



Evaluation of the number and size of blubber adipocytes as a method to establish body condition in striped dolphins (*Stenella coeruleoalba*)

Laura Balboa, Ayoze Castro-Alonso, Manuel Arbelo, Antonio Fernández, Yara Bernaldo de Quirós

Veterinary Histology and Pathology, Atlantic Center for Cetacean Research, University Institute of Animal Health and Food Safety (IUSA), Veterinary School, University of Las, Palmas de Gran Canaria, Canary Islands, Spain

ayoze.castro@ulpgc.es

INTRODUCTION

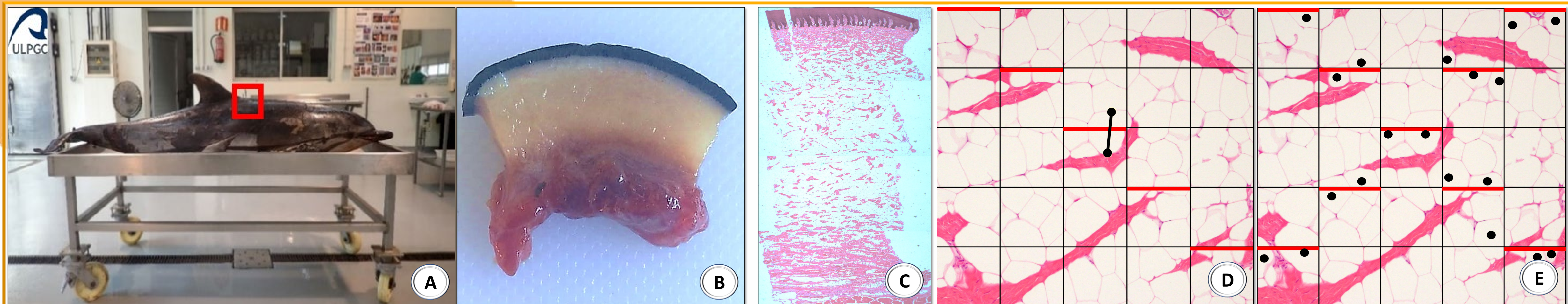
Climate change and anthropogenic impacts on the ocean can alter the body condition of cetaceans [1]; this parameter can be used as an estimator of their health, as it represents their nutritional status over time and is related to their distribution, physiology, environmental adaptations, the ecosystem health and its state of conservation [1][4][5][7] [10]. Body condition has a direct impact on the individual's survival, reproduction rate, and calf survival rate [3][9][11][12]. Recent studies have shown that **body-mass/body-length² is a good index to characterize body condition** [6]. However, body mass is difficult to estimate at sea. Large efforts have been made to estimate the body condition of cetaceans at sea, although there is no agreement about the best method to do so.

Blubber is an important energy storage in cetaceans that is frequently sampled in the form of biopsies for various purposes. Mammalian adipocytes usually decrease in size during fasting periods and increase during fattening periods rather than changing in number [2][15]. However, there is little information on changes in the number and size of adipocytes as body condition varies in cetaceans [8].

OBJECTIVES

The aim of this study was to assess whether the number and size of adipocytes estimated in the total blubber and within each layer (i.e., superficial, middle, and deep) would be good indirect methods to estimate body condition in free-range striped dolphins through biopsies.

MATERIAL & METHODS



We studied the dorsal blubber, the most frequent sampling location in biopsies, in stranded striped dolphins as an experimental model to validate the technique. For doing this, **skin samples were taken from thoracic dorsal blubber** (anterior to the dorsal fin) and processed to obtain a histological sample (Figures A and B).

The adipocytes from the total blubber and within each layer (i.e., superficial, middle, and deep), of 15 striped dolphins stranded in the Canary Islands (Spain) were counted and measured using microphotographs at 10X and the ImageJ software (Figures C, D and E).

RESULTS & DISCUSSION

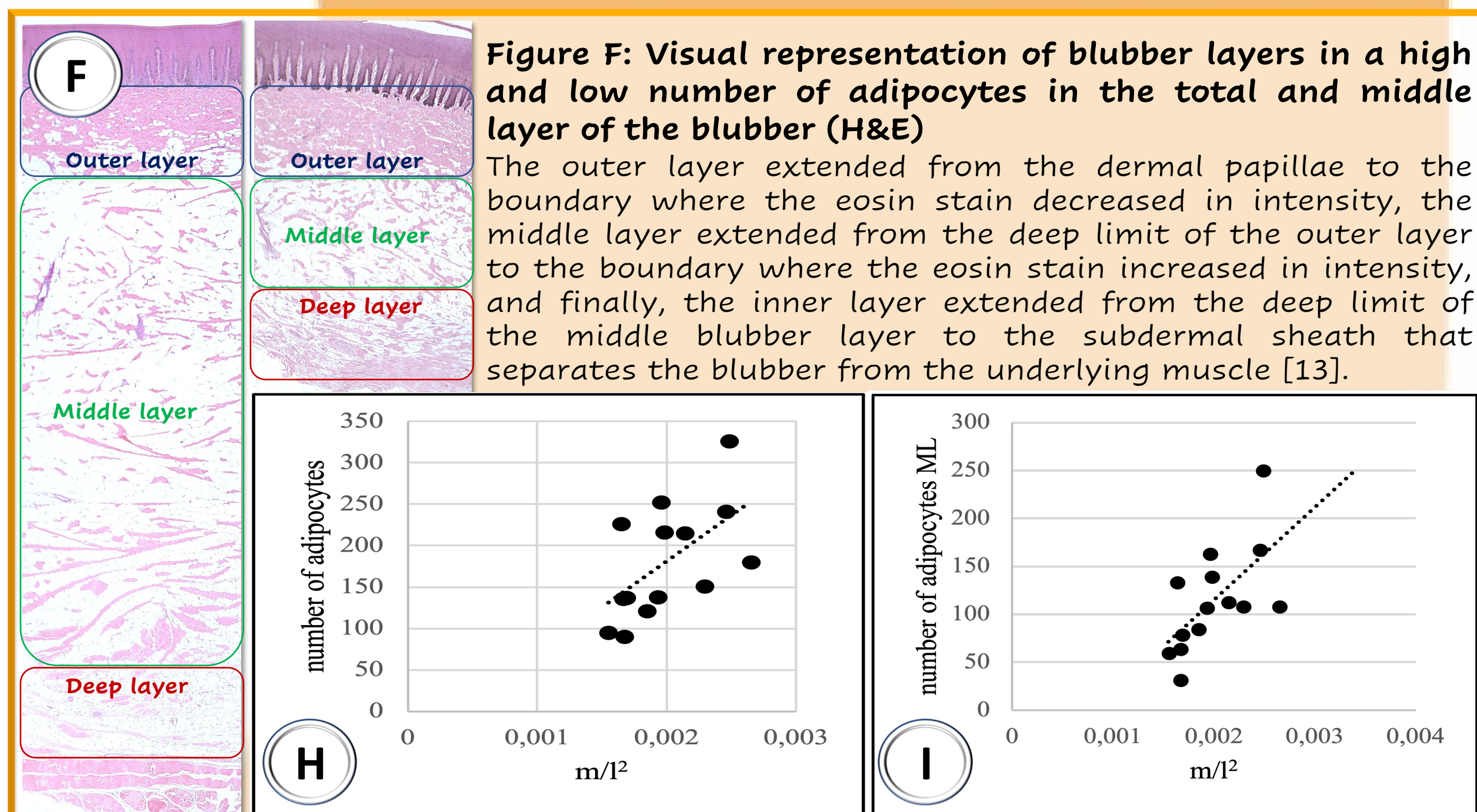


Figure G: Different size of the adipocytes in the blubber from big, middle and small sizes (H&E 10X). Although in some animals the differences were evident during the histological examination we could not find any statistically significant correlation with body conditions.

A significant relationship was observed between body condition (body-mass/body-length²) and the number of adipocytes present in the total blubber ($R^2 = 0.320$, $P = 0.035$) and in the middle layer ($R^2 = 0.375$, $P = 0.020$) Figures H and I. These results suggest that this parameter could be an objective and good method for the evaluation of body condition in free-range striped dolphins through biopsies. On the contrary, **no significant relationship was observed between body condition (body-mass/body-length²) and the size of adipocytes** present neither in the total blubber nor in the middle layer.

Some authors claim that in bottlenose dolphins (*Tursiops truncatus*) there is no relationship between body condition and the number of adipocytes [13][16]. Although initially striped dolphins (*Stenella coeruleoalba*) are expected to show similar results, it is possible that each species uses its lipid reserves differently and that these animals lose part of their adipocytes in times of fasting and gain them in times of abundance of food, as it has been seen in harbor porpoises [8] and in humans [14]. Regarding the size of the adipocytes, other authors have reported a relation with body condition in harbor porpoises and bottlenose dolphins. [8][13][16]. **This study increases our current knowledge in how the adipocytes in the blubber of dolphins are related to body condition.** This information is important for management and conservation tools.

CONCLUSIONS

Our results indicate that **in striped dolphins there is a relationship between the Quetelet's index (body-mass/body-length²) and the number of adipocytes** in both the total and the middle blubber; that is why the number of adipocytes seems to be a good estimator of body condition in striped dolphins.

Secondly, it has been seen that changes in the body-mass of striped dolphins affects the size of their adipocytes in the total blubber; but it was not the case with the Quetelet's index, neither in the total nor in the middle blubber. That is why **the size of the adipocytes does not seem to be a good estimator of body condition in striped dolphins.**

Thirdly, the middle blubber layer showed significant variations in the number and size of its adipocytes with respect to body condition, as **the superficial and deep blubber were minimally affected.**

Fourthly, **it has been validated an objective method for estimating the body condition of striped dolphins (necropsy/biopsy).**

REFERENCES

- Castillon, J. & Bengtson Nash, S. (2020). Evaluating cetacean body condition: a review of traditional approaches and new developments. *Ecology and Evolution*, 11(10), 1-14.
- Groscostas, R. (1990). Metabolic adaptations to fasting in emperor and king penguins. *Penguin Biology*, Davis, L. and Darby, J. (eds.), Ed. Academic Press, San Diego, 269-296.
- Hodges, K. E., Stefan, C. I. & Gilles, E. A. (1999). Does body condition affect fecundity in a cyclic population of snowflake hare? *Canadian Journal of Zoology*, 77(1), 1-6.
- Jobin, M. J., Pakas, M. A., Morse, B., Harty, C. T., Rose, K. S., Sharp, S. M., Nemejyer, M. E., Paolucci, K. M., Sharp, W. B. & Moore, M. J. (2014). Body condition scoring system for dolphins based on short-beaked common dolphins (*Delphinus delphis*). *Journal of Marine Animals and their Ecology*, 7(2), 5-13.
- Kerns, B. L., Ewing, R. Y. & Schaefer, A. M. (2019). Evaluation of body mass index as a prognostic indicator from two rough-toothed dolphin (*Steno bredanensis*) mass strandings in Florida. *Ecology and Evolution*, 9(18), 10544-10552.
- Kershaw, J. L., Sherrill, M., Davison, N. J., Brownlow, A. & Hall, A. J. (2017). Evaluating morphometric and metabolic markers of body condition in a small cetacean, the harbor porpoise (*Phocoena phocoena*). *Ecology and Evolution*, 7(10), 3494-3506.
- Kershaw, J. L., Brownlow, A., Ramp, C. A., Miller, P. J., & Hall, A. J. (2019). Assessing cetacean body condition: is total lipid content in blubber biopsies a useful monitoring tool? *Aquatic Conservation: Marine and Freshwater Ecosystems*, 29, 271-282.
- Koopman, H. N., Pabst, D. A., Møller, W. A., Dillaman, R. M. & Read, A. J. (2002). Changes in blubber distribution and morphology associated with starvation in the harbor porpoise (*Phocoena phocoena*): evidence for regional differences in blubber structure and function. *Physiological and Biochemical Zoology*, 75(5), 498-512.
- Lockyer, C. (1986). Body fat condition in Northeast Atlantic fin whales *Balaenoptera physalus* and its relationship with reproduction and food resource. *Can. J. Fish. Aquat. Sci.* 43, 142-147.
- McKinney, M. A., Alwood, T., Dietz, R., Somme, C., & Peacock, E. (2014). Validation of adipose lipid content as a body condition index for polar bears. *Ecology and Evolution*, 4(4), 516-527.
- Miller, J. & Hocking, G. (1990). Fasting endurance and the evolution of mammalian body size. *Functional Ecology*, 4(1), 5-12.
- Miller, J. M., Siten, A., Irvine, R. J., Aborn, S. D., Languth, R., & Ropstad, E. (2003). Body condition in Svalbard reindeer and the use of blood parameters as indicators of condition and fitness. *Canadian Journal of Zoology*, 81(9), 1566-1578.
- Montle, E. W., Garvin, S. R., Fair, P. A., Bossart, G. D., Mitchem, G. B., McFae, W. E., Speakman, T., Starczak, V. R. & Hahn, M. E. (2008). Blubber morphology in wild bottlenose dolphins (*Tursiops truncatus*) from the Southeastern United States: influence of geographic location, age, class, and reproductive state. *Journal of Morphology*, 269(4), 495-511.
- Prins, J. B. & O'Rahilly, S. (1997). Regulation of adipose cell number in man. *Clinical Science*, 92(1), 3-11.
- Ramsey, M., Matasik, G. & Pond, C. (1992). Seasonal and sex differences in the structure and chemical composition of adipose tissue in wild polar bears (*Ursus maritimus*). *Journal of Zoology*, 228(4), 533-544.
- Saenz, D. J., McEllan, W. A., Dillaman, R. M., Blum, J. E., Kricklak, I. B. & Pabst, D. A. (2004). Blubber development in bottlenose dolphins (*Tursiops truncatus*). *Journal of Morphology*, 259(1), 7-20.