

## **Predicting lethality from vessel and gear trauma in North Atlantic right whales**

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Human-induced traumas in North Atlantic right whales (*Eubalaena glacialis*) fall in to three categories (Campbell-Malone *et al.* In press; Moore *et al.* 2004): sharp propeller incisions, blunt vessel impacts and constrictive laceration by fishing gear. Accurate prognoses from field observations of live but impacted animals are essential for triage of entanglements and accurate prognostication of the likelihood of a particular case being fatal. The latter being an essential part of governmental regulatory process. Data were synthesized from management records of persistent entanglement cases, photo identification of live sightings of entangled or vessel struck whales, and from necropsy reports. Vessel interactions tend to be peracute to acute whereas entanglement in animals that are unable to immediately shed the gear is typically very chronic with fatal cases having an average duration of 5 months, and persistent non-lethal cases up to many years (Moore *et al.* 2006).

Out of 77 mortalities recorded since 1970 a necropsy was performed on 45 cases (Campbell-Malone 2007; Moore *et al.* 2004): vessel collision has been the cause of death in 24 of them. Of the ship-strike related mortalities, the cause of death in 56% (15) of the cases was acute sharp trauma alone, while 20% (9) were attributed to blunt trauma. Others were more complex. A scoring matrix was established for propeller wounds: a sum of the product of cut depth (0 to 4) and number of cuts for each of head, upper and lower back, peduncle and fluke. Results were (mean +/- SD (N): Alive 7.4 +/- 4.5 (24) and Dead 16.0 +/- 15.2 (15). Cuts in the upper back and head were more likely to be lethal than in the caudal part of the body, although lethal cuts were observed in all body regions (Figure 1). External evidence in blunt trauma cases was absent in 44% (4/9). Thus the extent of non-lethal blunt trauma is not known. Skeletal fractures were observed in 89% (8/9) of the lethal blunt trauma cases and a broken mandible was observed in 33% (3/9) of all lethal blunt trauma cases examined by necropsy. As a fully healed mandibular fracture has never been observed in a right whale, a fractured mandible is believed to represent a fatal injury. The apparent density and mechanical properties of bone tissue from the mandible were determined experimentally. These data were then used as inputs for a finite element model capable of predicting the stress sufficient to induce fatal fracture of a mandible (Campbell-Malone 2007). On-going work will compare such

stresses with the forces produced by vessels to determine the vessel speed and size combinations capable of fracturing a mandible.

Since 1970 to July 2007 there have been 47 cases of significant entanglement, 15 entanglement related deaths and 6% of the cases are presumed to be dead given an absence from the sighting record for 6 or more years. For entanglement trauma, significant parameters were scored subjectively in terms of severity (Table 1). For 18 persistent entanglement cases where a full data set were available, scores on a scale of 0-35, were lethal above 17 and non lethal below 14, and of mixed outcome between those numbers. We are still refining the model to deal with cases where data are missing. We hope to rank cases in terms of severity, and compare the ultimate outcome.

Ongoing development of the biomechanical model and a simple scoring system to evaluate entanglement and propeller cut cases should enhance our prognostic capacity.

Campbell-Malone, R. 2007. Biomechanics of North Atlantic right whale bone: mandibular fracture as a fatal endpoint for blunt vessel-whale collision modeling. Doctoral thesis, Woods Hole Oceanographic Institution and Massachusetts Institute of Technology Joint Program in Biological Oceanography.

Campbell-Malone, R., S. Barco, P.-Y. Daoust, A. Knowlton, W. McLellan, D. Rotstein and M. Moore. In press. Gross and histologic evidence of sharp and blunt trauma in North Atlantic right whales (*Eubalaena glacialis*) killed by ships. *Journal of Zoo and Wildlife Medicine*.

Moore, M., A. Bogomolni, R. Bowman, P. Hamilton, C. Harry, A. Knowlton, S. Landry, D. Rotstein and K. Touhey. 2006. Fatally entangled right whales can die extremely slowly. *Oceans'06 MTS/IEEE-Boston, Massachusetts* September 18-21, 2006 - ISBN: 1-4244-0115-1.:3 pp.

Moore, M.J., A.R. Knowlton, S.D. Kraus, W.A. McLellan and R.K. Bonde. 2004. Morphometry, gross morphology and available histopathology in North Atlantic right whale (*Eubalaena glacialis*) mortalities (1970-2002). *Journal of cetacean research and management* 6:199-214.

**Table 1 – Preliminary coding in a scoring system under development to determine lethality of entanglement for North Atlantic right whales**

| FACTORS                   | <u>NOT ENTANGLED</u>            | <u>ENTANGLED</u>             |                                 |
|---------------------------|---------------------------------|------------------------------|---------------------------------|
|                           | 0 Points                        | 1 point minimum              | Max (5 except body parts)       |
| # of lines                | No lines - No entanglement      | 1 line                       | More than 4                     |
| # of Wraps                | No wraps - No entanglement      | 1 wrap                       | More than 3 (Multiple)          |
| Cyamids coverage          | No cyamids - No entanglement    | 1% - 20%                     | 81% - 100%                      |
| Line cutting in           | No cutting in - No entanglement | Just removing external layer | Into bone                       |
| Associated weight to gear | No weight associated - No gear  | Just gear                    | More than 500lb                 |
| # of body parts entangled | No entanglement                 | 1 part entangled (1pt.)      | 10 body parts entangled (10pts) |

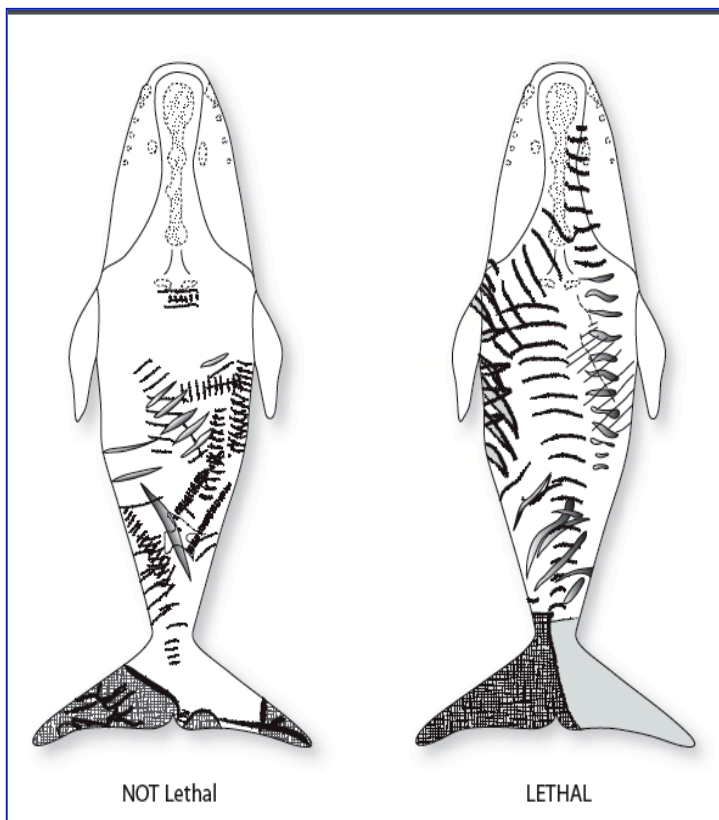


Figure 1 – Composite sketch of propeller trauma in cases that were not lethal (left) and lethal (right) – Sketch by Eden Maloney and Paul Oberlander (WHOI).