

Morphometric analysis of fossil ear bones as a tool to investigate delphinoid diversity in the southern North Sea during the late Neogene

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In and around the city of Antwerp (Belgium) many paleontological discoveries were made in the context of the construction of fortification belts and the expansion of the harbour. This led to the discovery of a large amount of fossil remains of Neogene marine mammals, among others. Because the specimens are generally fragmentary and the fossil record is relatively scarce, a clear overview of the diversity and time range of these extinct species is difficult to obtain. The ear bones of cetaceans, including the periotic (housing the inner ear) are more compact than other cranial material, often resulting in a better preservation, although these elements are generally found isolated. Furthermore, the periotic preserves many diagnostic features, especially concerning delphinoids, the superfamily including delphinids (oceanic dolphins), phocoenids (porpoises), and monodontids (belugas and narwhals). Therefore, these fossils can aid improving our comprehension of the diversity of delphinoids in the southern North Sea during the late Neogene (Late Miocene and Pliocene). Based on a morphological comparative analysis of 187 fossil periotics from the Antwerp area, recovered mainly from the Pliocene Kattendijk and Lillo formations, with identified fossil and modern periotics, combined with a principal component analysis based on 13 measurements, the periotics were divided in morphological groups which, in a second step, were given a family attribution and, in most cases, affinities with one or two genera. At least nine delphinid, three phocoenid, and two monodontid genera were tentatively recognised. Additional support could be obtained for the presence in the southern North Sea during the late Neogene (mainly, but possibly not only, the Pliocene) of close relatives to the modern pilot whales *Globicephala* spp. and the extinct large dolphin *Hemisyntrachelus*, as well as porpoise species closely related to *Haborophocoena toyoshimai* and *Numataphocoena yamashitai*. Furthermore, a hypothetical extension into the Pliocene of the time range in the southern North Sea of taxa closely related to (or even within) the delphinid genera *Stenella*, *Delphinus*, *Lagenorhynchus*, and *Tursiops*, the phocoenid *Phocoena*, and the monodontids *Delphinapterus* and *Monodon* are proposed. Additional support for several trans-Arctic dispersal events of extinct porpoise lineages between the North Pacific and the northern Atlantic realm is provided, as well as for a more southern distribution for extinct relatives of the beluga and narwhal. The presence of close relatives to the delphinids *Astadelphis gastaldii* and *Arimidelphis sorbinii*, both previously only recorded from the Mediterranean, indicates a possible interchange between the latter sea and the North Sea during the Pliocene. Unfortunately, precise stratigraphic information could be obtained only for a part of the studied periotics. Furthermore, due to their isolated nature, the identifications remain tentative and do not reach the species level. As a result, there is a need to find new in situ material, as well as periotics associated to other cranial elements.