Online Journal of the Natural History Museum Rotterdam,
with contributions on zoology, paleontology and urban ecology
deinsea.nl

DEINSEA

New finds of giant raptorial sperm whale teeth (Cetacea, Physeteroidea) from the Westerschelde Estuary (province of Zeeland, the Netherlands)

Jelle W.F. Reumer [1,2], **Titus H. Mens** [1] **& Klaas Post** [2]

[1] Utrecht University, Faculty of Geosciences, P.O. Box 80115, 3508 TC Utrecht, the Netherlands

[2] Natural History Museum Rotterdam, Westzeedijk 345 (Museumpark), 3015 AA Rotterdam, the Netherlands

ABSTRACT

Two large sperm whale teeth were found offshore from Breskens in the Westerschelde estuary. Comparison shows they share features with the teeth of the stem physeteroid *Zygophyseter*, described from the Late Miocene of southern Italy. Both teeth are however significantly larger than the teeth of the *Zygophyseter* type material, yet still somewhat smaller than the teeth of the giant raptorial sperm whale *Livyatan melvillei*, and confirm the presence of so far undescribed giant macroraptorial sperm whales in the Late Miocene of The Netherlands.

Keywords Cetacea, Odontoceti, Westerschelde, *Zygophyseter*

Cite this article Reumer, J.W.F., Mens, T.H. & Post, K. 2017 - New finds of giant raptorial sperm whale teeth (Cetacea, Physeteroidea) from the Westerschelde Estuary (province of Zeeland, the Netherlands) - Deinsea 17: 32 - 38

Submitted 26 June 2017
Accepted 28 July 2017
Published 23 August 2017

Author for correspondence
Jelle W.F. Reumer:
j.w.f.reumer@uu.nl

Editors of this paper
Bram W. Langeveld
C.W. (Kees) Moeliker

DEINSEA online
ISSN 2468-8983

INTRODUCTION

Fossil Physeteroidea are not uncommon in Neogene marine or coastal sediments. Most of the finds concern isolated teeth. Here we study two large fossil teeth from the collections of the Natural History Museum Rotterdam (NMR 9991-00010227 and NMR 9991-00010228, Figs. 1 and 2)) that were trawled from the seabed of the Westerschelde Estuary, off the coast of Breskens, province of Zeeland, the Netherlands. Based on their size, the massive and robust roots, the presence of small enamel caps, and the presence of occlusal scars indicating the presence of teeth in both maxilla and mandibula they are identified as physeteroid teeth (Gol'din & Marareskul 2013). So far, physeteroid teeth like the two under study were commonly ascribed to the genus *Scaldicetus* Du Bus, 1872, a grade taxon with no diagnostic value (Bianucci & Landini 2006, Kimura *et al.* 2006).

Only three crown physeteroid species, in two genera, are still extant: the large sperm whale *Physeter macrocephalus* Linnaeus, 1758 and the pygmy sperm whales *Kogia breviceps* (Blainville, 1838) and *K. sima* Owen, 1866. All three are specialized

cephalopod feeders lacking or nearly lacking dentition in the upper jaws. However, fossil stem physeteroids, e.g. *Brygmophyseter* Barnes, 2006, *Acrophyster* Lambert *et al.*, 2008, *Livyatan* Lambert *et al.*, 2010, and *Zygophyseter* Bianucci & Landini, 2006, are supposed to be generalistic carnivores (piscivores or cetivores), have teeth in both upper and lower jaws (which feature they share with some Miocene physeterids and kogiids) and are commonly coined macroraptorial sperm whales (Lambert *et al.* 2016).

Diagnostic features characterizing the superfamily Physeteroidea are mainly located in the cranium, and in some soft tissue structures. Therefore, attributing loose dental elements to a genus or species is often hazardous. The two teeth from the Westerschelde are compared to literature data and to material in several collections.

MATERIAL AND METHODS

The two physeteroid teeth were trawled by fishing vessels near the mouth of the Westerschelde Estuary, off the coast of Breskens. They are now in the collection of the Natural History Museum Rotterdam (the Netherlands), having inventory numbers NMR 9991-00010227 and NMR 9991-00010228 (hereafter NMR 10227 and NMR 10228). Measurements were taken with digital Vernier calipers. The teeth did not belong to the same individual; they were found in different years and they differ in coloration and state of preservation, NMR 10227 being better preserved than the heavily eroded NMR 10228. Although we lack absolute certainty, we consider the two teeth to belong to the same species on the basis of similarities in size and morphology.

For comparison, we used physeteroid material stored in the Natural History Museum Rotterdam (NMR), the provincial archives of Zeeland/Zeeuws Museum (HZA) in Middelburg (the Netherlands), the Belgian Institute of Natural Sciences (RBINS) in Brussels (Belgium) and in two private collections, those of Mr. Mark Bosselaers and Mr. Harald van der Steen. We used material that was registered as belonging to the genus *Scaldicetus*, and other physeteroid teeth or tooth fragments that showed resemblance to our teeth.

SYSTEMATIC PALAEONTOLOGY

Order Cetacea Brisson, 1762
Suborder Odontoceti Flower, 1867
Superfamily Physeteroidea Gray, 1821
Physeteroidea indet. cf. *Zygophyseter* sp.
(Figures 1 and 2)

NMR 10227 (Fig. 1) is a complete, well-preserved, massive tooth with a robust root. It is curved and has a length of 215 mm. The crown was not long, with an estimated length of 20-35 mm and a maximum diameter of 22 mm. The crown shows natural wear; only the posterior part of the enamel is preserved. This enamel fragment (Fig. 1C) shows a striped pattern. A constriction is observed below the enamel crown, the tooth has a diameter of 62 mm in mesiodistal direction and 69 mm in labial-lingual direction at about two thirds of the height. The pulp canal is open; the cementum is smooth with some grooves. An occlusion facet indicates wear on the anterior (mesial) side, below the crown. The tooth is somewhat laterally curved and can tentatively be identified as one of the anterior most elements, probably an incisor.

NMR 10228 (Fig. 2) is also a massive tooth with a robust root. It is less well preserved than NMR 10227. The crown and the root apex are broken; its length can therefore only be estimated to have been more than 210 mm. A small enamel fragment remains (Fig. 2C) and the pulp canal is open. In general the shape resembles that of NMR 10227, with the greatest width (of 85 mm in mesiodistal direction and 72 mm in labial-lingual direction) at two thirds of the height. Just above the greatest width a band (named the gingival collar in Bianucci & Landini 2006) indicates the former margin of the gum. We consider this tooth to be one of the central elements, i.e. neither from an anterior or a posterior position in the jaw, based on the lesser degree of curvature in comparison to NMR 10227.

DISCUSSION

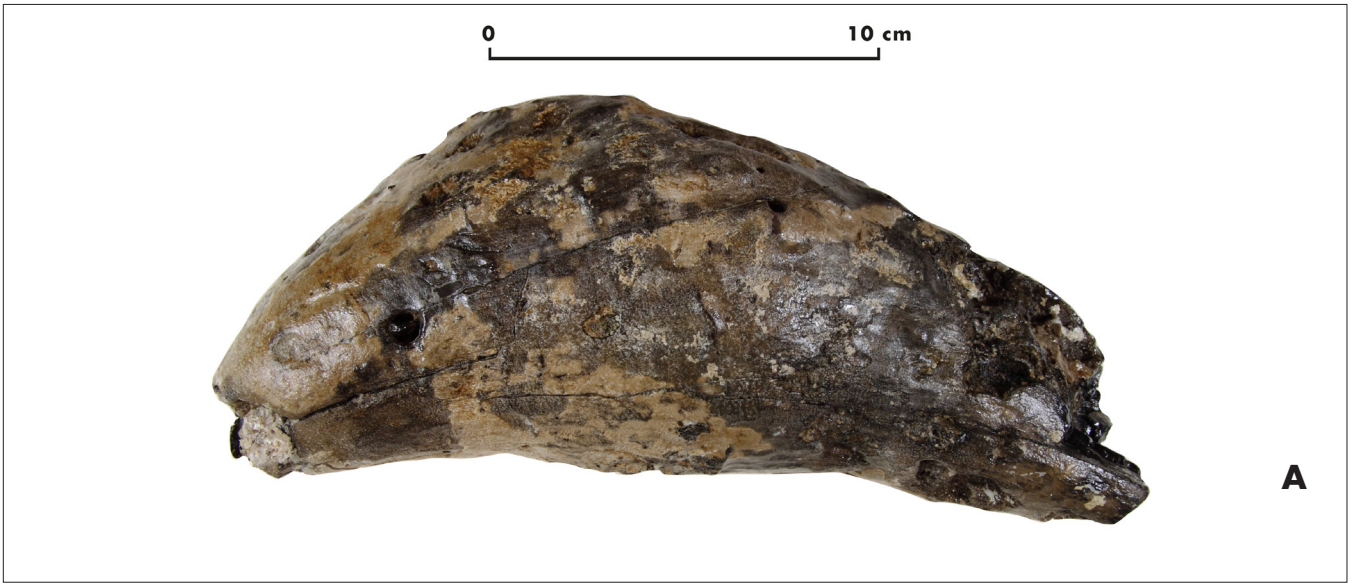
Shape and size of the fossils corroborate an identification as physeteroid teeth. NMR 10227 differs from most Physeteridae *sensu* Bianucci & Landini (2006) by the presence of an enamel crown cap. In addition, there is an occlusion surface, which indicates the presence of functional teeth in both the maxilla and the mandibula, and the teeth have massive, robust roots. Although occlusion surfaces are not restricted to stem physeteroids, this combination of characters confirms the attribution to stem Physeteroidea, which include published genera such as *Hoplocetus* Gervais, 1848; *Scaldicetus* Du Bus, 1867; *Zygophyseter* Bianucci & Landini, 2006; *Brygmophyseter* Kimura *et al.*, 2006; *Acrophyseter* Lambert *et al.*, 2008; *Livyatan* Lambert *et al.*, 2010; and *Albicetus* Boersma & Pyenson, 2015.

Of the stem physeteroids, the genus *Scaldicetus* was originally described from the same region as where our two teeth were found, i.e. the Schelde paleoestuary in the Antwerp/Zeeland region (southwestern Netherlands, northwestern Belgium). In addition, *Eudelphis mortezelensis* Du Bus, 1872 is described from Belgium, *Hoplocetus* from France, Belgium and Germany (Hampe 2006), *Zygophyseter* is described from Italy (Bianucci & Landini 2006), *Brygmophyseter* from Japan (Bianucci & Landini 2006, Kimura *et al.* 2006), *Acrophyseter* and *Livyatan* from Peru (Lambert *et al.* 2008, 2010), *'Aulophyseter' rionegrensis* Gondar, 1975 from Argentina, and the enigmatic *Albicetus* from California (Boersma & Pyenson 2015)

Since the original description by Du Bus (1867, 1872) quite many species were described within the genus *Scaldicetus*. Abel (1905) briefly described teeth (45 specimens that might have belonged to one single individual animal) that appear similar to the ones described by us, as *Scaldicetus caretti* Du Bus, 1867 from the 'Environs d'Anvers', Belgium. This unspecified locality is situated some 50-60 kilometer upstream of the place where our teeth were found. Our two teeth fall within the size range given by Abel (1905; see Table 1).

However there appears to be no consensus about the validity of this genus or its position in either the superfamily Physeteroidea (Fitzgerald 2011, Gol'din & Marareskul 2013), the family Physeteridae (Abel 1905, Varola *et al.* 1988, Hirota

Figure 1 Physeteroidea indet. cf. *Zygophyseter* sp., Westerschelde, NMR999100010227 in **A** slightly oblique buccal view, **B** slightly oblique lingual view, lines indicate the wear facet, **C** detail of the apex. (Natural History Museum Rotterdam)



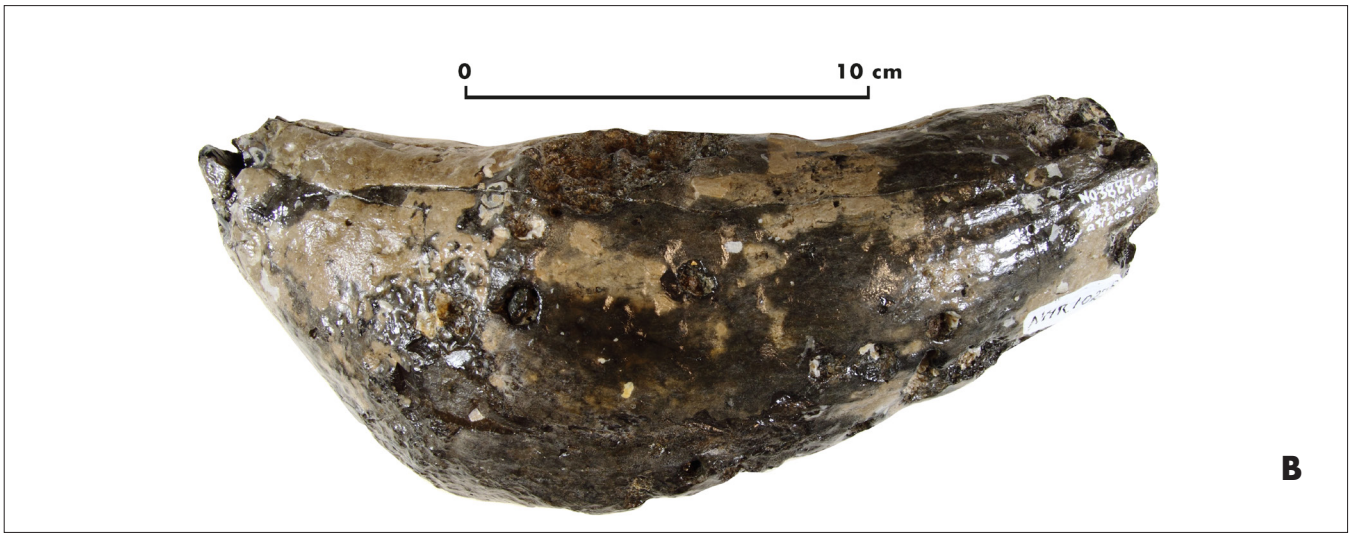


Figure 2 Physeteroidea indet. cf. *Zygophyseter* sp., Westerschelde, NMR999100010228 in **A** slightly oblique buccal view, **B** slightly oblique lingual view, **C** detail of the apex. (Natural History Museum Rotterdam)

Table 1 Measurements in mm of teeth of various fossil physteroids.

taxon/specimen	total length of tooth	greatest diameter	
		mesiodistal	lingual-labial
NMR 9991-00010227	215	62	69
NMR 9991-00010228	210	85	72
Zygophyseter varolai [1]	175.6 (range 150-205)	52.4 (range 47-56)	–
Z. varolai [2]	178.6 (range 161-198)	48 (range 44.3-52.3)	–
Albicetus oxymycterus [3]	–	–	80, 82, 93
A. oxymycterus [4]	–	–	73.1 (range 54-90.5)
A. oxymycterus [5]	–	90.4 (range 50-120)	78.2 (range 54-122)
Hoplocetus ritzi [6]	117.7 (range 95-150)	40.1 (range 27-47)	40.0 (range 32-46)
Scaldicetus caretti [7]	140-260	–	–

[1] based on Varola *et al.* (1998: Table II)
[2] based on illustration in Bianucci & Landini (2006)
[3] sizes given by Kellogg (1925) for three teeth
[4] Kellogg (1925) for 'greatest transverse diameter of roots of first through tenth tooth'
[5] Boersma & Pyenson (2015) for alveolar measurements (and thus an overestimation)
[6] based on Hampe (2006)
[7] based on Abel (1905)

& Barnes 1994, Whitmore & Kaltenbach 2008) or the subfamily Hoplocetinae within the Physeteridae (Kazár 2002, Hampe 2006, Toscano *et al.* 2013). The genus was originally ill-defined with a great number of brief and short descriptions. This fact, and the sometimes incoherent interpretations of these descriptions, led in the course of time to the denomination of many species within *Scaldicetus*, because most of these denominations were based on non-diagnostic, isolated teeth. Many species have now either been referred to other genera, or been declared *nomen nudum*, or have disappeared into synonymy. A complete revision of the genus *Scaldicetus* and even of its validity is, however, beyond the scope of the present paper and therefore we refrain from attributing our material to this genus.

Among the *Scaldicetus* species, *S. degiorgii* Varola & Pilleri, 1988, was described based on a single isolated tooth, but is now considered to be a synonym of *Zygophyseter varolai* Bianucci & Landini, 2006 (Bianucci & Landini 2006). A well-preserved skull with mandibles and dentition was discovered to which the single tooth belonged and on which the description of *Z. varolai* is based. In the formal diagnosis of this taxon by Bianucci & Landini (2006, p. 107) the only remark about the teeth is: 'teeth with enamel crown'. The subsequent description provided by Bianucci & Landini (2006) is more extensive. Important features of the teeth are: the relatively small crowns with crenulated enamel, the presence of a gingival collar at the greatest diameter of the tooth and the presence of shallow longitudinal grooves on the roots. These characters are present in our two teeth, but can also be observed in several other stem physteroids.

The length of the teeth of *Zygophyseter varolai* was not given by Bianucci & Landini (2006), but was published earlier by Varola *et al.* (1988). It appears the average length is 175.6 mm (range 150 - 205 mm). This is on average 13.7% (range 4.7 - 30.2%) below the measured 215 mm of our material, but individual tooth size is rather unconstrained and depends on the exact position in the maxilla or mandibula. The same applies to the greatest diameter, which in *Zygophyseter varolai* is 52.4 mm (range 47 - 56 mm); in our material we found sizes between 62 and 85 mm.

The material of *Hoplocetus ritzi* Hampe, 2006 described from northwestern Germany is considerably smaller: lengths of the teeth range from 95 - 150 mm; maximum diameter between 27 - 47 mm (Hampe 2006).

A tentative conclusion is that our Westerschelde teeth could belong to *Zygophyseter* on the basis of their morphology, and that they might belong to an as yet undescribed species larger than *Z. varolai*. It cannot be completely excluded that the similarity with *'Scaldicetus' caretti* could lead to an attribution to this

taxon, but a prudent approach urges us to formally identify the teeth as Physeteroidea indet. cf. *Zygophyseter* sp.

The Westerschelde estuary is known for its rich deposits yielding fossil marine mammals, mostly cetaceans from Middle and Late Miocene strata (e.g., Post & Reumer 2016, Veenhof *et al.* 2016). Other finds of large odontocetes from other parts of the world also show an abundance of these top-predators during the later part of the Tertiary (e.g., Lambert *et al.* 2010), mostly (but not exclusively) from the late Middle or Late Miocene. We therefore tentatively hypothesize our two Westerschelde teeth to also be of a late Middle or Late Miocene age.

CONCLUSIONS

The described teeth originate from a macroraptorial sperm whale, and are here tentatively attributed to Physeteroidea indet. cf. *Zygophyseter* sp. The find is interesting because it confirms that raptors larger than *Zygophyster* and almost as large as *Livyatan* roamed the North Sea Basin during Miocene times.

ACKNOWLEDGEMENTS

We wish to thank Mark Bosselaers and Freddy van Nieulande (Zeeuws Museum, Middelburg, the Netherlands), Harald van der Steen (Oss, the Netherlands) and dr Olivier Lambert (KBIN, Brussels, Belgium) for their hospitality and for making comparative material under their care available for study. Olivier Lambert gave helpful comments that greatly improved the quality of the manuscript.

REFERENCES

Abel, O., 1905 - Les odontocètes de Boldérien (Miocene supérieur) d'Anvers. *Mémoires du Musée Royal d'Histoire Naturelle de Belgique* 3: 1-155

Bianucci, G. & Landini, W., 2006 - Killer sperm whale: a new basal physeteroid (Mammalia, Cetacea) from the Late Miocene of Italy - *Zoological Journal of the Linnean Society* 148(1): 103-131

Boersma, A.T. & Pyenson, N.D., 2015 - *Albicetus oxymycterus*, a New Generic Name and Redescription of a Basal Physeteroid (Mammalia, Cetacea) from the Miocene of California, and the Evolution of Body Size in Sperm Whales - *PLoS ONE* 10(12): e0135551, doi:10.1371/journal.pone.0135551

du Bus, B.A.L., 1867 - Sur quelques Mammifères de Crag d'Anvers - *Bulletins de l'Academie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique* 24 : 562-577

du Bus, B.A.L., 1872 - Mammifères nouveaux du Crag d'Anvers - *Bulletins de l'Academie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique* 34 : 491-509

Fitzgerald, E.M.G., 2011 - A fossil sperm whale (Cetacea, Physeteroidea) from the Pleistocene of Nauru, equatorial southwest Pacific - *Journal of Vertebrate Paleontology* 31(4): 929-931

Gol'din, P.E. & Marareskul, V.A., 2013 - Miocene Toothed Whales (Cetacea, Odontoceti) from the Dniester Valley: The First Record of Sperm Whales (Physeteroidea) from The Eastern Europe - *Vestnik Zoologii* 47(5): 409-414

Gondar, D., 1975 - La presencia de cetáceos Physeteridae en el Terciario Superior ("Rionegrense") de la provincia de Río Negro - *Actas I Congreso Argentino de Paleontología y Bioestratigrafía* 2: 349-356

Hampe, O., 2006 - Middle/Late Miocene hoplocetine sperm whale remains (Odontoceti: Physeteridae) of North Germany with an emended classification of the Hoplocetinae - Fossil Record - *Mitteilungen aus dem Museum für Naturkunde in Berlin* 9(1): 61-86

Hirota, K. & Barnes, L.G., 1994 - A new species of Middle Miocene sperm whale of the genus *Scaldicetus* (Cetacea; Physeteridae) from Shiga-mura, Japan - *Island Arc* 3(4): 453-472

Kazár, E., 2002 - Revised phylogeny of the Physeteridae (Mammalia: Cetacea) in the light of Placoziphius Van Beneden, 1869 and *Aulophyseter* Kellogg, 1927 - *Bulletin-Institut royal des sciences naturelles de Belgique* 72: 151-170

Kellogg, R., 1925 - Two fossil physeteroid whales from California - *Contributions to Paleontology, Carnegie Institution of Washington* 348: 1-34

Kimura, T., Hasegawa, Y. & Barnes, L.G., 2006 - Fossil sperm whales (Cetacea, Physeteridae) from Gunma and Ibaraki prefectures, Japan; with observations on the Miocene fossil sperm whale *Scaldicetus shigensis* - *Bulletin Gunma Museum Natural History* 10: 1-23

Lambert, O., Bianucci, G. & de Muizon, C., 2008 - A new stem-sperm whale (Cetacea, Odontoceti, Physeteroidea) from the Latest Miocene of Peru - *Comptes Rendus Palevol* 7(6): 361-369

Lambert, O., Bianucci, G., Post, K., de Muizon, C., Salas-Gismondi, R., Urbina, M., & Reumer, J., 2010 - The giant bite of a new raptorial sperm whale from the Miocene epoch of Peru - *Nature* 466(7302): 105-108

Lambert, O., Bianucci, G. & de Muizon, C., 2016 - Macroraptorial sperm whales (Cetacea, Odontoceti, Physeteroidea) from the Miocene of Peru - *Zoological Journal of the Linnean* Society, doi: 10.1111/zoj.12456

Post, K. & Reumer, J., 2016 - History and future of paleontological surveys in the Westerschelde Estuary (Province of Zeeland, The Netherlands) - *Deinsea* 16: 1-9

Toscano, A., Abad, M., Ruiz, F., Muñiz, F., Álvares, G., Garcia, E.X. & Caro, J.A., 2013 - Nuevos restos de *Scaldicetus* (Cetacea, Odontoceti, Physeteridae) del Mioceno superior, sector occidental de la Cuenca del Guadalquivir (sur de España) - *Revista Mexicana* 30(2): 436-445

Varola, A., Landini, W. & Pilleri, G., 1988 - A new *Scaldicetus* (Cetacea: Physeteridae) from the Pietra leccese (Late Miocene) - *Investigations on Cetacea* 21: 16-38

Veenhof, R., Post, K., Van de Schootbrugge, B. & Reumer, J., 2016 - Inside the head of Miocene whales: using dinoflagellate cysts to constrain the age of marine megafauna from the Westerschelde - *Poster, ICP12 (12th International Conference on Paleoceanography, Utrecht, 28 August - 2 September 2016)*

Whitmore, F.C. & Kaltenbach, J.A., 2008 - Neogene Cetacea of the Lee Creek Phosphate Mine, North Carolina - *Virginia Museum of Natural History Special Publication* 14: 181-269

DEINSEA

DEINSEA - the online open-access Journal of the Natural History Museum Rotterdam
publishes contributions on zoology, paleontology and urban ecology
editor-in-chief Jelle W.F. Reumer | editors Bram W. Langeveld & Cornelis W. Moeliker
design TANK | layout Jaap van Leeuwen | content, back-issues & guidelines www.deinsea.nl

Natuurhistorisch Museum Rotterdam | Westzeedijk 345 (Museumpark) | 3015 AA Rotterdam | the Netherlands | www.hetnatuurhistorisch.nl