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SHARK – the How and Why of an Exhibit

Why This Exhibit?

For more than a decade, it has been a tradition at the Natuurhistorisch Museum Maastricht (NHMM; province of Limburg, the Netherlands; see Fig. 1) for the curators to work out concepts for new temporary exhibits, write all texts, select natural specimens to be put on display, and co-operate closely with technicians and designers. Half a year prior to the dismantling of "Biomimicry", the theme of the next exhibit had already been fully established, and a "skeleton" of the displays and texts devised. On 25 June 2016, the exhibit HAAI (Dutch for shark) was opened (see: www.nhmmaastricht.nl/exposities/haai.html; www.facebook.com/NatuurhistorischMuseumMaastricht).

But why sharks? In most of us, sharks inspire strong feelings of fear, panic, or repulsion. This is undoubtedly a question of "ignorance breeds contempt", and that is something that definitely needs to be remedied. In fact, sharks are amongst the greatest evolutionary success stories of animal life on Earth[1]. To-

[1] S. Weigmann: Annotated Checklist of the Living Sharks, Batoids and Chimaeras (Chondrichthyes) of the World, with a Focus on Biogeographical Diversity. *Journal of Fish Biology*, vol. 88, no. 3, 2016, pp. 837–1037. doi: 10.1111/jfb.12874. G.J.P. Naylor, J.N. Caira, K. Jensen, K.A.M. Rosana, N. Straube, C. Lakner: *Elasmobranch Phylogeny: A Mitochondrial Estimate Based on 595 Species*. In: *Biology of Sharks and Their Relatives*. London 2012, pp. 31–56. G.J.P. Naylor, J.N. Caira, K. Jensen, K.A.M. Rosana, W.T. White, P.R. Last: A DNA Sequence-based Approach to the Identification of Shark and Ray Species and Its Implications for Global Elasmobranch Diversity and Parasitology. *Bulletin of the American Museum of Natural History*, no. 367, 2012, pp. 1–262. S.P. Iglésias: *Handbook of the Marine Fishes of Europe and Adjacent Waters (A Natural Classification Based on Collection Specimens, with DNA Barcodes and*

day's oceans are still yielding new, undescribed species, particularly from the deeper parts[2]. Around 400 million years ago, there were already fish that we would now unhesitatingly refer to as sharks, which proves that the "invention" of the shark was spot on right from the start and that subsequently very few changes were needed. In short, it was a cast-iron design.

Unfortunately, these magnificent creatures are now threatened in their habitats around the globe, mostly as a result of overfishing, but also through human ignorance. To do justice to them, the focus is on sharks and rays in this exhibit. All special features are highlighted – their streamlined body shape and remarkable "revolver jaws", sandpaper-like skin, and much more. Their presence in today's oceans and seas, including the North Sea, as well as in prehistoric times is also reviewed. For example, during the Late Cretaceous, between 68 and 66 million years ago, over 100 species of shark, ray, and chimaera lived in the seas that covered what we now know as Maastricht and its environs.

Material, Screening, and Workflow

From the start, it was clear that we needed to co-operate closely with shark specialists, both at home and abroad. Frederik Mollen of Elasmobranch Research (Bonheiden, Belgium) is an authority on both extant and extinct sharks, rays, and related chimaeroid fish, with a well-stocked library and a representative, ever-growing collection. A selection of prepared jaws of Recent cartilaginous fish to be borrowed was made, and background information, illustrations, and items of literature were acquired. In addition, a partial skin of a zebra shark, *Stegostoma fasciatum* (Hermann, 1783), was obtained through the help of Frederik Mollen and Wim Wouters (Brussels, Belgium) and taken to taxidermist Leon Bouten at Venlo, the Netherlands. Additional fossil material (isolated teeth and vertebrae), of Late Cretaceous (Maastrichtian, *c.* 67-66 million years old [Ma]) and of Miocene-Pliocene (15-5 Ma) age, was received on loan from two private collectors (Jacques Severijns, Frans Smet).

In the meantime, the booklet to accompany the exhibit (Fig. 2) was written, first in Dutch and later in English, and a selection of illustrations made to

Standardized Photographs). Volume I (Chondrichthyans and Cyclostomata). Provisional version 08, 2014, 105 pp.

[2] W.T. White, P.R. Last, G.J.P. Naylor: *Rhinobatos manai* sp. nov., a new species of guitarfish (Rhinopristiformes: Rhinobatidae) from New Ireland, Papua New Guinea. *Zootaxa*, vol. 4175, no. 6, 2016, doi: 10.11646/zootaxa.4175.6.6. J. Pollerspöck, N. Straube: Bibliography database of living/fossil sharks, rays and chimaeras (Chondrichthyes: Elasmobranchii, Holocephali), www.shark-references.com, 2016.

be submitted to the graphic designer, Arthur Marks (Maastricht). Subsequently, these texts were modified to serve as background information on the series of panels in the exhibit (Fig. 3). The panels are 2.44 metres in height and 1.22 metres in width, and cover all walls of the mediaeval chapel of the Grauwzusters cloister, which is an integral part of the museum at De Bosquetplein 6-7, Maastricht. The shutters of the upper-level windows were closed in order to be able to project moving images of sharks and rays on white cloth. A beamer projects images of light reflecting on water, and together with the "air-bubble-showcases", arranged in four clusters, this makes visitors feel as if they are standing on the bottom of the ocean, surrounded by sharks and rays.

The Opening and an Associated Programme

Katrien Vandevelde with her husband Jan Wouters (www.blueshark.be), both of whom are divers and photographers, were asked to present a 30-minute lecture on underwater photography of sharks and rays, and the necessity of worldwide protection programmes for these beautiful animals. The pictures of face-to-face encounters with sharks and rays were especially appealing, and the message could not have been misunderstood by any of the more than 60 people present in the museum auditorium. A lighter tone was struck for the formal opening act – a remote-controlled, helium-filled shark balloon left the auditorium to "swim" into the exhibit hall, assisted by two 14-year-old boys, our "young fans" of sharks. In order to increase the impact of the exhibit and to reach as many people as possible, an associated programme of Sunday-afternoon lectures was agreed upon. The first talk, held in August by one of us (JWMJ), outlined what the curator responsible had learnt about cartilaginous fish, and sharks and rays in particular, from staging this exhibit. In September, Katrien Vandevelde returned to the museum to tell us all about protection programmes for sharks and rays, and why these are so urgently needed; this lecture was repeated in December 2016. Early October, a very special "Meet and Greet" session with representative species of sharks and rays from tropical seas (Elasmobranch Research collections, Bonheiden) was staged in the museum garden – over 200 people, including numerous children, marvelled at the specimens on display and learnt much about each species. During the last weekend of October, several private collectors put parts of their extensive collections of extinct sharks and rays (from close to home and far-flung places alike) on the table and made the visitors partake of their enthusiasm. A highlight during this weekend was the unveiling of a reconstructed jaw of the extinct mackerel shark (Fig. 4), *Carcharomodus escheri* (Agassiz, 1843) from the Mio-Pliocene of Mill-Langenboom (province of Noord-Brabant, the Netherlands), now in the collection of Erik Meeuwsen (Nijmegen). Near the end of November 2016, the HAROkit programme for Belgian fishermen was outlined by Krien Hansen (www.natuurpunt.be), coupled with a selection of typical shark and ray species from the North Sea and a gourmet session of smoked dogfish shark. In 2017, Dos Winkel (www.seafirst.nl) talked about the deplorable state of our oceans (January), while Guido Leurs (www.guidoleurs.org) explained to us why protective measures are so needed (March).

During the first two months following the opening in June, over 7,000 people had already visited the exhibit, which is why it was decided to extend it until 19 March 2017. Overall, the exhibit and the associated programme were well received by press and public alike[3], and featured on local and regional television and radio, also in neighbouring Belgium and Germany.

The Exhibit Itself

Seventy square metres (Fig. 5) is not a lot, so inevitably compromises needed to be made. Space is limited, but working upwards helps in getting the message across. On a considerable number of panels there is a load of information, but these texts are also included in the free booklet that accompanies the exhibit. Visitors can take this home, and read it at their leisure. The design of the exhibit (poster, booklet, and panels), the idea behind and execution of the "air bubbles", in which jaws are lit from below, the moving images, and stand-alone screen were by Arthur Marks, Rob van Avesaath, Johan Strijckers, and Milo Kusmic, respectively (Figs 6, 7).

The exhibit is divided into four portions – the shark phenomenon, a listing of all groups currently recognised and shark evolution (with notable cul-de--sacs), an overview of extinct sharks from the Maastricht area, with a good copy of Louis Agassiz's masterpiece (Fig. 8), and from the Oligocene, Miocene, and Pliocene of the Antwerp area (northwest Belgium), and, finally, examples of what humans are now doing to sharks, and their relatives. The museum shop stocks pens and pencils with shark motifs, cuddly toys, and squeaky rubber sharks, at least for the duration of the exhibit (Fig. 9).

[3] YF: Haaien in de slachtofferrol. *New Scientist*, September 2016, p. 84. R. Cobben: Stokoud maar vlijmscherp. *Dagblad de Limburger*, 31 October 2016 (Regio), p. 3.

The Shark Phenomenon

The public perception of sharks has been greatly influenced by films like "Jaws" (1975) and later productions of the film industry. Yet, few of us will ever experience a face-to-face encounter with sharks in their natural habitat. We will have to content ourselves with waterparks, zoos, and documentaries on TV and the Internet. In general, these do a good job with getting rid of our "inbred" fear of sharks and provide scientifically accurate information. In addition, conservation organisations at home and abroad are working hard to improve sharks' image and are calling for action where needed. We should move from fear to respect and admiration.

First of all, the form (morphology) and body structure (anatomy) of sharks and rays are explained and illustrated to allow us to fathom these animals' perfection, from the teeth in their mouths to the tooth-like dermal denticles on their skin, from their fins and fin spines to their senses, from their internal organs to their mode of reproduction and their place in the ecosystem. Sharks and rays – with cartilaginous skeletons – belong to the subclass Selachii, while chimaeroids are assigned to the Holocephali. These are mostly deep-sea denizens which lack a skin flap on the gill slits and dermal denticles, while the upper jaw is fused with the skull roof. Males have a tentacle on the head; this is absent on sharks and rays[4]. Although far less species-rich than bony fish, over 1,130 species of shark and ray have been identified to date. They are found in fresh and brackish waters, in temperate and subpolar seas, and in every ocean: from just below the surface to thousands of metres deep, and in coastal areas as well as in mid-ocean. This is the outcome of an evolutionary process that has been going on for millions of years. Every year new, previously unknown species are added to the list.

Sharks have paired and unpaired fins, each with a specific purpose – balance, propulsion, slowing down, or swerving – and supported by an internal skeleton made of cartilage arranged in parallel rows. Most species have two dorsal fins, but the position of these varies. The dorsal and anal fins counter the lateral power of propulsion generated by the tail and keep the shark on course. The tail fin provides propulsion. In many species this is asymmetrical (heterocercal), because the end of the vertebral column bends upwards and lends support to the upper lobe, which is often (much) larger than the lower one. Occasionally both lobes are nearly equal in size, resulting in a sickle-shaped tail.

The skin texture is remarkable – rubbed "against the grain" it feels rough to the touch, on account of the placoid scales or dermal denticles. The base of these dermal denticles is anchored in the skin and consists of bony tissue resembling

[4] M.J. Benton: *Vertebrate Palaeontology* (Second edition). Oxford 2000.

the dentine of the teeth in the mouth. On the base there stands a spine that is directed backwards. The form of this spine is species-specific and may have ridges, combs, or grooves. The spines also consist of dentine, but have a thin layer of enamel. Discarded placoid scales (up to 20,000 a year) are replaced; they grow larger as the shark grows older. Shark skin is essentially a patchwork of scales of varying size, shape, and structure, depending on the position on its body. Their primary function is to cover and protect the body and senses (receptors), but they also help reduce friction and prevent damage while moving over rocky sea floors. Remarkably, in many species the dermal denticles of males and females differ.

What is characteristic of sharks is that the teeth in the mouth are attached to the jaw bone by ligaments; the tooth roots are not directly connected to the jaw. The internal cavity is filled with pulp and covered by a thin layer of dentine and vitrodentine (enamel). Lacking organic material, the latter is extremely strong, hard, and durable. Throughout their entire lives, sharks continually replace their teeth. Their gum tissue is constantly growing, pushing their teeth upwards and forwards, in a kind of "revolver dentition". Tooth replacement occurs every 8 to 15 days. Each species has its own particular kind of teeth, depending on their prey and ecological niche, and many species can be recognised from their teeth alone. This makes the study of extinct sharks much easier. In some species all the teeth are the same shape, but in others they differ according to the position in the mouth. The front teeth are often much larger than those in the back – this pattern is referred to as heterodont or dimorphic. Finally, tooth difference in males and females also occurs, so-called sexual dimorphism.

Sharks have very special jaws. In nearly all modern species, the upper jaw is not connected to the skull. This is referred to as a hyostylic jaw attachment. It results in more moveable jaws. In the course of evolution, shark jaws became shorter, but the snout became wider and longer, which was linked to the position of their sense organs. The process of prey attack has been extensively studied in the white shark and comprises five stages. First, the head is pulled backwards, the lower jaw flips down, and in this way moves the snout 30 to 40 per cent upwards. The upper jaw then moves forwards and outwards; the teeth in the upper jaw now protrude from the mouth cavity, upon which the mouth is nearly closed by the upward movement of the lower jaw. In the final stage, the snout and head move downwards and the upper jaw returns to its original position (Fig. 10). A bite takes less than a second to complete. The wild movements made by the shark ensure optimum use of the teeth in the shearing process. The bite force of a mako shark is calculated to be around 3 tonnes per square centimetre.

Without exception, all cartilaginous fish have well-developed senses. What is of great importance is the sense of smell, which explains the large nostril size. The organs used to smell are themselves round or elliptical and situated on either side of the snout, in general close to the mouth. Sometimes they are even connected with the mouth. Scent traces are followed, often up to the direct vicinity of the prey, upon which an attack follows. Scents of animals of the opposite sex (and of sexual maturity) are also recognised in this way. The prey is not always swallowed completely, but is occasionally spat out, which proves that taste buds also play a role. In general, shark eyes are comparatively large and well developed, but apparently they cannot focus well on nearby objects. The diameter of the pupils adapts to light conditions. Requiem sharks have a third eyelid that protects the eye during attacks, while the white shark, *Carcharodon carcharias*, can even roll its eyes inwards. Hammerhead sharks have their eyes on lateral extensions of the head; because of this position and the broad movements made with their heads, these sharks have an enormous field of vision. It would appear that sharks can recognise colours (not only grey). An important specialisation in the eye is the so-called “tapetum lucidum” behind the cornea. This provides a reflective surface which reflects light and gives them sharper vision.

On the flank, the side line functions as a kind of sonar. The presence of other animals nearby can be recognised by the vibrations they produce. The ampullae of Lorenzini serve to perceive electrical fields (such as those generated by the muscular and nervous activity of other animals). These are hundreds of pores on and in the shark’s skin. The ampullae proper are clusters of elongate, blind tubes with a gel-like filling and tactile cells at their extremities. The pores are arranged conspicuously around the head and snout. Some species, especially hammerhead and whale sharks, travel long distances, sometimes via a fixed route. This is made possible by an internal geomagnetic compass which allows the animals to orientate themselves.

The section illustrating all types of shark and ray currently known is arranged according to order, listing typical features (dentition, body outline, number of gills and fins), depth, and dietary preferences, names of representative genera and species, and pictures of typical representatives. These include: frilled sharks and cowsharks (Hexanchiformes), bullhead sharks (Heterodontiformes), carpet sharks (Orectolobiformes), mackerel sharks (Lamniformes[5]), dogfish sharks (Squaliformes), angel sharks (Squatiniformes), sawsharks (Pristiophoriformes), ground sharks (Carcharhiniformes), bramble sharks (Echinorhiniformes), sawfishes (Pristiformes), wedge fishes (Rhiniformes), guitarfishes (Rhinobatiformes), electric rays (Torpediniformes), stingrays (Myliobatiformes), and skates (Rajiformes).

[5] L. Schnetz, C. Pfaff, J. Kriwet: Tooth Development and Histology Patterns in Lamniform Sharks (Elasmobranchii, Lamniformes) Revisited. *Journal of Morphology*, vol. 277, no. 12, 2016, doi: 10.1002/jmor.20597.

Extinct Sharks, Rays, and Chimaeras – Cretaceous

Ever since the late eighteenth century, isolated teeth of sharks and rays and tooth plates of chimaeras have been collected from the limestone deposits of Sint-Pietersberg (the Netherlands) and environs, and illustrated and described in the scientific literature[6]. In 1843 the Swiss scientist Louis Agassiz assigned Latin names to several species from Maastricht that are still valid today.

Collectors often know exactly where to search, and that also holds true here – gritty levels in the chalk deposits often yield beautifully preserved isolated teeth with shining enamel. On the basis of these teeth, over one hundred species have already been distinguished. Often these are very small and can only be found when the chalky sediment is washed and sieved. A considerable number of species have not yet been formally described and await their proper scientific designation. A range of families have already been documented, some of them representing extinct groups like the Anacoracidae, Otodontidae, and Palaeospinacidae[7]. Occasionally, loose, partially calcified, and comparatively large vertebrae are found. Smaller, more compact vertebrae of angel sharks (Squatinidae) are also known. A very rare find from the ENCI quarry (Maastricht) is that of the snout of a sawfish with "teeth", *Ganopristis leptodon* (Arambourg, 1952). This specimen will now allow scientists to study all kinds of preserved anatomical details (e.g., the ampullae of Lorenzini). Finds of vertebrae and over 25 teeth of a large-sized shark, *Squalicorax lindstroemi* (Davis, 1890) from Haccourt (Liège, Belgium) and of a male chimaera (with spine and clasper) from Eben Emael (Belgium) also appeal to our imagination.

66 million years ago, as a result of a meteorite impact in Yucatán (Mexico), marine lizards (mosasaurs) in the seas went extinct, and large sharks cashed in on the new situation. Shark, ray, and chimaera species now known from the

[6] L. Agassiz: *Recherches sur les poissons fossiles*. Neuchâtel, 1833-1844, xlix + 188 pp.; xii + 310 + 366 pp.; viii + 390 + 32 pp.; xvi + 296 pp.; xii + 122 + 160 pp.; 10 +149 + 83 + 61 + 91 pls. A. Brignon: Faujas de Saint-Fond, Reinwardt, Cuvier et les poissons fossiles du Crétacé de la "Montagne Saint-Pierre" de Maastricht (Pays-Bas). *Geodiversitas*, vol. 37, no. 1, 2015, pp. 59–77.

[7] H. Cappetta: *Handbook of Paleoichthyology. Volume 3E. Chondrichthyes. Mesozoic and Cenozoic Elasmobranchii. Teeth.* München 2012. K. Shimada, R.E. Chandler, O. Lok Tao Lam, T. Tanaka, D.J. Ward: A New Elusive Otodontid Shark (Lamniformes: Otodontidae) from the Lower Miocene, and Comments on the Taxonomy of Otodontid Genera, Including the "Megatoothed" Clade. *Historical Biology*, vol. 29, no. 5, 2016, doi: 10.1080/08912963.2016.1236795. K. Shimada, E.V. Popov, M. Siversson, B.J. Welton, D.J. Long: A New Clade of Putative Plankton-feeding Sharks from the Upper Cretaceous of Russia and the United States. *Journal of Vertebrate Paleontology*, vol. 35, no. 5, 2015 (e981335), pp. 1–13. D.J. Ehret, B.J. MacFadden, D.S. Jones, T.J. Devries, D.A. Foster, R. Salas-Gismondi: Origin of the White Shark *Carcharodon* (Lamniformes: Lamnidae) Based on Recalibration of the Upper Neogene Pisco Formation of Peru. *Palaeontology*, vol. 55, no. 6, 2012, pp. 1139–1153.

younger chalk levels in the area are reminiscent of faunas from colder regions like Denmark[8].

Younger Sharks

In some places in the Netherlands and on adjoining Belgian territory well-preserved shark and ray teeth may be found. On the coast of Zeeland, near Cadzand and Het Zwin, dark blue and black teeth of species of Eocene age (56–41 million years old) are washed ashore; collecting these has become a real sport for amateur palaeontologists and tourists alike[9]. Closer to Maastricht, excavations for the canal near Elsloo yielded huge numbers of 15-million-year-old shark and ray teeth during the first half of the last century. These included a tooth of the largest shark species ever to have lived on Earth, *Otodus megalodon* (Agassiz, 1843), which had a cosmopolitan distribution. Even richer, particularly in the number of species (around 50), is a similarly aged fauna from Winterswijk-Miste[10]. Remarkably, many of these are closely related to extant species living in warm-temperate and subtropical shallow seas today.

The perfectly preserved shark teeth found at Mill-Langenboom and Liessel (Noord-Brabant) are slightly younger. Hundreds of specimens of certain species – such as *Cosmopolitodus hastalis* (Agassiz, 1843) and *Carcharomodus escheri* – are preserved in private collections throughout the country. They give us a fantastically rich picture of faunas that no longer occur in the North Sea or the north-east Atlantic. One particularly remarkable find is the calcified nose of the porbeagle *Lamna nasus* (Bonnaterre, 1788) at Liessel. Finally, there is the Antwerp harbour area, where dock extension work created plenty of opportunity for collecting. Larger species of Pliocene age (5.3–2.58 million years ago) became particularly sought-after collector's items. From time to time more than just isolated teeth were recovered, although the teeth already reflected huge diversity. A more or less complete devil ray jaw and portions of the gill rakers and vertebral column of the basking shark, *Cetorhinus maximus* (Gunnerus, 1765), are of note.

[8] J.S. Adolfssen, D.J. Ward: Crossing the Boundary: An Elasmobranch Fauna from Stevns Klint, Denmark. *Palaeontology*, vol. 57, no. 3, 2014, pp. 591–629. J.S. Adolfssen, D.J. Ward: Neoselachians from the Danian (Early Paleocene) of Denmark. *Acta Palaeontologica Polonica*, vol. 60, no. 2, 2015, pp. 313–338.

[9] H. Cappetta, D. Nolf: Révision de quelques Odontaspididae (Neoselachii: Lamniformes) du Paléocène et de l'Eocène du Bassin de la mer du Nord. *Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre*, vol. 75, 2005, pp. 237–266.

[10] T. Bor, T. Reinecke, S. Verschueren: Miocene Chondrichthyes from Winterswijk-Miste, the Netherlands. *Palaeontos*, vol. 21, 2012, pp. 1–136.

Extinct Sharks Reconstructed

Given their cartilaginous skeleton, it is understandable that only a handful of complete (or near-complete) fossil sharks and rays have ever been found. Nonetheless, in recent years there have been a considerable number of "chance finds". These include the partial skeleton of Miocene (11.6-5.3 million years old) mackerel sharks from Peru and northern Germany and that of a much older species (*c.* 83.5 million years old) from Kansas (US), *Cretalamna hattini*. In the latter specimen, parts of the skull are preserved. This is exceedingly rare[11]. The most spectacular find of recent years is arguably that of a new mackerel shark, *Haimirichia*, from the Late Cretaceous of Morocco. This had a hitherto unknown type of placoid scale (dermal denticle) which was possibly directly connected with electroreceptors that differed from the "normal" ampullae of Lorenzini[12].

Even isolated elements of skeletons and jaws can provide us with a wealth of data on vertebral structure (and annual growth phases), total body length, and bite circumference, among other things[13]. When numerous teeth are available

[11] M. Siversson, J. Lindgren, M.G. Newbrey, P. Cederström, T.D. Cook: Cenomanian-Campanian (Late Cretaceous) Mid-palaeolatitude Sharks of *Cretalamna appendiculata* Type. *Acta Palaeontologica Polonica*, vol. 60, no. 2, 2015, pp. 339–384. B.B. Hansen, G. Cuny, B.W. Rasmussen, K. Shimada, P. Jacobs, C. Heilmann-Clausen: Associated Skeletal and Dental Remains of a Fossil Odontaspidid Shark (Elasmobranchii: Lamniformes) from the Middle Eocene Lillebælt Clay Formation in Denmark. *Bulletin of Geological Society of Denmark*, vol. 61, 2013, pp. 37–46. J. Kriwet, H. Mewis, O. Hampe: A Partial Skeleton of a New Lamniform Mackerel Shark from the Miocene of Europe. *Acta Palaeontologica Polonica*, vol. 60, no. 4, 2015, pp. 857–875. K. Shimada, D.J. Ward: The Oldest Fossil Record of the Megamouth Shark from the Late Eocene of Denmark and Comments on the Enigmatic Megachasmid Origin. *Acta Palaeontologica Polonica*, vol. 61, no. 4, 2016, pp. 839–845.

[12] R. Vullo, G. Guinot: Denticle-embedded Ampullary Organs in a Cretaceous Shark Provide Unique Insight into the Evolution of Elasmobranch Electroreceptors. *Science and Nature*, vol. 102, 2015, pp. 1–8. R. Vullo, G. Guinot, G. Barbe: The First Articulated Specimen of the Cretaceous Mackerel Shark *Haimirichia amonensis* gen. nov. (Haimirichiidae fam. nov.) Reveals a Novel Ecomorphological Adaptation within the Lamniformes (Elasmobranchii). *Journal of Systematic Palaeontology*, vol. 14, no. 12, 2016, pp. 1–22.

[13] A. Blanco-Piñón, K. Shimada, G. González-Barba: Lamnoid Vertebrae from the Agua Nueva Formation (Upper Cretaceous: Lower Turonian), Northeastern Mexico. *Revista Mexicana de Ciencias Geológicas*, vol. 22, no. 1, 2005, pp. 19–23. H. Cappetta, S. Adnet, D. Akkrim, M. Amalik: New *Squalicorax* Species (Neoselachii: Lamniformes) from the Lower Maastrichtian of Ganntour Phosphate Deposit, Morocco. *Palæovertebrata*, vol. 38, 2014, pp. 1–13. D.J. Cicimurri, C.N. Ciampaglio, K.E. Runyon: Late Cretaceous Elasmobranchs from the Eutaw Formation at Luxapalila Creek, Lowndes County, Mississippi. *PalArch's Journal of Vertebrate Palaeontology*, vol. 11, no. 2, 2014, pp. 1–36. C.G. Diedrich, U. Scheer: Marine Vertebrates from the Santonian Coastal Carbonates of Northwestern Germany – a Tool for the Reconstruction of a Proto-North Sea Basin Intertidal Dinosaur-exchange Bridge. *Open Geoscience*, vol. 7, 2015, pp. 342–361. J. Kriwet, A. Engelbrecht, T. Mörs, M. Reguero, C. Pfaff: Ul-

from the same locality and from a single level, as at Mill-Langenboom, reconstructions of the entire lower and upper jaws can be made, including the place where the jaw halves meet, the symphysis. Using dental formulas, the position of each and every tooth can be computed. Well-versed specialists are able to determine whether an isolated tooth was from the upper or lower jaw, and whether this was originally in an anterior or intermediate position. Finally, because most fossil species (*c.* 70 million years old or younger) can be directly compared with recent representatives, the isolated teeth of sharks and rays can also yield data on the water depth and ecological niche of the seas they once occupied.

Humans and Sharks

Flipping through the pages of old books makes it immediately clear that the relationship between humans and sharks has always been an ambivalent one. On the one hand, fear predominates, with the consequent urge to remove the source of that fear. This anxiety – bred of ignorance – has already led to the death of innumerable sharks, and today's overfishing of our seas and oceans is having similarly disastrous effects. In fact, amongst the many eye openers during the preparatory phase of the exhibit there was the fact that in countries bordering the North Sea and the Mediterranean, shark meat is often offered on fish markets under different names (Table 1), posing as bony fish or crustaceans.

On the other hand, there is our fascination with these wonderful animals – just take a walk through one of the tunnelled shark tanks at zoos and aquariums, and experience the feeling! Sharks and rays have also served as an inspiration for everyday items, as well as less commonly used ones. We might mention, for instance, the painted "shark's teeth" on our streets or hedge-cutters with their sawblade that looks like it has been modelled on the rostrum of a sawfish from

timate Eocene (Priabonian) Chondrichthyans (Holocephali, Elasmobranchii) of Antarctica. *Journal of Vertebrate Paleontology*, vol. 36, no. 4, 2016, doi: 10.1080/02724634.2016.1160911. M.G. Newbrey, M. Siversson, T.D. Cook, A.M. Fotheringham, R.L. Sanchez: Vertebral Morphology, Dentition, Age, Growth, and Ecology of the Large Lamniform Shark *Cardabiodon ricki*. *Acta Palaeontologica Polonica*, vol. 60, no. 4, 2015, pp. 877–897. J. Pollerspöck, B. Beaury: Eine Elasmobranchierfauna (Elasmobranchii, Neoselachii) aus der Oberen Meeresmolasse (Ottnangium, Unteres Miozän) des Heigelsberger Grabens bei Teisendorf, Oberbayern. *Zitteliana*, vol. A54, 2014, pp. 23–37. J. Pollerspöck, B. Beaury: *Parasquatina zitteli* nov. sp. (Elasmobranchii: Orectolobiformes) aus dem Maastricht von Oberbayern (Gerhartsreiter Schichten, Siegsdorf) und Bemerkungen zur Verbreitung der Ordnung Orectolobiformes. *Zitteliana*, vol. A54, 2014, pp. 147–164.

the ray family Pristidae[14]. Borrowing from nature – it is biomimicry *in optima forma*. What inspired the designer of the "gills" in certain models of car is not hard to guess, and also the special swimsuits ("fastskin") that became so popular a while ago are in fact a one-to-one copy of sharkskin – a skin with placoid scales arranged in such a way as to keep seawater friction to a minimum, and permit greater speed and manoeuvrability.

Today, the world's ever-growing human population is putting natural habitats under even greater pressure. Just take a moment to consider the huge impacts of deforestation, mineral extraction and overfishing. It is as if human activity has become entirely divorced from nature – the very nature that produced our own species after millions of years of evolution. The subtle balance that exists in food chains on the land and in the seas – with top predators as the "final stage" – is being disrupted by human activities across the globe. Removing just a single shark or ray from its natural habitat is not without consequence, let alone the culling of an entire group.

Although Steven Spielberg's film "Jaws" is the best known of the genre, a whole range of motion pictures could be listed in which sharks are given a very bad press indeed. The small selection of this kind of films shown in the exhibit needed no further comment. Even comic books, TV cartoons, and cinema films ("Finding Nemo", "Shark Tale", and others) appeal to the inborn human fear of sharks. There are exceptions to the rule, but not that many – in any case not nearly enough. Thankfully, there is also more positive news. At the top of the list, there are the unending efforts of nature conservationists across the globe, ranging from direct protection at sea to educating all those who have an impact on the habitats of sharks and rays, whether in commercial or non-commercial activity. Zoos and waterparks (occasionally with special breeding programmes) are also doing their bit to improve the image of sharks. Yet, statistics show that at least 107 species of ray and 74 species of shark are currently threatened or severely threatened with extinction. All in all, this means that over a quarter of all known species are under threat. When this is compared with the very small number of people killed annually by sharks and rays (often "accidentally"), it soon becomes clear who the hunter is, and who the prey. If this exhibit has contributed in any way to engendering greater respect and admiration for these creatures, then we have succeeded in our objective.

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[14] J. Kriwet, K. Kussius: Paleobiology and Paleobiogeography of Sclerorhynchid Sawfishes (Chondrichthyes, Batomorphii). *Revista Española de Paleontología*, nº extraordinario, 2001, pp. 35–46. M.M. Smith, A. Riley, G.J. Fraser, C. Underwood, M. Welten, J. Kriwet, C. Pfaff, Z. Johanson: Early Development of Rostrum Saw-teeth in a Fossil Ray Tests Classical Theories of the Evolution of Vertebrate Dentitions. *Proceedings of the Royal Society B*, vol. 282, no. 1816, 2015, 20151628.

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Table 1

Names in various European languages under which shark meat is “hiding” (Source: www.blueshark.be)

Dutch	English	French	Greek	German	Spanish	Italian
Zeepaling Surimi	Flake Huss Catfish Dogfish Greyfish Steakfish Whitefish Lemon Fish Cape Steak Rock Salmon Smoked Rock Salmon Smoked Dogfish Rigg Gummy Sea Ham Sokomoro	Chiens Petite Roussette Grande Roussette Anguille de Mer Saumonette Taupe Veau de Mer	Galeos	Seeaal Meeraal Schillerlocken Kalbsfisch Speckfisch Dornfisch Karbonadenfisch Königsaal Steinaal Steinlachs Seestör Wildstör Forellenstör Falsche Jakobsmuscheln Falsches Krabbenfleisch (Surimi)	Gallina del mar Alo Rosado Lobito Cazón Tintorera Caella	Palombo Smeriglio Cani Spellati Gattucci Spinaroli

Figure 1. The main entrance of the Natuurhistorisch Museum Maastricht, De Bosquetplein 7, Maastricht; on the left-hand side there is the chapel of the former Grauwzusters cloister (photograph: J.W.M. Jagt).

Figure 2. Title page of the 44-page-booklet in A5 format (Dutch version) accompanying the exhibit and available to all visitors (graphic design by Arthur Marks, Maastricht).

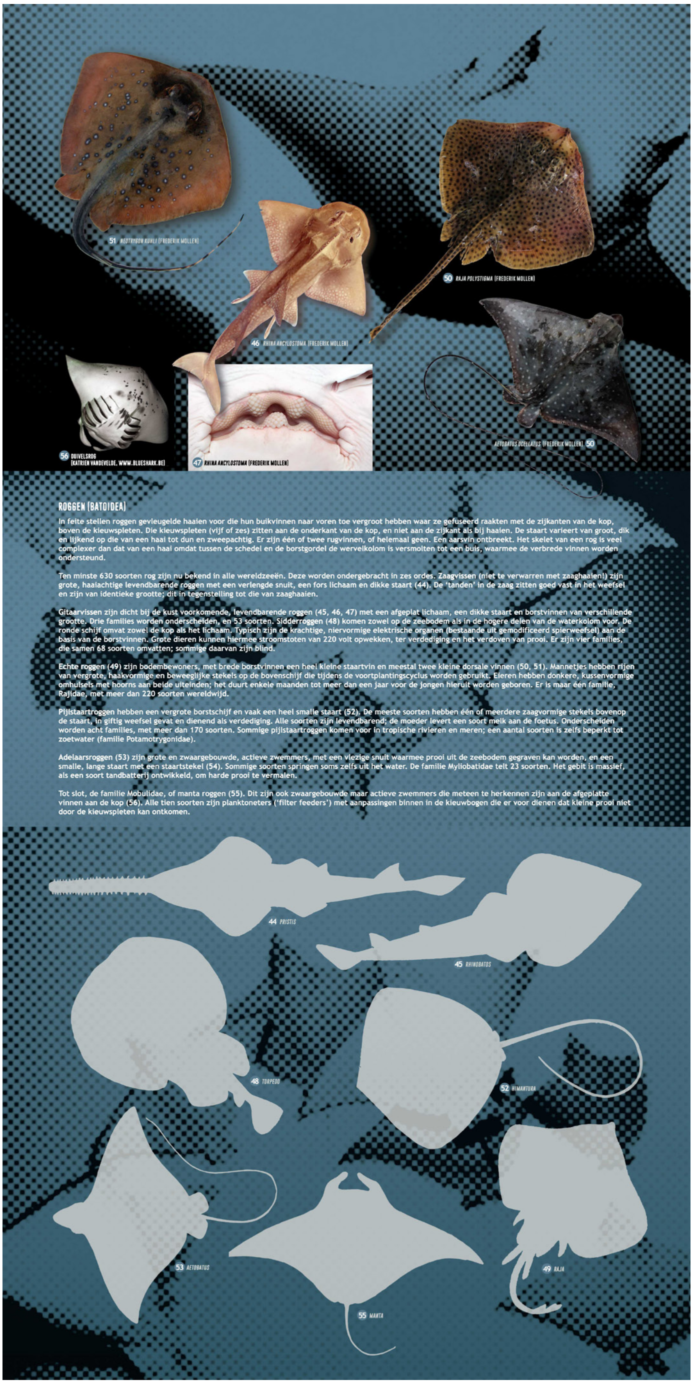

Figure 3. One of the panels in the exhibit, with specific information on rays (Batoidea) (graphic design by Arthur Marks, Maastricht).

Figure 4. Reconstructed jaws, with genuine teeth from the Mio-Pliocene of Mill-Langenboom (the Netherlands), of the extinct mackerel shark, *Carcharomodus escheri* (Agassiz, 1843) (Erik Meeuwsen Collection, Nijmegen; photograph: J.W.M. Jagt).

Figure 5. General overview of part of the exhibit HAAI (photograph: J.W.M. Jagt). The life-size model of the white shark, *Carcharodon carcharias*, was produced by Rob van Avesaath (Maastricht).

Figure 6. Detail of one of the "air bubbles" with the jaws of a white shark, *Carcharodon carcharias* (Frederik Mollen Collection) (photograph: J.W.M. Jagt).

Figure 7. Part of the exhibit, with other shark, ray, and chimaerid species in "air bubbles" (photograph: J.W.M. Jagt).

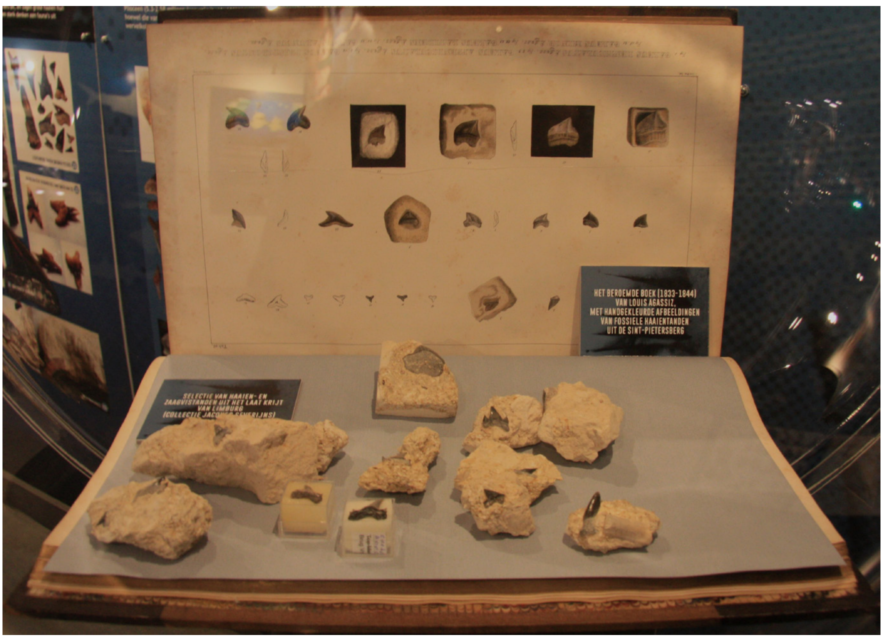

Figure 8. A copy of Louis Agassiz's (1843) "Recherches sur les poissons fossiles", opened to the page with the original, hand-coloured drawings of *Corax pristodontus* (now *Squalicorax pristodontus*), one of the commoner shark species in the Maastrichtian type area (photograph: J.W.M. Jagt).

Figure 9. Cuddly sharks in the museum shop (photograph: J.W.M. Jagt).

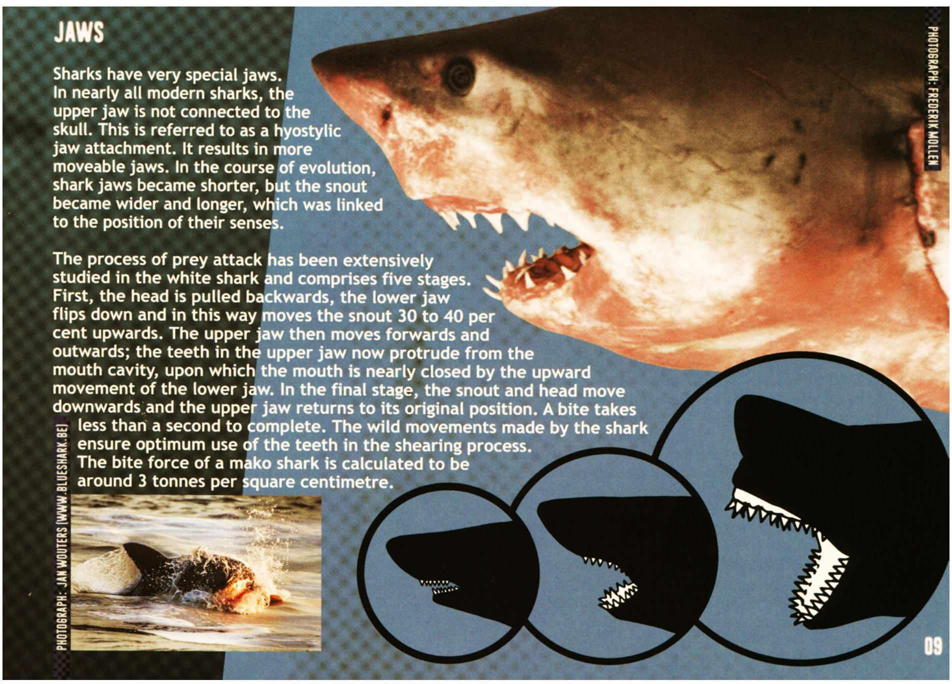

Figure 10. One of pages in the exhibit booklet, with specific information on shark jaws and bite force (graphic design by Arthur Marks, Maastricht).