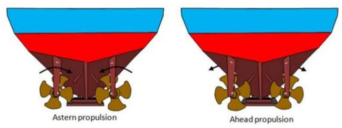
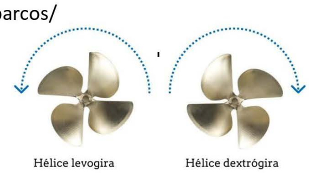
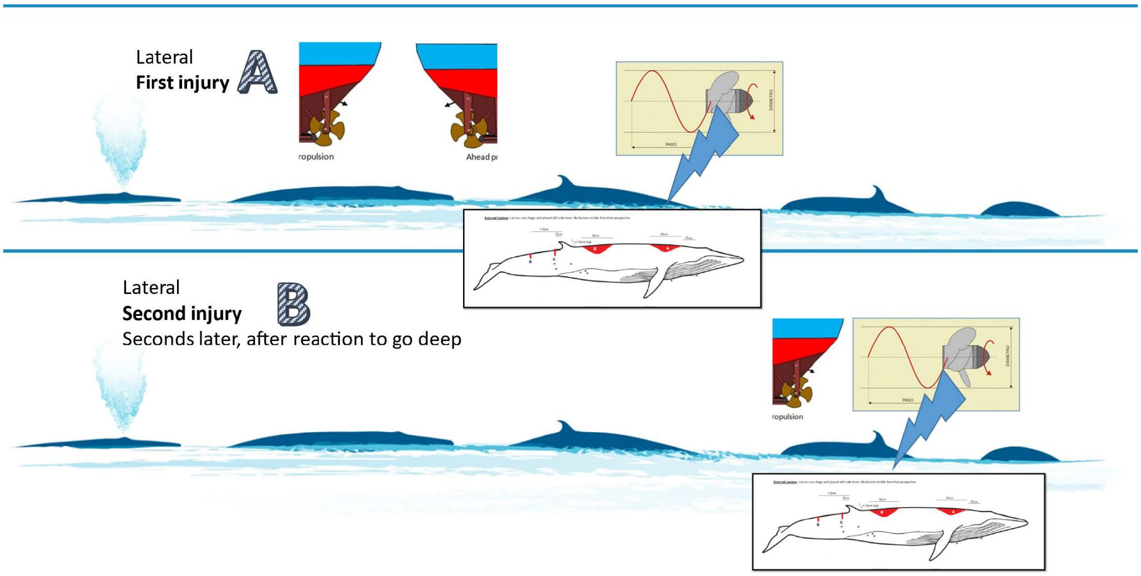
https://www.centramar.es/tipos-de-helices-de-barcos/







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Two examples of propollers

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Alive pilot whale after collision. https://www.eldiario.es/canariasahora/sociedad/choque-ballena-barcos-canarias-cetaceos-camaras-termicas-colision-gran-canaria_1_8931220.html