has a total length of 61 cm. The specimen is similar to the one of Beddard (1915), here too the lower jaw is about as long as the rest of the head.

A slightly larger foetus is described by Kükenthal (1914, pl. III b figg. 34, 35). The specimen had a total length of 74 cm, the lower jaw does not reach the anterior border of the head as is especially apparent in a ventral view (cf. fig. 2 k). The ventral part of the muzzle is almost vertical, the dorsal half is obliquely cut off (cf. fig. 2 j).

Three young sperm whales in which the teeth of the lower jaw had not yet cut the gum have been described. One of these (Wheeler, 1933) had a length of 13 feet 3 inches (404 cm), its lower jaw is much shorter than the dorsal part of the head (cf. fig. 2 m). Of the second specimen the head only is known, it is described by Pouchet and Beauregard (1892). The length of the head was 147 cm, taking this as one third of the total length the animal would have measured 441 cm. Here again the dorsal part of the head extends distinctly beyond the tip of the lower jaw. In the third specimen (Raven and Gregory, 1933) too the lower jaw is much shorter than the rest of the head. The total length of this animal was 18 feet 3½ inches (approximately 557 cm). In the three young animals mentioned above the muzzle had a more or less oblique anterior surface, the dorsal part of the head being the foremost.

34. Remarks on the shape of the head of the sperm whale.

In the previous pages repeatedly mention has been made of figures in which the head of the sperm whale was represented as squarely truncated in front. In the description of the head of the sperm whale by Melville (1851) the following statement is found (quoted from p. 292 of an edition of 1930): ".....the front of his head presents an almost wholly vertical plane to the water; you observe that the lower part of that front slopes considerably backwards, so as to furnish more of a retreat for the long socket which receives the boom-like lower jaw;....." Photographed specimens, however, almost invariably show that the head is not as strongly truncated, but more or less rounded in front.

As remarked above on several occasions, many figures of sperm whales show the fault of representing the lower jaw as long as the upper part of the head or nearly of this length. Several authors have drawn attention to the fact that this is incorrect. Already Robertson (1771) remarked that in his specimen the upper jaw projected five feet over the lower. Fleming (1828), referring to the specimen stranded at Limekilns in 1689 described by Sibbald, remarks that the upper jaw projected 2½ feet beyond the

lower. Harmer (1918 b, 1927) too points to the fact that the lower jaw of the sperm whale is shorter than the rest of the head.

Pouchet and Chaves (1890) remark that the muzzle of adult sperm whales may project beyond the tip of the lower jaw for a distance of nearly two meters. The sperm whales figured by them and by Pouchet and Beauregard (1889 a) had a more or less evenly rounded anterior part of the head. Ritchie and Edwards (1913) remark that the specimen which they examined had an enormous squarely truncated pre-oral rostrum; the shape of the head was entirely different from that figured by Lillie (1910), but it differed as much from the round-muzzled Azores specimens of Pouchet and Chaves.

Kükenthal (1914) gives a figure of a specimen with a truncated rostrum. He remarks that this proves that Pouchet and Chaves were wrong in regarding the figures given by Beale, Scammon, and Turner as incorrect.

Beddard (1915) regards the truncated form of the head in adult sperm whales as a retention of an embryonic character.

Perhaps the best description of the head of the sperm whale is that given by Stead (1930, p. 130), which reads: "The head is relatively, and actually of enormous size, being commonly more than one-third of the entire length of the animal, and is high and squarish, the profile being bluff and squarish, rounded off at the summit and below on each side. Very few of the illustrations of the Sperm Whale convey anything like a proper idea of the shape of this remarkable head, which is usually shown as far too wide and square at the snout. Viewed from above the latter is seen to be somewhat like a rounded wedge, which, though high at the extremity, is fairly narrow. The snout projects far beyond the end of the lower jaw."

Taking into account the numerous opinions on the head of the sperm whale expressed by different authors we may come to the following conclusion. In young animals the snout does not project appreciably beyond the tip of the lower jaw. During growth the snout gradually becomes larger. In females and in young males the anterior part is slightly tapering in front when viewed from the side, or more or less evenly rounded at its anterior extremity. In full grown male sperm whales the dorso-ventral diameter of the snout is about equal to that of the rest of the head; in a lateral direction the foremost part of the head is somewhat compressed and wedge-shaped. A transverse section of the anterior part of the head shows a broad dorsal ridge, separated by shallow grooves from the convex lateral regions. The latter towards the ventral part of the head gradually slope downwards until at the ventral surface there is a more or less sharp keel. In full grown males the central part of the anterior surface of the head forms a vertical plane, the margins of the anterior surface are smoothly rounded and pass without sharp contours into the lateral parts of the head.

IV. THE TEETH OF THE SPERM WHALE

1. The mandible and its alveoli.

Descriptions and figures of lower jaws of sperm whales with complete series of teeth are found in numerous publications. In the older works often all the teeth are drawn of one size, but in later publications figures were given which show that the hindmost teeth and a few of the foremost are much smaller than those of the greater part of the jaw. One of the first figures showing the complete dentition in the lower jaw and the difference in size of the teeth is that of Camper (1820, pl. XXVII). In later years many of these correct figures were published.

Repeatedly attention has been drawn to the fact that sometimes male sperm whales are found with abnormally curved or twisted jaws. Usually this is explained as a result of fighting of two animals (cf. Beale, 1839; Thomson, 1867). Figures of such deformed jaws are given by Murie (1865) and Fischer (1867). In these figures the jaws are drawn without the teeth, so that the alveoli are visible, but represented rather diagrammatically.

In the literature on the sperm whale which has come to my notice no other figures of the alveoli of the lower jaw are found. In the accompanying figure (fig. 6) the symphysial part of the lower jaw of the larger specimen is represented, showing the size and shape of the alveoli. The figure was made after the gum and the other soft parts of the lower jaw had been removed.

In comparison to the alveoli of other mammals those of *Physeter* are very indistinct. Along the whole of the symphysial part of the lower jaw and somewhat farther in a posterior direction there is a continuous groove in each half of the lower jaw. This groove is imperfectly divided into smaller cavities by partitions which remain much lower than the sides of the grooves. The partitions as well as the bottom of the cavities are full of canals for blood vessels and nerves. In each of the cavities, the alveoli, a tooth was implanted surrounded by a thick mass of the gum. The description given by Turner (1903) of these alveoli reads: "The sockets of the teeth were elongated antero-posteriorly. Those which had the largest teeth were 8 inches in length and about 3¼ inches in greatest breadth. In each alveolus the hinder end was the deepest part, from which it gradually shallowed forward." (l.c., p. 427). With the exception of the sizes this description fits in with the alveoli of our specimens. Here the maximum length is about 16 cm, and the maximum breadth 6½ cm.

The figure shows that the toothrows of the two sides do not correspond in place. In each half the two anterior alveoli are more or less confluent; in the following part each tooth of the left half is slightly in front of the corresponding tooth of the other side so that already the seventh tooth of the left side is in the same transverse plane as the sixth of the right side. The alveoli behind those of the eighteenth teeth become more and more indistinct; in the posterior part of the groove there is hardly any division into separate cavities.

Already in the older literature remarks are found on the alveoli of the sperm whale with their loosely implanted teeth. Hunter (1787), who draws attention to the shallow and imperfect alveoli of this animal, thinks that there is a continuous formation of new teeth in the posterior part of the jaw: "It would appear, that the jaw, as it increases posteriorly, decays at the symphysis, and while the growth is going on, there is a constant succession of new teeth, by which means the new-formed teeth are proportioned to the jaw. The same mode of growth is evident in the Elephant, and in some degree in many fish; but in these last the absorption of the jaw is from the whole of the outside along where the teeth are placed. The depth of the alveoli seems to prove this, being shallow at the back part of the jaw, and becoming deeper towards the middle, where they are the deepest, the teeth there having come to the full size. From this forwards they again become shallower, the teeth being smaller, the sockets wasting, and at the symphysis there are hardly any sockets at all. This will make the exact number of teeth in any species uncertain." (Hunter, 1787, p. 400).

This manner of succession of functional teeth would not be unique among mammals, as it occurs in the manatee (cf. Weber, 1928, p. 489), in which

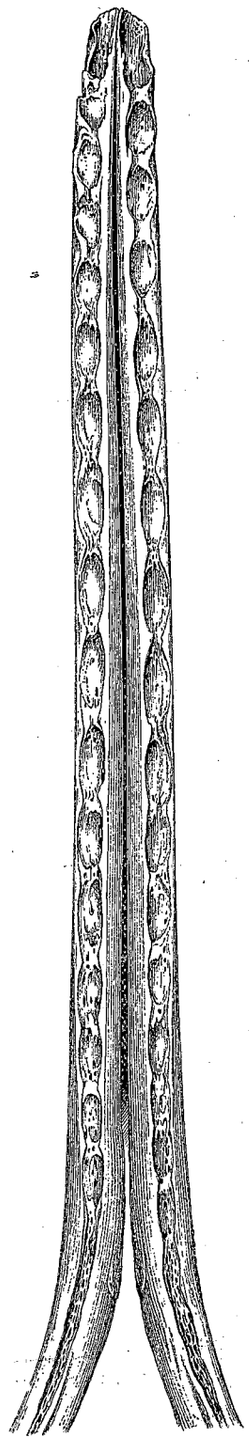


Fig. 6. Symphysial part of the lower jaw of the larger specimen, showing the alveoli. × 1/16.

till 20 molars are formed in each jaw, of which 5 to 8 are functional at the same time. The worn, oldest, foremost teeth drop out and they are replaced by new ones in the posterior part of the jaw. During this process the walls of the alveoli are resorbed in front of the teeth and formed anew behind them.

In *Physeter*, however, no more than about 25 teeth are formed in each half of the lower jaw, and in full grown specimens all these teeth may be functional at the same time. The foremost few teeth are of smaller size than those towards the middle of the jaw, and they remain smaller during the life of the animal. The hindmost group of teeth in each half of the lower jaw often show a fully closed pulp cavity when still of small size, so that they never could grow out again into the large teeth with widely open pulp cavity as they occur in the middle part of the jaw. The teeth are not gradually shifting in the alveolar groove from back to front, but remain in the alveoli in which they are formed, whilst in the hindmost group of teeth there is a strong tendency to become rudimentary.

2. The literature on the teeth of the sperm whale, especially on the maxillary teeth.

Especially the mandibular teeth of the sperm whale have been known for a long time. In the older literature these teeth were described and figured as long tusks, e.g., by Olaus Magnus (1567) and by Gesner (1558). Probably Masius (1874)was influenced by these statements when he wrote: "40—50 Zähne starren fusslang aus dem Unterkiefer."... As soon as sperm whale teeth found their way to the cabinets of curiosities, descriptions of these objects appeared in the literature, often accompanied by accurate figures. Some of these may be mentioned here.

To the figure of the animal stranded at Nice published by Baier (1733) this author has added a figure of a tooth from his own collection, undoubtedly that of a sperm whale. The tooth has a conical shape, it is slightly truncated at the top; the extent of the pulp cavity is indicated with a dotted line. The shape of the tooth figured by Klein (1741, pl. IV fig. 3) is similar in nearly every respect. In both figures the topmost part of the tooth shows the dentine, as the cement is abraded here by use.

Pennant (1776, pl. VII) gives, besides a figure of a tooth of a dolphin, four figures of teeth of sperm whales. One of these is from the "High-Finned Cachalot", two are from the "Round-Headed Cachalot". The first is of conical shape with a broad, laterally flattened fang and a comparatively blunt top. The larger of the two teeth of the "Blunt-Headed Cachalot" is conical too, but slenderer and with a sharper top. The smaller has a curved

shape, its fang is narrowed beneath and the pulp cavity at the back of the tooth is open to the outside by a broad cleft. The figure shows a kind of excrescence at the top of this cleft which might represent a mass of osteodentine. It is not impossible that this tooth came from the upper jaw, as it corresponds in its general aspect with some of the maxillary teeth described below. The tooth of the "Round-Headed Cachalot" figured by Pennant has a flat top, possibly on account of abrasion, and a narrow constricted fang. Probably this tooth came from the posterior part of the lower jaw of a sperm whale.

There are numerous other figures of mandibular teeth of sperm whales, but the few examples given here may suffice to illustrate the general shape. In former times the teeth were regarded as important characters, as a number of different species were described based on the different shape of the teeth. One more figure may be referred to here as it illustrates the composition of sperm whale teeth, viz., that of Owen (1840—1845, pl. 89 fig. 2). The figure represents a section of a mandibular tooth, it shows the dentine, composed of successive layers, the surrounding layer of cement, and in the pulp cavity the irregular masses of osteodentine which during growth have become imbedded in the dentine. The same figure is found in Owen (1866—1868, vol. 1, fig. 239) and in Pouchet and Beauregard (1889 b, fig. 168).

As a result of abrasion during use the mandibular teeth of the sperm whale may completely lose their sharp points and gradually become evenly rounded. This had happened in our specimens, but it is known in other specimens too. Some writers of the seventeenth century (van Meteren, 1647; Bor, 1684) compared the teeth of such a specimen to large hen's eggs. It is well known that especially the hindmost teeth can be strongly abraded (van Beneden and Gervais, 1868—1880; Pechuel, 1869).

An interesting figure is found in a paper by Wood (1885). It represents a few mandibular teeth surrounded by the gum. The tops of the teeth protrude for some distance above the gum and above these tops the surface of the palate is drawn with an indication of the pits into which the teeth are fitting when the mouth is shut.

In the following pages a review is given of the literature concerning the opinions about the presence or absence of maxillary teeth and on the development of our knowledge of these teeth.

In the more or less mythical figures of *Physeter* in the works of Olaus Magnus (1567, first edition 1555), Herold (1557), and Gesner (1558) the lower jaw possesses two or three large tusks, in some of these figures moreover a number of smaller teeth are found in the lower as well as in the upper jaw.

Clusius (1605) and Worm (1655) state that the lower jaw possesses teeth, but do not mention explicitly that the upper jaw is devoid of teeth. A similar statement is given by Egede (1746), and Linné (1758, 1759), and among later authors by Nemnich (1795), Retzius (1800), Blumenbach (1814), and Fleming (1822).

With his "Burhvalur" Bartholini (1657) undoubtedly meant the sperm whale, as he refers to the spermaceti. According to this author the animal has seventy comparatively small teeth: "omnes tamen adeo parvos, ut ex illis commode fabricari non possit qvicqvam, nisi calculi scaccichi & cultrorum manubria". (l.c., p. 275).

Dudley (1725, p. 258) writes: ..."there are Rows of fine ivory Teeth in each Jaw, about five or six Inches long." The size indicates that the lower jaws are meant here only.

Many authors write that the teeth of *Physeter* are confined to the lower jaw only. This view is expressed by Gesner (1560), Paré (1604), Aldrovandus (1613), Jonston (1657, 1660), Willoughby (1686), Sibbald (1692) [1]), Molyneux (1698), Ray (1713), Ruysch (1718), Artedi (1738), Despelette (1744), Brisson (1756), Houttuyn (1762), Robertson (1771), Müller (1776), Pennant (1776, 1812), Erxleben (1777), Borowski (1781 a), Hermann (1783), Hunter (1787), Gmelin (1789), Kerr (1792), Blumenbach (1796—1810), Virey (1803), F. Cuvier (1835—1836), G. Cuvier (1805, 1808), Low (1813), Desmoulins (1822), Alderson (1827), Lesson (1828), Woods (1829), Beale (1835), Mulder (1836), Drapiez (1837, 1853), Burmeister (1843, 1860), Duvernoy (1851), Anon. (1856), Gosse (1856), Schlegel (1857, 1862, 1872), Milne Edwards (1860), Claus (1868, 1882), Pokorny (1868), Carus (1868—1875, 1889—1893), Pechuel (1869), Gray (1871), Pechuel-Loesche (1871), Guérin (1874), Schmarda (1878), Ludwig (1883), Bolau (1884, 1895), Hoernes (1884), Blasius (1892), Rombouts (1893), Keller (1895), Matschie (1895), Marshall (1896), Acloque (1900), Calkoen (1903), Monaco (1905, 1913), Abel (1907), Vosmaer (1908), Ziegler (1909), Doflein (1910), Trouessart (1910), Brandt (1911), Schäff (1911), Thompson (1912, 1928 a), Hentschel (1914, 1937), Grobben (1917), Tesch (1920), Perrier (1924), Russell and Yonge (1928). The same view is expressed by Bory de St. Vincent (year of publication?).

According to Cuvier (1825) so little is known of sperm whales, that it is not certain whether they are really devoid of teeth in the upper jaw or not.

Wall (1851) refers to the literature on the existence of teeth in the upper jaw of *Physeter*, but states that in the specimen studied by him no such teeth could be found.

1) fide Anon. (1695) and Allen (1881).

In the specimens examined by Heckel (1853) no maxillary teeth were found, but in Heckel's opinion these teeth probably were lost in the hurried process of flensing by unskilled labourers.

Turner (1871) cites a letter of Mr. James Paterson of 1701 on a sperm whale stranded at Crawmond, with teeth only in the lower jaw, "which, according to Sir R. Sibbald, is the characteristick of yt kind which has ye sperma cete" (Turner, 1871, p. 367). In a specimen studied by Turner (1872) no teeth were visible in the upper jaw. In a specimen examined by Lillie (1910) no sign of teeth could be found in the upper jaw; concerning another specimen Harmer (1918 a) states that no vestigial teeth were found in the upper jaw.

Several authors admit that teeth may occur in the upper jaw of *Physeter*, they describe these as very small or rudimentary, irregular, functionless, embedded in the gum, or not visible, their number as a few or uncertain. A statement of this kind is given by the following authors: Anon. (1771), Camper (1786), G. Cuvier (1798, 1817, 1829, 1838), de Lacepède (1802, 1804, 1818), von Froriep (1804), Sonnini (1804), Duméril (1806, 1830), Tiedemann (1808), von Zimmermann (1811), Oken (1816), de Blainville (1817), Desmarest (1817, 1822), Bowdich (1821), Ranzani (1821), Risso (1826), Griffith (1827), Lesson (1827), Eichwald (1831), Voigt (1831), Jenyns (1835), Kaup (1835), Bell (1837), Jardine (1837), Rapp (1837), Bonaparte (1840), Schinz (1840), Pouchet (1841), Schlegel (1841), De Kay (1842), de Quatrefages (1844, 1867), Eschricht (1845, 1863), Schinz (1845 b), Troschel and Ruthe (1848), Pöppig (1851), Vogt (1851), Hamilton (1852), Curtman and Walter (1854), Gervais (1855), Reichenbach (1855), Blasius (1857), Giebel (1857), Chenu (1858?), van der Hoeven (1859), Burgersdijk (1864—1873), Schlapp (1868), Cornalia (1870?), Gill (1871), Nicholson (1871), Troschel (1871), Lenz (1873), Lilljeborg (1874), Brehm (1877), Southwell (1881), von Mojsisovics (1883), Trouessart (1884), Knauer (1887), Lydekker (1887, 1895, 1906, 1909, 1910), van Beneden (1888), Flower (1888, 1898), Blanford (1888—1891), Nicholson and Lydekker (1889), Flower and Lydekker (1891), Pechuel-Loesche (1891), Zittel (1891—1893), Murie (1892), von Hayek (1893), Aflalo (1896), Heck (1897, 1915), Reynolds (1897), Elliot (1901), Sclater (1901), Beddard (1902), Ménégaux (1903—1904), Hutton and Drummond (1904), Ritzema Bos and Bos (1904), Tomes (1904), Weber (1904, 1928), Abel (1905, 1912, 1913), Boas (1905), de Pauw and Willemsen (1905), Sedgwick (1905), Millais (1906), Schmiedeknecht (1906), Winge (1908), Keller (1909), Newman (1910), de Terra (1911), Sørensen (1912), van Balen (1914), Andrews (1916), Cuní (1918), Harmer (1918 b, 1927), Fitzsimons

(1920), Haagner (1920), Dollo (1922), Bütschli (1924), Jennison (1927), Bourret (1928), Daniel (1929?), de Beaux (1930), Mohr (1931), van Deinse (1932), Freund (1932), Jenkins (1932), Perrier (1932), Romer (1933), Bailey (1936), Fraser (1937), Mell (1937). Moreover in this connection Pizzetta and Jones (years of publication?) must be cited.

Tago (1937, p. 2199) remarks: "Teeth are present in both upper and lower jaws; only those on lower jaw are functional". On a following page of the same paper, however, a quite different opinion is given: "There are 40—50 conical teeth in the lower jaw, but none in the upper. What appears like teeth in the upper jaw in some of the Sperm whales is nothing but thickenings of the skin and they have no function as teeth". (l.c., p. 2220).

In the young specimen of *Physeter* dissected by Jackson (1845) no maxillary teeth were found. Jackson gives, however, the testimony of Capt. Benjamin Chase: "He states that he has more than once seen teeth of a considerable size in the upper jaw of the adult females, though always covered by the gum; the males, he says, being much larger, are cut up differently, and in such a way as not to expose the teeth." (Jackson, 1845, p. 140).

Gray (1850, 1866) cites these observations.

According to Post (1854) the upper jaw has seldom any teeth, and when it does they are very small.

Malm (1871) describes a tooth which he regards as undoubtedly from the upper jaw.

Brehm (1865) remarks that both jaws of *Physeter* possess a variable number of teeth, many of which disappear with age or are covered by the gum; comparatively large are the teeth of the lower jaw only. According to von Schubert (1882) both jaws bear conical teeth, those of the lower jaw, however, are exceedingly larger.

Strack (1820?) remarks that *Physeter macrocephalus* (represented by a figure after Matham or van der Gouwen) has no teeth in the upper jaw, whilst *Physeter microps* (represented by a figure after Anderson, showing the animal which in the literature often is indicated as *Physeter cylindricus*) has curved and pointed teeth, in the lower jaw more than in the upper.

F. Cuvier (1829) remarks that in the sperm whale persistent teeth occur in the lower jaw only. Gegenbaur (1901) states that in *Physeter* all the teeth disappear from the upper jaw; a similar remark is made by Anderson (1896), by Hilzheimer (1913), and by Abel (1919), the latter adds that old specimens lose their maxillary teeth. Burckhardt (1906) states that only the teeth of the lower jaw remain. Vrolik (1861) remarks that young specimens have a row of minute teeth on each side of the upper jaw;

Trouessart (1890?) mentions that these teeth occur in young specimens only, they generally disappear completely in the adults. Winge (1918, 1921, 1924) is of the same opinion; he explains the cause of the phenomenon as follows: "In the lower jaw the teeth continue to be well developed; but in the upper jaw they atrophy and disappear either wholly or essentially so. It is not clear what the reason can be for this difference between the upper and lower jaws. Perhaps the difference is connected with the great lateral broadening out of the maxillary whereby the upper toothrows are so pushed outward that they lose their interaction with the lower toothrows which retain their ancestral position in the closely appressed mandibular rami." (Winge, 1921, p. 42).

This explanation, however, cannot be upheld, as the toothrows of the upper jaws correspond with the impressions of the teeth of the lower jaws or are found in a more medial position, a fact already recorded by Bennett (1836, 1840). This situation is present from the very first beginning of development of the teeth: Beddard (1923, fig. 1) has shown that the rudiments of the teeth of the upper jaw appear in a distinctly more medial plane than those of the lower jaw.

Flower (1869) drew attention to the fact that the maxillary of *Physeter* has a strongly marked groove running longitudinally, he regards this groove as the remains of the dental groove for the teeth of the upper jaw, and thinks that these rudimentary teeth are implanted in or near this groove. The groove, however, runs in an oblique direction, and especially in the posterior region of the jaw it is found at a considerable distance from the median plane. As the maxillary teeth occur in the neighbourhood of the median plane the groove referred to cannot represent the dental groove.

In the literature cited above the maxillary teeth of *Physeter* are mentioned in a more or less general way. A more definite description of the teeth of the sperm whale is given by Fabricius (1780, pp. 41/42): "Maxilla superior longior latiorque inferiori, lateribus se versus hanc incuruans, intus excauata lacuna lanceolata vt receptaculo maxillae inferioris eiusdem figurae. In maxilla inferiori duobus ordinibus dentes permulti, conici, antice posticeque subcompressi, curui introrsum tendentes, validi longi obtusiusculi, exterioribus minoribus curuioribus acutioribusque, albi medulla cinerea minus dura, dicuntur numero 40—46, quos tamen numerandi occasionem non habui. Veteres minus curvatos, crassiores autem, longioresque, interdum basi 3 vnc. latos et 6 vnc. longos, habent; iuniorum radice parum caua. In maxilla superiori dentes veros s. visibiles quidem non habet: attamen in lacuna supra memorata dantur cauitates vt receptacula dentium maxillae inferioris, quarum interstitia eminentia condunt dentes minutos admodum

curuatos, fere horizontaliter iacentes, acuminatos, latere interiori ad apicem oblique explanato-concauos, quae planities polita sola nuda (reliquo dentis carne tecto) ad cauitatem sequentem offendit, vbi etiam apex dentis inferioris occurrit, indeque politura eius." (Cf. also the Danish translation in Helms, 1929, p. 84).

Shaw (1801), Fleming (1828), Brandt and Ratzeburg (1829), Tilesius (1835), and Cuvier (1836), citing Fabricius, repeat in a complete or a more or less abridged form the statements made by this author. Although they do not refer to Fabricius as the authority of the statement, rudimentary maxillary teeth occurring in the intervals between the pits of the upper jaw, or just behind each of these pits, are mentioned by de Lacepède (1804), Sonnini (1804), Gérardin (1817), Virey and Desmarest (1816), Wagner (1846), and Desmarest (1847).

In Sir Robert Sibbald's History of Fife (not seen; referred to by Walker, 1871—1872) there is a statement on the sperm whale which reads (quoted from Walker, l. c., p. 146): "There is another sort of them, which I take to be the Orca very Plinii, it hath big teeth in the lower jaw, and small teeth in the interstices betwixt the cases, which receive into them the great teeth of the lower jaw. One of these stranded above Crammond-Inch. It was but fifty and some odd feet long; I take it to have been a young one. Both these mentioned had spouts in their foreheads, by which they threw up water," etc. The presence of teeth, the size, and the position of the blowhole prove that the animal was a sperm whale.

Other authors again maintain that the teeth of the upper jaw are found in the bottoms of the sockets into which the mandibular teeth enter when the mouth is closed, or that the teeth of the lower jaw strike upon those of the upper jaw. This statement is made by Illiger (1811), Fischer (1829), Beale (1839), Gloger (1842), Schinz (1845 a), Döbereiner (1850), Gray (1864, 1866), and Bullen (1905). The latter author adds that the maxillary teeth are abortive, not growing, because they have no roots. In his opinion they are the survival of teeth that once had been perfect and useful.

Bouvier (1889) remarks that the rudimentary teeth of the upper jaw of *Physeter* are feebly attached, and that they occur in the neighbourhood of the sockets in the upper jaw, or even in the sockets themselves.

Bennett (1836, 1840) could examine a number of sperm whales, he gives a distinct description of the maxillary teeth: "The upper jaw is not altogether toothless, as usually described. On the contrary, it has on either side a short row of teeth, which, for the most part, are placed more interior than the depressions which receive the teeth of the lower jaw; though they sometimes, also, occupy the bottom of those cavities. Their entire length is

three inches; they are curved backwards, and elevated about half an inch above the soft parts, in which they are deeply imbedded, having only a slight attachment to the maxillary bone. In two instances, I found their number to be eight on each side. They exist in both sexes of the Sperm Whale; and although visible externally only in the adult, they may be seen in the young animal upon removing the soft parts from the interior of the jaw.

Although these palatine teeth are perfect in their structure, their relatively small size will not permit us to regard them as more than rudimental". (Bennett, 1840, p. 163; in Bennett, 1836, the same statement is found with some slight alterations).

Other authors cite Bennett or remark that eight small teeth occur on each side of the upper jaw: Owen (1840—1845), Wagner (1846, Gray (1850), Giebel (1855a, 1859, 1875), Harting (1863), Martin (1882), Flower and Garson (1884), Bouvier (1889), Snijders (1920), and Harmer (1926). Wood (1861) too mentions that each side of the upper jaw has eight partly hidden teeth, he adds that these are apt to fall out together with the softer parts, as their attachment to the jawbone is very slight.

An even larger number of maxillary teeth in *Physeter* is mentioned by Bonnaterre (1789, p. 13): "La mâchoire supérieure est garnie d'autant d'alvéoles, qu'il y a de dents à la mâchoire d'en bas; mais ce qu'on doit remarquer principalement, c'est que dans les interstices qui séparent ces cavités, on trouve environ vingt petites dent situées horizontalement, & élevées d'une ligne au dessus de la chair; elles sont très-pointues du côté opposé à leur insertion, & présentent une surface plane, unie, & oblique, qui remplit l'intervalle qui sépare les alvéoles: il n'y a que cette surface oblique qui soit visible; le reste de la dent est recouvert de chair. Très-peu d'Observateurs ont fixé leur attention sur la forme & la disposition de ces dents: de là vient qu'on a conclu presque généralement que les *Cachalots* n'avoient point de dents à la mâchoire supérieure."

A similar statement is made by Dewhurst (1834).

The occurrence of two small teeth in the upper jaw of "*Physeter microps*" is mentioned by Pasteur (1800).

Several times, especially in the older literature, mention was made of the occurrence of molars (molaires, dents mâchelières, Backzähne) in the upper jaw as well as in the lower jaw of *Physeter*. This is the result of a misunderstanding. In 1723 was published T. Hasaeus, De Leviathan Jobi et Ceto disquisitio, Bremae [1]). The booklet was translated into Dutch by

1) Not seen; title from Brandt and Ratzeburg (1829).

Köhne (1724), the first and second appendix of the latter work contain a number of observations by Adriaan Adamzen Ooms, commander of a whaling ship. The following quotation refers to one of these observations: "In dit bovenste kakebeen zitten zes ook agt tanden, te weten in yder helft drie of vier. De welke uyt het tandvlees niet verder als een halve of op zijn hoogste maar eenen geheelen duym uytkomen, na voren toe staan en als de bek gesloten word, tusschen de onderste indringen". (Köhne, 1724, p. 244).

In English this would run approximately as follows: "In this upper jaw-bone there are six or eight teeth, namely in each half three or four. Which protrude from the gum no more than half an inch or at the utmost an inch, are pointing forwardly, and, when the mouth is closed, penetrate between those of the lower jaw." No mention is made here of molars, but Anderson (1747, p. 236) writes concerning Köhne's sperm whale: ....."in dem obern Kiefer hat er zu jeder Seiten 3 oder 4 Hinter- oder Backenzähne, übrigens aber nur Höhlen oder Scheiden, worein die Zähne des Unterkiefers passen."

Köhne's book seems to be rare, and, as it was written in the Dutch language it became not universally known, whilst Anderson's book appeared at least in two German, two Dutch, a Danish, an English, and two or three French editions (cf. Allen, 1881). It is, therefore, not astonishing that, besides Anderson, the following authors maintain that the upper jaw of *Physeter* contains molar teeth: de la Chenaye des Bois (1759), Houttuyn (1762), Cranz (1767), Müller (1773), Borowski (1781a), Duhamel du Monceau (1782), Anon. (1784), de Jong, Kobel and Salieth (1792), Pasteur (1800), Valmont-Bomare (1800), Bechstein (1801), Oken (1816), Virey and Desmarest (1816), Tilesius (1835), and Giebel (1855b).

In 1741 a sperm whale stranded in the river Adour near Bayonne. According to Pouchet and Beauregard (1889a) the registers of the city of Bayonne state that this specimen had three curved teeth in the middle part of the palate. Fischer (1872) already made a similar remark. In the paper by Despelette (1744), however, it is stated that the upper jaw only presents the sockets for the teeth of the lower.

Concerning the thirty two sperm whales stranded in the Bay of Audierne in 1784 there is a letter by Le Coz in the Mercure de France [1]) of that year. Camper (1820) mentions that according to Le Coz a few specimens possessed very small, white and flat maxillary teeth, protruding from the gum for one inch and a half.

A sperm whale found dead in the Balearic islands possessed 10 maxillary

1) Not seen.

teeth, 5 on each side (Barceló, 1879). The teeth occurred in the anterior part of the jaw, the foremost were visible in the bottoms of the cavities for the teeth of the lower jaw, the other maxillary teeth were covered by the gum.

Sclater (1891) remarks that a specimen of *Physeter* washed ashore at Madras in January 1889 possessed on either side of the upper jaw 12 rudimentary teeth imbedded in the gum.

According to Zenkovič (1934) near Kamchatka 57 male sperm whales were captured in 1933. He remarks (p. 391): "In comparatively many of the specimens captured, teeth were found in the upper jaw (up to 18 in number) and in some cases they were functional. ... The teeth of the upper jaw were small and intact, while those of the lower jaw were in the majority hollow."

In the specimen stranded at Bridlington in January 1937, the skeleton of which now is in the British Museum (Natural History), there were three small tooth vestiges on one side of the upper jaw (Anon., 1937).

None of the papers cited above contains figures of maxillary teeth.

It is not impossible that a figure of a maxillary tooth of *Physeter* appeared already as early as 1776. Pennant (1776, right hand upper figure of plate VII) figures a tooth of a sperm whale which bears a strong resemblance to the fourth maxillary teeth of our larger sperm whale. It has a similar curved shape, and the figure shows a large slit in the fang, whilst it looks as if the top of the pulp cavity is filled with osteodentine which even protrudes from the opening. The same figure occurs in a later publication (Pennant, 1812, pl. IX fig. 3).

The first figures made after teeth of sperm whales which undoubtedly came from the upper jaw are found in Owen (1840—1845, pl. 89 figs. 3 and 4); the tooth is strongly curved, it measures from tip to tip about 55 mm. Its pulp-cavity is closed and the crown-end shows a smooth surface probably by contact with the end of the opposite large tooth. In a later work (Owen, 1866—1868) mention is made of the occurrence of a few small curved teeth in the upper jaw. Owen regarded these teeth as specimens of the primitive foetal series of teeth; Beddard (1923), however, has shown that they belong to the permanent dentition.

Van Beneden and Gervais (1868—1880, pl. XX fig. 5) represent a maxillary tooth of a length of about 48 mm, of a rather straight shape. They add that these teeth may be irregular or curved, and suppose that they fall out very soon.

In his description of the skeleton of *Physeter* Flower (1869) mentions ten teeth which undoubtedly came from the upper jaw. They had a length of 2 or 3 inches, a diameter of about ¾ inches at the thickest part. Their

pulp-cavity was completely closed, and, in most specimens "more or less surrounded by rough, irregular, spiculated outgrowths" (l.c., p. 320). The figure (l.c., fig. 1) shows a tooth with strongly curved basal part and irregular outgrowths pointing more or less towards the top of the tooth. In the publication of Flower and Garson (1884) mention is made of the same teeth and other specimens from the upper jaw of a female sperm whale.

The curiously shaped tooth of a sperm whale described and figured by Murie (1869) undoubtedly came from the upper jaw. It is bent like a horseshoe, it must have remained completely hidden in the gum, as the crown end is not worn. On the concave side of this tooth there is an irregular mass of spicular outgrowths, evidently consisting of osteodentine protruding from a cleft in the fang.

De Sanctis (1881) could examine a large sperm whale stranded at the Italian shore. At each side of the upper jaw, in the bottom of the fifth depression in the gum, caused by the tips of the teeth of the lower jaw, a rudimentary tooth was found, the extremity of which protruded from the gum (l.c., pl. V fig. X). De Sanctis supposes that originally there had been more of these teeth, but that they gradually had fallen out with the exception of the last pair.

Important contributions to the knowledge of the maxillary teeth were published by Pouchet and Beauregard. In one paper (Pouchet and Beauregard, 1889a) they describe the teeth which occurred in a part of the palate of a young male or an adult female from the Azores, these teeth were curved, to 35 mm long, their tip was directed backwards. One of these is figured (l.c., pl. 6 fig. 6). They regard the described teeth as young forms and remark that afterwards the pulp-cavity would have closed and then gradually the teeth would fall out. In the same paper they give a number of notes on the literature on the teeth of the sperm whale. In another publication of the same year (Pouchet and Beauregard, 1889 b) the remark is found that *Physeter* possesses a small number (8 to 10) of maxillary teeth of irregular shape, imbedded in the gum, more or less perpendicular to the surface. In the following year the same authors (Pouchet and Beauregard, 1890) could study a young male specimen (13.5 m long) stranded at the île de Ré. They remark that the small teeth of the upper jaw, which did not show signs of wear, were found at regular distances from each other. More particulars about these teeth are found in a following paper (Pouchet and Beauregard, 1891). Their maximum dimensions are: height 8 cm, breadth at the base 2 cm; they are of variable shape. In some of them the extremity is slightly eroded. The authors are convinced that the upper jaw contained as many teeth as the lower, this is based upon the examination of two

pieces of the palate which they took off from the specimen. One of these pieces contained 5 teeth, Pouchet and Beauregard give the following distances of the centers of the teeth; the 2nd to the 3rd, 10 cm; the 3rd to the 4th, 9.5 cm; the 4th to the 5th, 7.5 cm. The other piece of the palate too contained 5 teeth, the distance of their centers was: the 1st to the 2nd, 5 cm; the 2nd to the 3rd, 5.5 cm; the 3rd to the 4th, 5.5 cm; the 4th to the 5th, 6.8 cm. Moreover the paper contains a short description and a figure (l.c., pl. IX fig. 5) of a tooth from the Azores, apparently taken from the upper jaw, with traces of wear at its extremity.

A description and figures of maxillary teeth of a sperm whale taken at the Shetland Islands was published by Turner (1903, figs. on p. 426; 1904, pl. I). Of the 64 teeth received by Turner, 42 were undoubtedly mandibular, 8 were from the upper jaw, probably 7 other teeth too, and of the remaining 7 it was uncertain whether they came from the upper or from the lower jaw. Two of the figured specimens are comparatively straight, one (the smallest) is strongly twisted, the fourth is one of the irregular teeth of which Turner (1903, p. 427) remarks: "Several had odontomatous excrescences on the concave aspect of the tooth, resembling the maxillary tooth figured by Sir W. H. Flower". The length of the maxillary teeth varied from 64 to 88 mm, the crown was not polished or worn, so that Turner presumed that they had not cut the gum. The figures referred to above are found also in a later paper (Turner, 1912, pl. IX), with a short description of these teeth; other maxillary teeth of sperm whales are mentioned in the same publication.

One of the six male sperm whales examined by Edwards (1912) had a row of small teeth, protruding from the gum for less than half an inch, close to the cavities into which the teeth of the lower jaw had fitted. Their crown was flattened and polished which shows that these teeth were functional. Another instance of functional maxillary teeth in a male *Physeter* was described by Ritchie and Edwards (1913), about a score of these occurred in a row along the inner side of the depressions caused by the mandibular teeth. Each tooth was situated near, and on the inner and posterior side of, a mandibular pit. One tooth was extracted with the surrounding gum; it had a length of 11 cm, was rather twisted, and distinctly worn at the top, so that the core of dentine was visible within its surrounding cement.

According to Neuville (1932) the upper jaw of *Physeter* possesses approximately the same number of teeth as the lower jaw. The maxillary teeth, however, are apt to fall out soon, because the pulp-cavity closes at an early stage. Neuville describes and figures a small maxillary tooth of 27 mm (l.c., figs. 5 and 6) and a few larger teeth of the upper jaw which

are distinctly worn at their tops (l.c., figs. 46 (in text) and 49 (on plate XIII)). In the larger part of the latter the pulp-cavity is still distinctly visible. Very interesting teeth of the lower jaws of sperm whales are described and figured by the same author (l.c., figs. 50 (in the text), 51 (on plate XIV), and 52—53 (in the text)), showing distinct facets or even rather deep grooves caused by the contact of maxillary teeth against the figured specimens. This proves that the sperm whales from which the figured mandibular teeth were taken must have had functional maxillary teeth. The maxillary teeth studied by Neuville had a maximum length of 7 cm. In a later paper (Neuville, 1935) the small maxillary tooth of 27 mm is figured again, together with a longitudinal section of the top of the same tooth. In Neuville's opinion this tooth must have projected for about 5 mm above the gum. As, however, the layer of cement at the top of the tooth shows no signs of wear, this supposition is highly improbable. In the same paper Neuville expresses as his opinion that the teeth of the upper jaw alternate with those of the lower, so that each maxillary tooth is found between two successive depressions caused by mandibular teeth. Neuville admits, however, that the instances of wear described by him previously (Neuville, 1932) cannot be explained otherwise than by contact of functional maxillary teeth against those of the lower jaw.

3. The maxillary teeth of the larger specimen.

At each side of the upper jaw of the larger specimen there are fifteen teeth. Individually they are of highly different shape but when considered as a whole they form a continuous series in which each consecutive pair is of a similar shape. They vary in length from 68 to 138 mm, being of considerably larger size than those previously recorded in literature. The measurements of these teeth are given in Table I.

In fig. 7 the series of maxillary teeth of the left side are represented. Of these the tops of the first, the seventh, the ninth and all following teeth extended beyond the gum, they may, therefore, be regarded as functional.

The first tooth is of slender form with pointed ends. The top projected for about 20 mm above the gum, it is worn so that the yellow dentine is visible within the layer of cement. The pulp cavity is completely filled with osteodentine which even projects for some distance.

The second and third teeth have a slightly irregular top, in shape they are similar to the first. Their pulp cavity is entirely filled with osteodentine which even projects from the basal part as irregular outgrowths.

The fourth to sixth teeth are slightly larger than the first three, they are of approximately the same shape. Their pulp cavity, however, is still open,

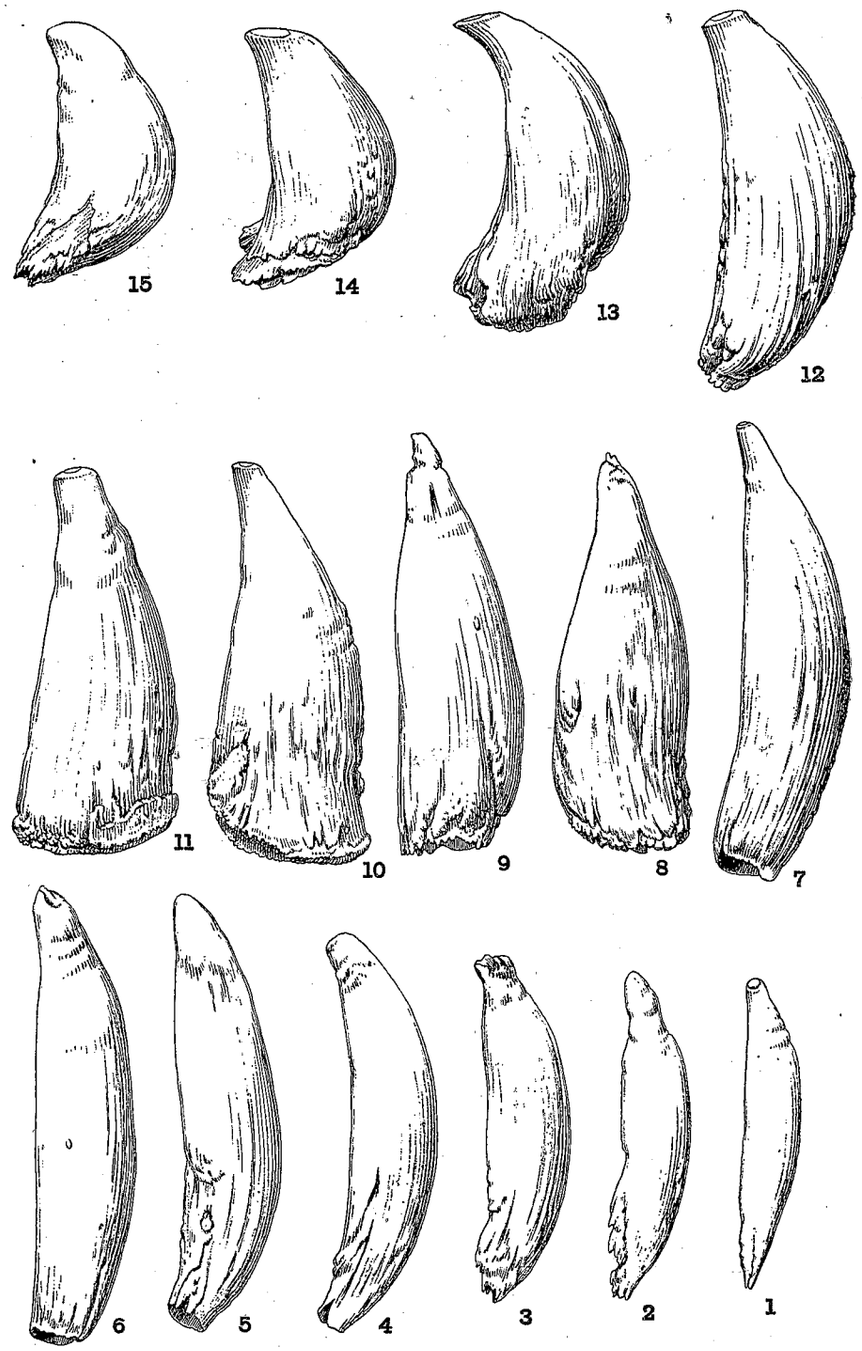


Fig. 7. Left maxillary teeth of the larger specimen. The labial surface of each tooth is represented. × ½.

Table I. Measurements in mm of the maxillary teeth of the larger specimen.

Left					Right				
Number	Length	Greatest breadth [1]	Greatest thickness	Thickness at base	Number	Length	Greatest breadth	Greatest thickness	Thickness at base
1	87	17	13	2	1	86	17	13	4
2	93	19	14	3	2	85	19	13	6
3	97	23	16	6	3	96	23	16	6
4	112	24	18	6	4	119	26	19	9
5	123	27	21	7	5	138	31	23	12
6	129	30	27	10	6	130	32	30	23
7	129	31	30	12	7	110	36	32	22
8	112	37	33	13	8	126	40	35	18
9	119	35	32	12	9	125	40	35	15
10	114	43	36	15	10	101	40	35	16
11	108	46	36	19	11	105	40	36	15
12	107	38	32	25	12	91	41	34	24
13	90	37	36	18	13	88	38	33	18
14	73	35	31	10	14	68	35	29	25
15	75	34	30	21	15	69	32	28	28

it has a depth of 4 to 6 mm; in the fifth the greater part of the pulp cavity is occupied by a lump of osteodentine. In the fourth and the fifth the fang has a longitudinal fissure in its basal part; this fissure is entirely filled with osteodentine.

In the seventh tooth the top projected for about 42 mm above the gum. At its pointed extremity it is slightly worn so that the dentine is visible inside the mantle of cement. The pulp cavity is about 16 mm deep. At its labial side the fang has a longitudinal fissure.

The eighth tooth is, as the three following teeth, rather strongly compressed in its basal part. The top is pointed, somewhat irregular, the pulp cavity is almost entirely filled with osteodentine.

In the ninth tooth the top shows signs of caries, this part projected for about 25 mm above the gum. The pulp cavity is nearly completely obliterated by osteodentine, there is a small cavity of 3 mm depth left. In this and in all the following teeth the top is abraded to some extent, so that the dentine becomes visible, contrasting by its darker colour with the surrounding cement.

The tenth tooth projected for about 25 mm above the gum. Its top shows

1) In this and in the following tables with "greatest breadth" is meant the maximum antero-posterior diameter.

some neatly polished facets which is astonishing, as on the tooth against which it should strike when the mouth is closed (the ninth of the lower jaw) no distinct facets are to be found. The pulp cavity has a depth of 8 mm, it is largely filled with osteodentine of which a large globular lump is seen at the bottom of the cavity. The fang has a longitudinal fissure which is entirely filled with osteodentine.

The top of the eleventh tooth projected for about 22 mm above the gum. In general the shape corresponds with that of the former. The compressed fang still has a pulp cavity with a depth of 8 mm.

The twelfth tooth protruded from the gum for about 25 mm. As the following teeth it has a somewhat contracted fang. The pulp cavity is largely filled with osteodentine, its depth amounts to 12 mm.

The thirteenth tooth is rather strongly curved, it arose above the gum for about 27 mm. The pulp cavity is entirely closed by osteodentine.

The fourteenth tooth is of a similar shape. On the labial side there is a slightly polished region, caused by contact with the fourteenth tooth of the lower jaw. At the broadly worn top the central canal of the dentine is distinctly visible. The pulp cavity is not only closed with osteodentine, but irregular masses of this material are seen protruding from the basal part of the tooth. The top of this tooth projected for about 20 mm above the gum.

In the fifteenth tooth the central canal of the dentine again is clearly visible. The fang is strongly contracted, nearly completely filled with osteodentine, which, moreover, is projecting basally as irregular outgrowths. The tooth projected for about 30 mm above the gum.

Each individual tooth of the right side of the upper jaw in the larger specimen bears a strong likeness the corresponding tooth of the other side (fig. 8).

Of the maxillary teeth of the right side the first, the sixth to twelfth, and the fifteenth projected above the gum, they may therefore, be considered as functional.

The first tooth of the right side was protruding through the gum for about 23 mm, its narrow fang is entirely filled with osteodentine.

The second and third teeth have a more or less irregular top, the pulp cavity has an oblique contour, as the dentine and cement have grown out towards the basal part in the anterior region only. This missing part is completed by a mass of osteodentine, which, moreover, fills the entire pulp cavity.

The fourth and fifth teeth again have a shallow pulp cavity (depth 4 and 9 mm respectively). In each of these teeth there are two longitudinal fissures in the basal region of the fang, now filled with osteodentine. In

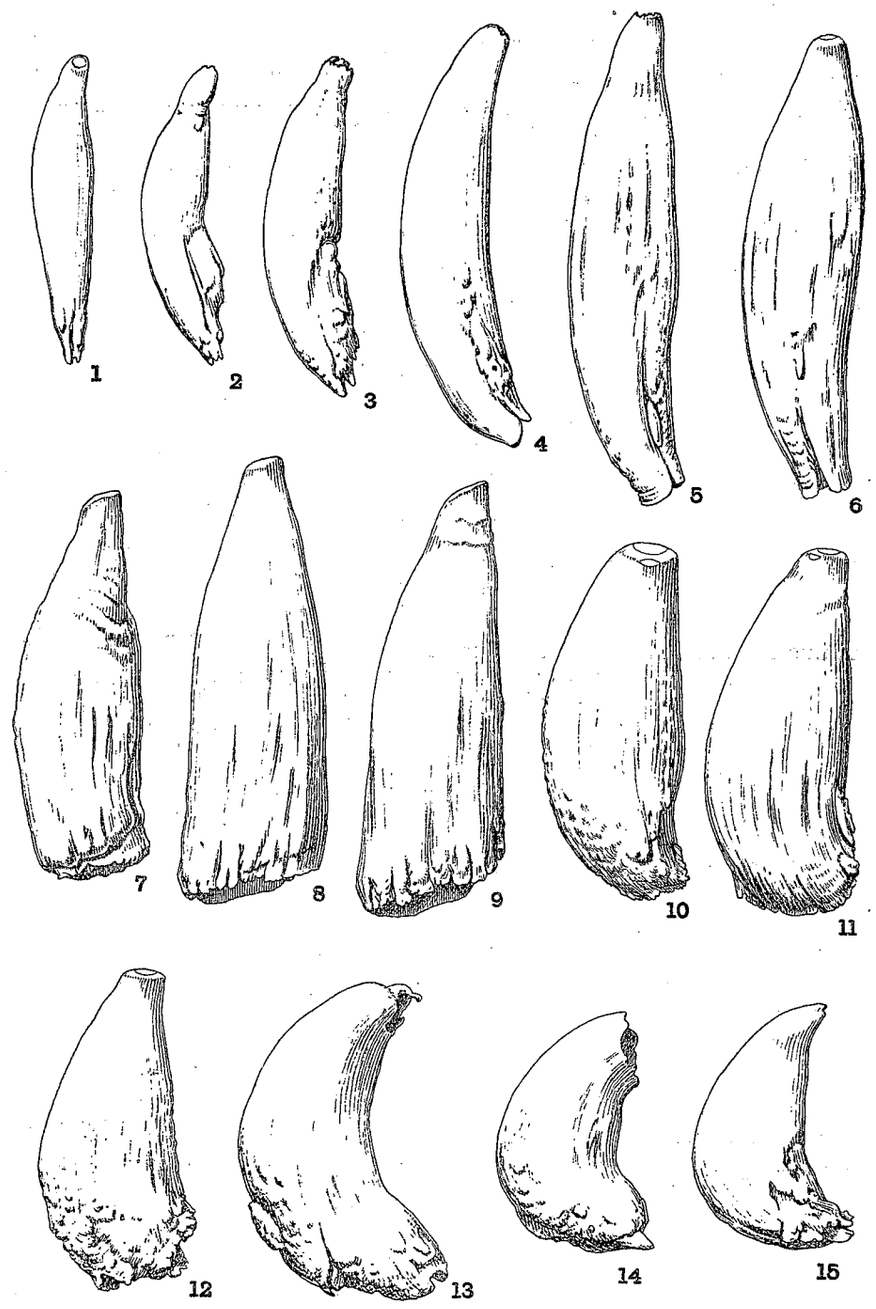


Fig. 8. Right maxillary teeth of the larger specimen. The labial surface of each tooth is represented. × ½.

both teeth the top possesses a ragged appearance on account of several minute outgrowths of the cement.

The sixth tooth projected for about 35 mm above the gum, it has a conical pulp cavity with a depth of 17 mm. In the basal region there are two short longitudinal fissures.

The seventh tooth protruded about 35 mm above the gum. Its top shows a number of neatly polished facets. The eighth tooth of the lower jaw, with which it must have come into contact when the mouth was shut, however, does not show any marked facets corresponding with those on the top of the maxillary tooth. The compressed fang of the seventh tooth is entirely filled with osteodentine, which projects even from the basal part of the tooth.

The eighth and the ninth teeth each project about 30 mm above the gum, both have a pulp cavity which has a depth of about 16 mm. In the eighth tooth this cavity contains a large oval lump of osteodentine (20 by 10 mm), in the ninth the bottom of the pulp cavity contains numerous minute granules of osteodentine.

The tenth tooth projects about 20 mm above the gum, the eleventh about 25 mm. In both teeth the fang is strongly compressed, it has a pulp cavity with a depth of 14 and 12 mm respectively. In each of these teeth the basal region has two longitudinal slits, filled with osteodentine. Both teeth possess in their top region, on the labial surface, a neatly polished small facet, indicating the region which came into contact with a tooth of the lower jaw when the mouth was shut.

The twelfth tooth was protruding for about 20 mm above the gum. Its basal part is of a rather irregular shape. This part of the fang is strongly compressed, when seen from below the pulp cavity is reduced to a rather narrow slit. The entire pulp cavity is filled with a mass of osteodentine, which, moreover, protrudes from the basal part, and, on the sides, through longitudinal fissures.

In the thirteenth tooth again the pulp cavity is strongly constricted so that it opened with a narrow slit. Now the entire pulp cavity is filled with osteodentine which here and there protrudes above the surface. The top part of this tooth has an irregular shape, it is hollow on account of caries. When the tooth was taken from the gum it was surrounded by an abscess just beneath the surface of the gum.

The fourteenth tooth is similar to the thirteenth. Here too the constricted pulp cavity is completely filled with osteodentine, its top shows caries to a large extent. As the thirteenth it was found in an abscess when it was taken from the gum.

The fifteenth tooth protruded for about 30 mm from the gum. Its basal part is narrowed and constricted, the pulp cavity is entirely filled with osteodentine.

As remarked above some maxillary teeth show distinct signs of caries.

Caries in the teeth of sperm whales is not altogether unknown. A case of this disease in the sperm whale is mentioned by Moodie (1923, p. 228), and Freund (1932) remarks that aged sperm whales often show caries of the teeth. On the other hand Melville (1930, first ed. 1851) remarks that the teeth in old whales are much worn down, but undecayed.

But also from causes other than caries decay of the teeth of sperm whales may occur, resulting into large cavities in the sides of these teeth. A tooth from the Nantucket Museum in which this kind of decay has taken place is figured in a paper by Pouchet and Beauregard (1889 a, pl. 6 fig. 3). Moreover in this paper the authors mention that sometimes the hindmost teeth of the lower jaw remain in the gum and partly decay within a kind of abscess.

Another instance is that described by Colyer (1936, p. 639, fig. 864 B), concerning a tooth of a sperm whale with a large area of absorption on one side of the root. Colyer suggests that the process may have started as a result of close contact of this tooth with its neighbour. If this explanation is true, it must have been a tooth of the upper jaw which came into contact with the decayed tooth, as the teeth in the lower jaw are too widely separated from each other.

In this connection McKenzie's remarks may be mentioned, who often saw sperm whales with "teeth rotten and decayed down to the jaw". On the same page specimens are referred to which had teeth "worn down level with the gum" (McKenzie, 1854, p. 367).

By their slender, curved shape and narrow, constricted fang the foremost teeth in the upper jaw of the larger specimen bear a strong resemblance to the tooth of *Squalodon grateloupi* v. Mey. figured by Staring (1860, pl. III fig. 1). According to Abel (1905) this tooth belongs to the species *Scaldicetus caretti* du Bus 1867, he includes into this species a number of forms previously described a distinct "species" by other authors. Especially many names given by Gervais (1859) are enumerated among these synonyms. Some of the figures given by Gervais (1859; e.g., pl. III fig. 12, pl. XX figs. 19—23) represent teeth of a similar shape as those of the upper jaw of our larger specimen. Perhaps these teeth of *Scaldicetus caretti* were from the upper jaw, as is indicated not only by their shape but moreover by their relatively small size. They differ from

those of *Physeter macrocephalus* by the system of longitudinal grooves in the uppermost parts.

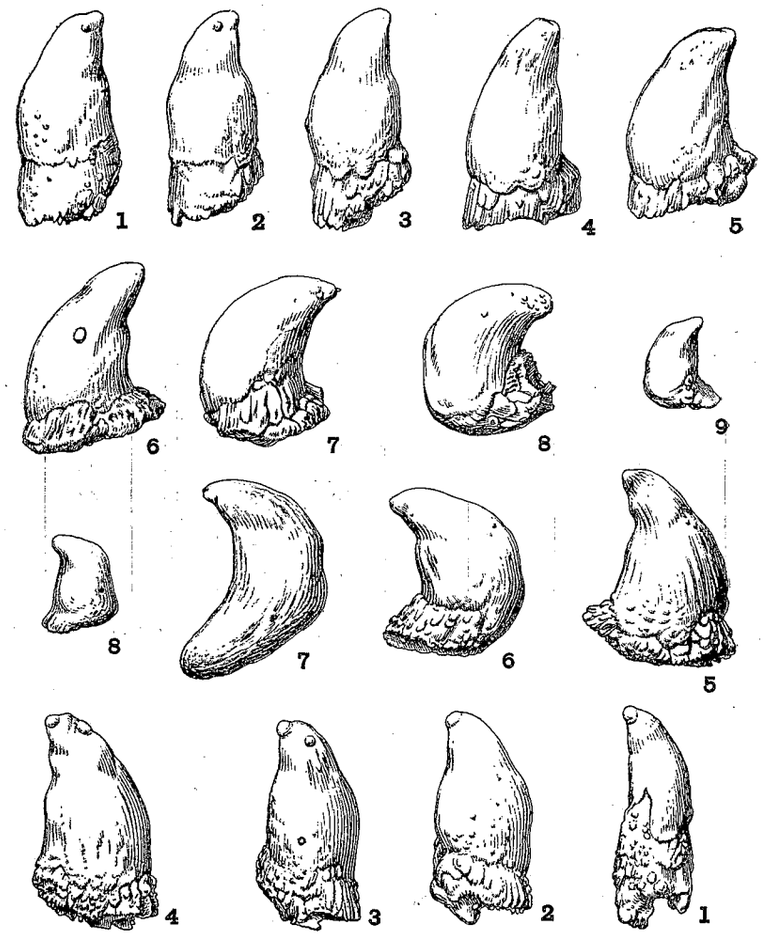


Fig. 9. Maxillary teeth of the smaller specimen. Upper half of the figure, those of the right side; lower half of the figure, those of the left side. The labial surface of each tooth is represented. × ½.

4. The maxillary teeth of the smaller specimen.

In the smaller specimen nine teeth were found on the right side of the upper jaw, eight on the left side (fig. 9). Moreover one tooth was found

in a detached part of the gum of which it could not be ascertained with certainty where it came from. This tooth is similar to those of the rostral half of the dentition. All the maxillary teeth of the smaller specimen were found buried in the gum. They vary in length from 25 to 62 mm, their measurements are given in Table II.

Table II. Measurements in mm of the maxillary teeth of the smaller specimen.

Left					Right				
Number	Length	Greatest breadth	Greatest thickness	Thickness at base	Number	Length	Greatest breadth	Greatest thickness	Thickness at base
1	61	22	15	13	1	61	28	18	17
2	59	28	22	22	2	61	26	21	21
3	59	28	26	25	3	62	27	27	27
4	61	36	27	27	4	58	33	28	28
5	54	42	29	29	5	54	36	40	40
6	48	28	30	28	6	53	40	42	42
7	57	28	30	25	7	48	35	37	37
8	28	19	18	18	8	43	35	32	32
					9	25	21	16	16

The first left maxillary tooth of the smaller specimen (fig. 9, right hand bottom corner) shows a distinct irregularly transverse groove at about half its length. The explanation of this must be the following. Originally the tooth was about half as long as now. Its pulp cavity was gradually filled with osteodentine, but this process continued afterwards so that a large basal part was formed. Therefore undoubtedly more than half of the tooth consists of osteodentine, built up from small granules which afterwards coalesced to form a compact mass. The basal region of this tooth is more or less compressed.

The second, third, and fourth teeth have undergone a similar development as the first, the accumulation of osteodentine at their basal part, however, is shorter. The basal part of these teeth is much thicker than that of the first, in the second and third teeth it is rather irregular, in the fourth the basis is more or less flat.

In the fifth tooth again the pulp cavity is completely filled with osteodentine, here too the process has continued beyond the pulp cavity and even around the basis of the original fang. The basis of this tooth again is comparatively flat.

In the sixth tooth the pulp cavity is filled with osteodentine in the usual way. The opening of the pulp cavity, however, pointed in a posterior direction, as the development of the dentine and cement stopped posteriorly at a much earlier stage than anteriorly. The anterior lamina of dentine and cement has grown out in a curved manner, till at last this part was growing in a horizontal direction. In this manner the pulp cavity became strongly contracted, so that the opening was turned towards the posterior side. In this spot a plug of osteodentine is seen now projecting from the tooth.

The seventh tooth is strongly curved, its fang is rather long, but contracted at the extremity. The pulp cavity is completely filled with osteodentine.

The eighth tooth is much smaller than the others, its pulp cavity is entirely filled with osteodentine, which, moreover, projects from the basis of the tooth in a posterior direction.

Apart from differences of minor importance the first five teeth of the right side of the upper jaw (fig. 9, upper row) bear a strong likeness to the corresponding teeth of the left side. Their pulp cavity is filled with osteodentine and their basal part is enlarged by an accumulation of the same matter, which gives them a comparatively flat and broad basis.

In the sixth tooth the osteodentine has broadened around the basal region, in the seventh the opening of the pulp cavity, before it was filled with osteodentine, was directed more or less posteriorly.

The eighth tooth is so strongly curved that the opening of the pulp cavity was completely pointing in a posterior direction. The layers of dentine and cement of the posterior part of the tooth have entirely encircled the basis whilst in the anterior region of the tooth these layers remained much shorter. Now the entire pulp cavity is filled with osteodentine which even projects from the cavity. Consequently a plug of osteodentine now is protruding in a posterior direction from the tooth.

The ninth tooth of this series corresponds closely with the eighth of the other side.

5. The mandibular teeth of the larger specimen.

In the left lower jaw of the larger specimen there are 22 teeth, in the right lower jaw 20. The length of these teeth varies from 80 to 183 mm, their measurements are given in Table III.

In the anterior part of the lower jaw of the larger specimen (fig. 10: 1, 2, 5) the teeth have a slender shape, they are only slightly compressed laterally. Towards the middle of the jaw they gradually increase in breadth (fig. 10: 10), in the posterior part they become much shorter (fig. 11),

Table III. Mearurements in mm of the mandibular teeth of the larger specimen.

Left					Right				
Number	Length	Greatest breadth	Greatest thickness	Thickness at base	Number	Length	Greatest breadth	Greatest thickness	Thickness at base
1	129	44	39	17	1	---[1])	48?	42?	26
2	166	52	50	27	2	170	57	52	30
3	176	54	51	35	3	176	57	52	31
4	181	57	51	32	4	183	60	53	33
5	173	60	52	27	5	171	68	52	22
6	173	66	52	26	6	175	75	52	28
7	174	69	52	27	7	165	85	53	28
8	166	85	57	25	8	156	82	52	28
9	160	88	53	28	9	155	82	52	29
10	161	87	53	32	10	149	84	52	28
11	158	75	54	31	11	147	78	51	26
12	149	71	52	28	12	140	70	50	26
13	136	71	50	27	13	141	66	49	26
14	121	66	48	21	14	121	60	45	17
15	115	63	45	22	15	116	56	43	20
16	115	56	43	20	16	118	52	40	19
17	123	53	39	19	17	111	49	38	15
18	121	50	37	17	18	113	50	35	14
19	96	47	33	14	19	93	42	32	16
20	98	43	31	11	20	84	41	30	12
21	85	40	28	13					
22	80	38	27	12					

whilst those at the end of the series are of a somewhat irregular shape or even rudimentary (fig. 11: 20, 22). The functional teeth of the lower jaw project for a distance of 20 to 45 mm above the gum.

As the teeth of the lower jaw of *Physeter* are well known, only a few particulars of these teeth are given here.

The first tooth of the left lower jaw of the larger specimen has a pulp cavity with a depth of 17 mm, in the second this cavity is 52 mm deep. The depth of this cavity then more or less gradually increases till it reaches 98 mm in the eleventh tooth. In the thirteenth the cavity has a depth of 60 mm, in the fourteenth of 25 mm, in the fifteenth it is already completely filled with osteodentine, which also occurs in all the following

1) Crown end broken.

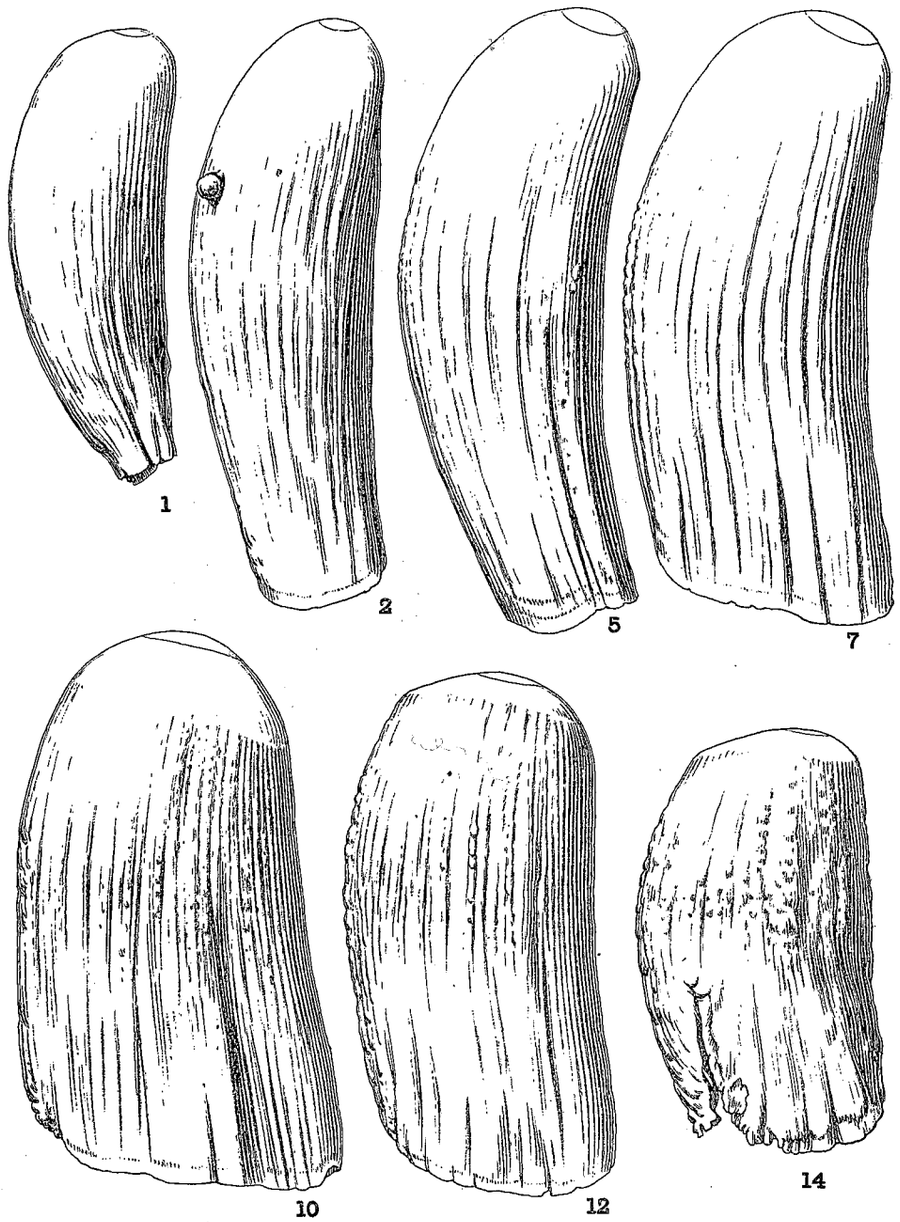


Fig. 10. Seven teeth from the left lower jaw of the larger specimen. The labial surface of each tooth is represented. × ½.

teeth. From the nineteenth to the twenty second teeth a large amount of osteodentine projects from the basal region.

In the first tooth of the left lower jaw the fang is strongly contracted. In transverse section it is more or less circular. This also holds for some of the following, but gradually the fang becomes compressed laterally so that already in the seventh and eighth teeth the transverse section is an elongated oval. From the eleventh onwards the fang shows longitudinal fissures in its basal part, these may be very large and broad on the lingual side (fig. 12, upper row). More particulars about these teeth will be mentioned in the following pages.

Numerous more or less irregular bodies of osteodentine were found in

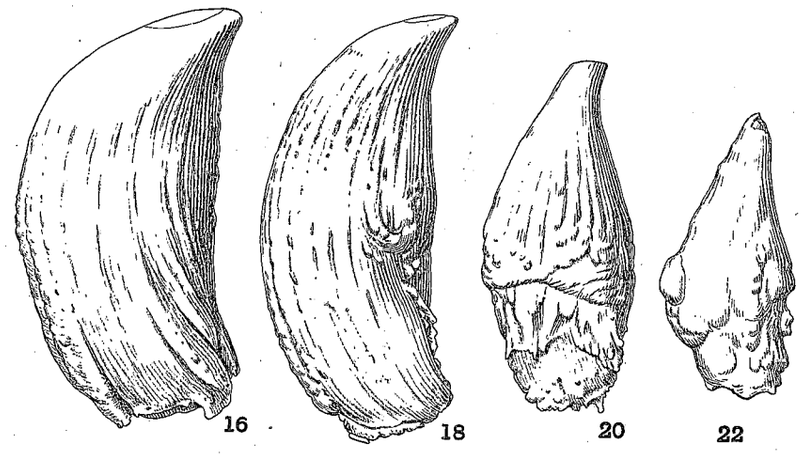


Fig. 11. Four teeth from the posterior part of the left lower jaw of the larger specimen. The labial surface of each tooth is represented. × ½.

the pulp cavities of these teeth. Originally they develop within the soft tissue, by further growth they may fuse with each other and form more or less irregular masses (fig. 19). When further developing they ultimately come into contact with the walls of the pulp cavity and unite with the tooth. In this manner the pulp cavity gradually becomes filled with osteodentine. Even then the process does not stop, for in the posterior teeth large masses of osteodentine are seen protruding from the basal part (fig. 11: 20, 22).

The twentieth tooth still projects for about 25 mm above the gum, the two following remain hidden under the gum.

The teeth of the right lower jaw of the larger specimen correspond with those of the left side. The fang of the first has a circular contour, gradually

this part becomes more elliptical, the seventh to the eleventh are very strongly compressed. The pulp cavity of the first tooth has a depth of

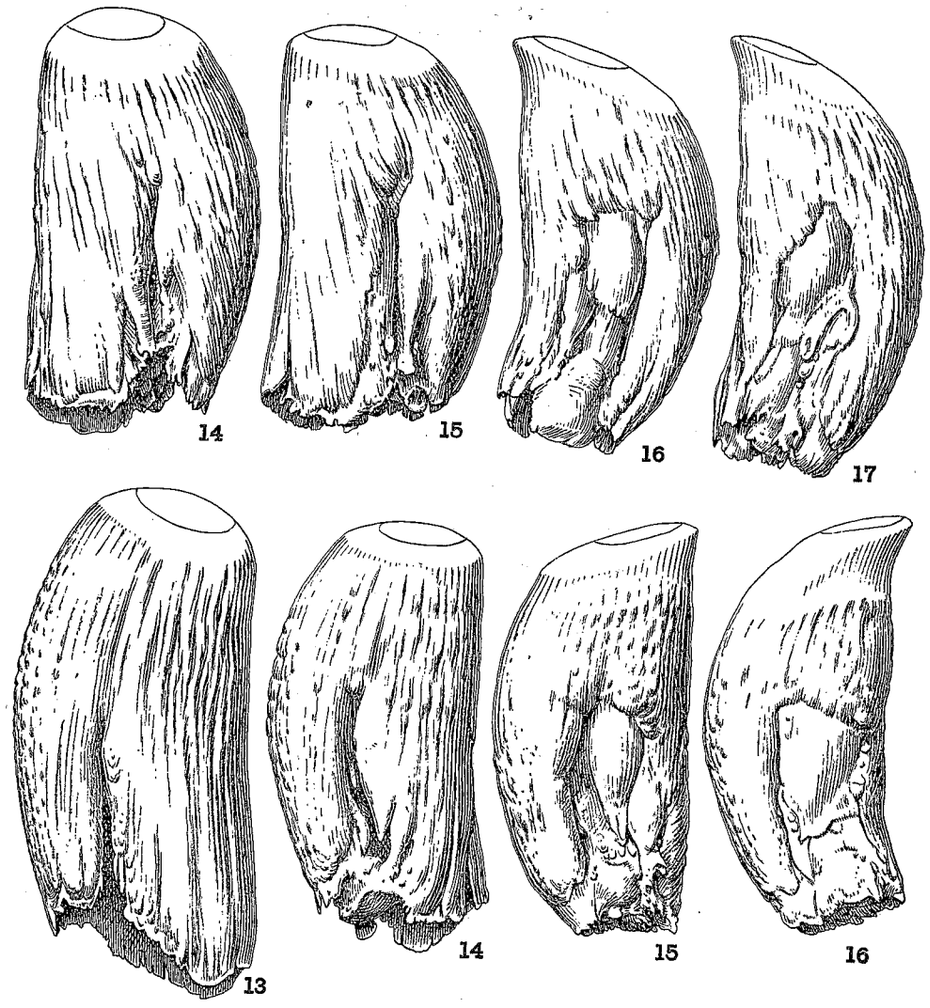


Fig. 12. Upper row, four consecutive teeth from the left lower jaw of the larger specimen; lower row, four consecutive teeth from the right lower jaw of the same specimen. The lingual surface of each tooth is represented. × ½.

40 mm, this depth more or less gradually increases to 97 mm in the tenth, then it rapidly decreases to 23 mm in the fourteenth, whilst the fifteenth and the following have the pulp cavity entirely filled with osteodentine.

In the nineteenth and especially in the twentieth teeth a considerable quantity of osteodentine is protruding from the base.

Already mention was made of longitudinal fissures in the fangs of several teeth of the lower jaw. These peculiarities must be discussed here in some more detail.

In a number of teeth a more or less pronounced longitudinal fissure is found (fig. 12: 13). Sometimes such a fissure occurs on the labial as well as on the lingual surface of a tooth (fig. 10: 14 and fig. 12, upper row: 14). Then the fang is more or less divided into two roots. Afterwards the cavity between the two "roots" has been filled entirely with irregular masses of osteodentine. In the fourteenth tooth of the right jaw (fig. 12, lower row) the fissure is obliterated by osteodentine especially in the basal part.

In the fifteenth tooth of the left jaw (fig. 12, upper row) there are two fissures in the fang, so that it seems as if the tooth had three roots, a small one between two larger. A similar case is that of the fifteenth tooth of the right side (fig. 12, lower row), although the smaller of the three "roots" here may have been formed entirely by osteodentine, which, moreover, has filled the entire pulp cavity as a solid mass.

In the other figured teeth (fig. 12, upper row: 16 and 17, lower row: 16) in a large part of the fang no dentine and cement seems to occur. The large gap in the fang now is completely filled with more or less irregular masses of osteodentine.

Some of the teeth represented in fig. 12 remind of the specimen described by Neuville (1929, and 1932, figs. 16—18), which shows a fang divided into three parts by conspicuous fissures and folds so that the tooth seems to have one small and two large roots. Another specimen with distinct fissures in the fang is figured by Neuville (1932, fig. 33). The author gives the correct explanation of these anomalities, they are caused by defective development of the lower part of the tooth. It is interesting that sometimes really double teeth occur in sperm whales. A beautiful example of this kind is described by Pouchet and Beauregard (1889 a, pl. 6 fig. 4) and in papers by Neuville (1928, and 1932, pls. III and IV). Especially the transverse section of this compound is interesting, as it shows the two separate central masses of dentine, surrounded by the layers of cement which have united in the plane of contact.

6. The mandibular teeth of the smaller specimen.

In the left lower jaw of the smaller specimen there are 23 teeth, in the right lower jaw 25. The length of these teeth varies from 59 to 148 mm; their measurements are given in Table IV.

Table IV. Measurements in mm of the mandibular teeth of the smaller specimen

Left					Right				
Number	Length	Greatest breadth	Greatest thickness	Thickness at base	Number	Length	Greatest breadth	Greatest thickness	Thickness at base
1	118	41	40	32	1	122	40	39	31
2	137	49	48	41	2	133	48	48	39
3	141	51	46	37	3	140	52	47	36
4	148	53	46	35	4	147	55	45	33
5	140	52	45	34	5	146	57	46	32
6	144	58	46	34	6	145	59	47	32
7	138	58	47	33	7	139	63	46	30
8	137	62	47	34	8	140	62	47	31
9	138	61	47	32	9	138	60	48	32
10	136	58	47	33	10	142	58	47	32
11	137	56	46	33	11	138	58	48	31
12	140	54	46	32	12	135	52	47	31
13	137	56	46	31	13	133	53	46	30
14	135	53	43	30	14	133	55	45	29
15	132	51	43	28	15	134	55	44	29
16	127	48	40	27	16	129	51	42	27
17	129	51	39	25	17	132	47	39	25
18	128	48	35	21	18	130	48	38	28
19	119	45	31	17	19	125	44	34	19
20	98	41	28	20	20	115	43	31	16
21	82	39	26	19	21	115	43	30	15
22	76	45	26	18	22	85	45	27	19
23	62	35	22	18	23	71	40	25	17
					24	67	37	25	16
					25	59	29	21	9

The series of teeth of the left lower jaw considered as a whole does not differ appreciably from the series of the right. As a number of teeth of the right lower jaw are represented here (fig. 13) these may be discussed first.

In the first three teeth the fang is more or less circular in cross section, towards the middle of the jaw this section becomes oval. The pulp cavity of the first tooth has a depth of 34 mm, in the second of 52 mm. Gradually this depth increases to 72 mm in the seventh and eighth, it then decreases again to 25 mm in the twentieth and 22 mm in the twenty-first tooth. In the four following teeth the pulp cavity is completely filled with osteodentine.

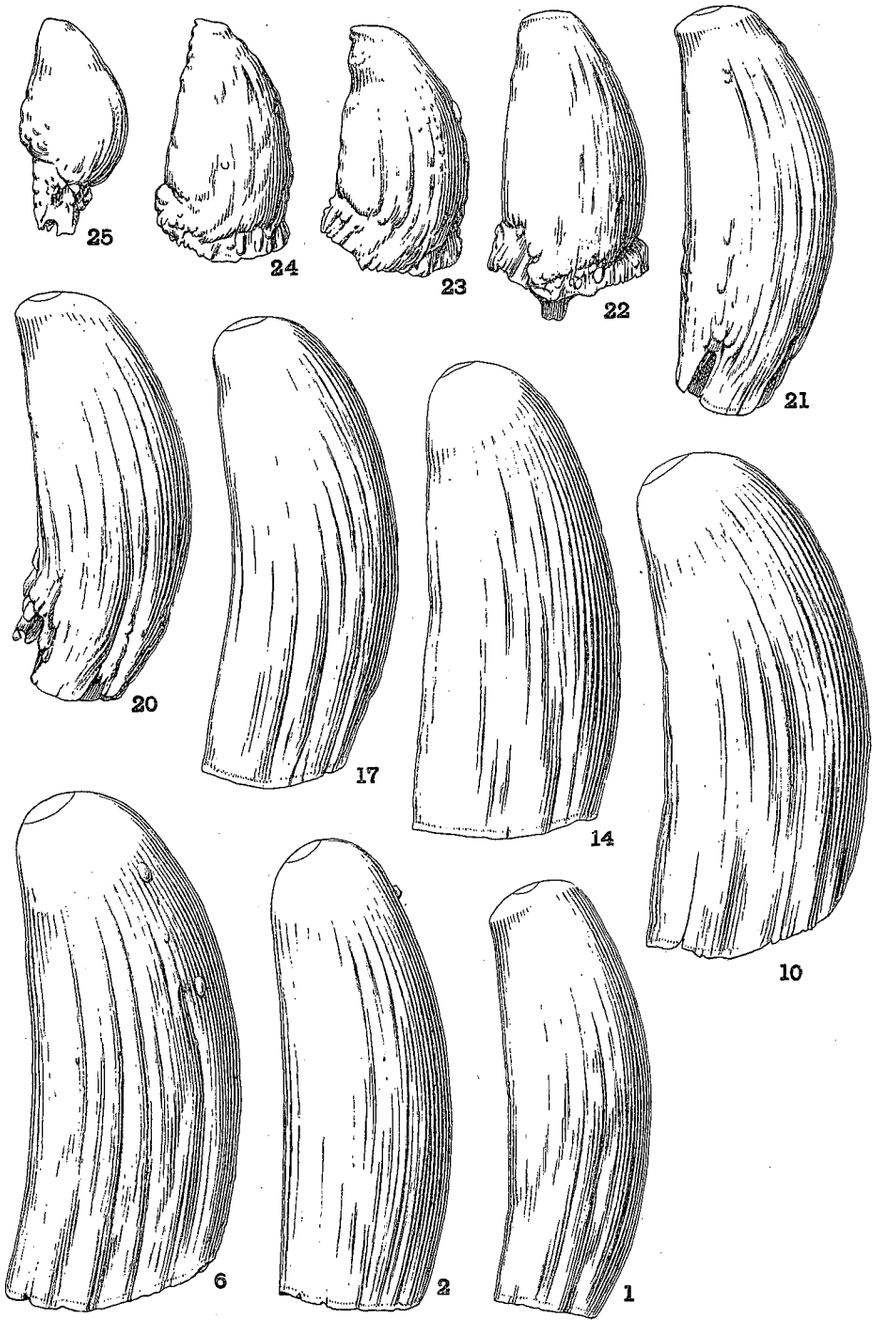


Fig. 13. Teeth from the right lower jaw of the smaller specimen. The labial surface of each tooth is represented. × ½.

In some of the teeth (fig. 13: 20, 21) there are small fissures in the fang largely filled with osteodentine. In the twenty-second to twenty-fifth masses of osteodentine have accumulated at the base, projecting beyond the dentine and cement.

With the exception of the twenty-fourth the teeth projected from 15 to 40 mm above the gum. Probably the twenty-fourth tooth was secondarily covered by the gum, as its top for about a distance of 15 mm is covered by layers of tartar as they are found on the functional teeth.

The mandibular teeth of the left jaw of the smaller specimen protruded for 18 to 35 mm above the gum, with the exception of the last which was not functional. The pulp cavity of the first tooth has a depth of 36 mm, of the second it is 50 mm deep. The deepest cavity is found in the seventh (70 mm), then it gradually diminishes to 28 mm in the nineteenth and 6 mm in the twentieth tooth. In the twenty-first to the twenty-third teeth the pulp cavity is entirely filled with osteodentine, which even protrudes beyond the cavity.

In comparison to the mandibular teeth of the larger specimen the teeth of the lower jaw of the smaller specimen contain little osteodentine. Especially in the anterior half of the jaw the pulp cavities are neatly conical cavities, towards the posterior end of the jaw the tendency to fill the pulp cavity with osteodentine becomes more pronounced.

7. The dentition of the two specimens.

During the process of cleaning of the skeletons of our two sperm whales the teeth were taken from their surrounding tissues after measurements had been taken of the distances between the centers of each consecutive pair of teeth. These distances are recorded in Table V for the larger specimen and in Table VI for the smaller specimen.

A diagram of the complete dentition of the larger specimen is given in fig. 14. The figure shows the position of the maxillary teeth as they are found in the gum. These teeth are drawn to scale as black spots as far as they protruded from the gum, the teeth which remained hidden under the surface are represented as small circles. In the palate rows of pits are found caused by the extremities of the teeth of the lower jaw when the mouth is shut. At the places where these pits occurred the teeth of the lower jaw are drawn in cross section, as black spots, except the few which had not pierced the gum, the latter are drawn as small circles. In this manner the whole dentition is drawn to scale, as may be seen when comparing the distances to those given in Tables V and VI. The relative position of the

teeth of the upper jaw and those of the lower could be easily ascertained as many maxillary teeth were distinctly visible.

Some interesting facts may be derived from this figure. In the first place it is evident that the row of right maxillary teeth is found far behind that of the left side. The first left maxillary tooth is implanted before the impression of the third mandibular tooth of the same side, whilst the first right maxillary tooth is found behind the impression of the fourth mandibular tooth of the same side.

In the second place the maxillary teeth seem to be arranged more or less

Table V. Distances between each consecutive pair of teeth in the lower and upper jaws of the larger specimen

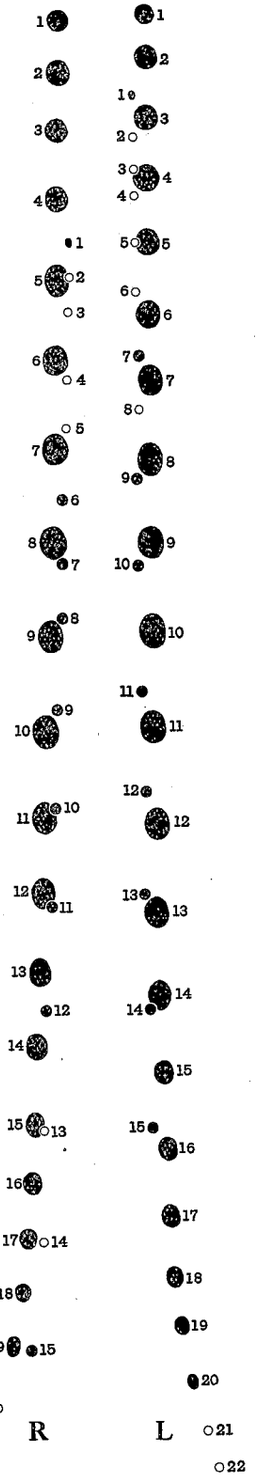
Lower jaw								Upper jaw			
Left				Right				Left		Right	
Number	Distance in cm	Number	Distance in cm	Number	Distance in cm	Number	Distance in cm	Number	Distance in cm	Number	Distance in cm
1		15		1		15		1		1	
	9		16½		11½		12½		8½		7
2		16		2		16		2		2	
	12½		14		12		13½		9		7½
3		17		3		17		3		3	
	13		13½		14½		11½		5½		14½
4		18		4		18		4		4	
	13½		10½		17½		11½		10		10½
5		19		5		19		5		5	
	15½		12		17		13½		10½		15
6		20		6		20		6		6	
	14½		10½		18½				13½		13½
7		21		7		7		7		7	
	17		8		20				11½		11½
8		22		8		8		8		8	
	18				20				14½		19½
9				9		9		9		9	
	19				20½				18½		21
10				10		10		10		10	
	20½				18½				26½		22
11				11		11		11		11	
	21				16				21		25½
12				12		12		12		12	
	19				17				21½		23½
13				13		13		13		13	
	17½				16				24		
14				14		14		14		14	
	16½				16½				25		23½
15				15		15		15		15	

at random when compared with those of the lower jaw. The teeth of the upper jaw do not alternate with those of the lower jaw, as one would expect. Some of the maxillary teeth are found in the pits caused by the mandibular teeth, others occupy a more or less intermediate place between two of these pits. Sometimes even two maxillary teeth are found between two successive pits in the gum of the upper jaw (the left maxillary teeth 2 and 3, and the right maxillary teeth 4 and 5).

At the left side the row of maxillary teeth nearly reaches the anterior

Table VI. Distances between each consecutive pair of teeth in the lower and upper jaws of the smaller specimen

Lower jaw								Upper jaw			
Left				Right				Left		Right	
Number	Distance in cm	Number	Distance in cm	Number	Distance in cm	Number	Distance in cm	Number	Distance in cm	Number	Distance in cm
1		13		1		13		1		1	
	9		13½		10		10½		13		13
2		14		2		14		2		2	
	12		12½		11		11½		13		9
3		15		3		15		3		3	
	12½		13		11½		12		16		11
4		16		4		16		4		4	
	13		13		13		11		16		11½
5		17		5		17		5		5	
	13		15½		13½		12½		15½		15
6		18		6		18		6		6	
	15		14		15		10½		17		15
7		19		7		19		7		7	
	14		11½		15		11		19		14
8		20		8		20		8		8	
	14½		11		14		11				17
9		21		9		21		9			
	14		10		14		10½				
10		22		10		22		10			
	11		8		14		9				
11		23		11		23		11			
	11				12½		6½				
12				12		24		12			
	13				9½		6				
13				13		25		13			



part of the upper jaw, at the right side the series of maxillary teeth continues almost to the posterior region of the upper jaw.

The dentition of the smaller specimen is represented diagrammatically in fig. 15. The distances of each consecutive pair of teeth are drawn here to scale, the teeth of the upper jaw are represented by small circles at the left side of the figure, the teeth of the lower jaw are given at the right side of the figure as they appeared as impressions on the palate. Unfortunately, in measuring the distances, no notice was taken of the distance of the first maxillary tooth of each side from the anterior part of the jaw. Therefore the exact place of the maxillary teeth in connection with the pits in the palate cannot be ascertained, the left part of the figure consequently could not be superimposed on the right part. Moreover it is not known whether the first maxillary tooth of the right side was found at the same level as the first of the left side or not.

The figure shows (as does Table VI) that in general the distances between two successive teeth of the upper jaw are larger than those between the teeth of the lower jaw. Especially in the hindmost teeth this difference is considerable. From this we may deduce that in the smaller specimen there could not be an alternation of the maxillary teeth with those of the lower jaw. Moreover some of the maxillary teeth must have occupied a place in or near the pits in the palate, whilst others were found in the intervals between two of

Fig. 14. Diagram of the palate of the larger specimen, showing the position of the maxillary teeth (the two inner rows of small spots and circles), and the corresponding position of the teeth of the lower jaw. The position of the latter (the two outer rows) is given by their impressions into the palate. The circles indicate the place of the teeth which remain covered by the gum, the black spots represent functional teeth.

these pits. The figure shows that the smaller specimen must have had a dentition with similar irregularities as that of the larger, but unfortunately the exact position of the teethrows of the upper jaw is unknown.

8. Evidences of contact between maxillary and mandibular teeth.

One peculiarity of the functional maxillary teeth must be described in some more detail. Fig. 14 shows that many maxillary teeth are implanted in the palate at the margin of the pits brought about by the mandibular teeth. It is therefore to be expected that at least some maxillary teeth come into contact with the corresponding mandibular teeth. In some cases even small polished facets are found in the place of contact.

The tenth right maxillary tooth of the larger specimen possesses a small facet on the labial border of the upper surface (fig. 16 a). On the corresponding tooth of the lower jaw, the eleventh, a facet is found of approximately the same diameter, on the lingual side of its upper part (fig. 16 b).

A similar, though smaller, facet is found on the labial side of the eleventh maxillary tooth (fig. 16 c). This facet corresponds with one of approximately the same diameter on the twelfth mandibular tooth (fig. 16 d).

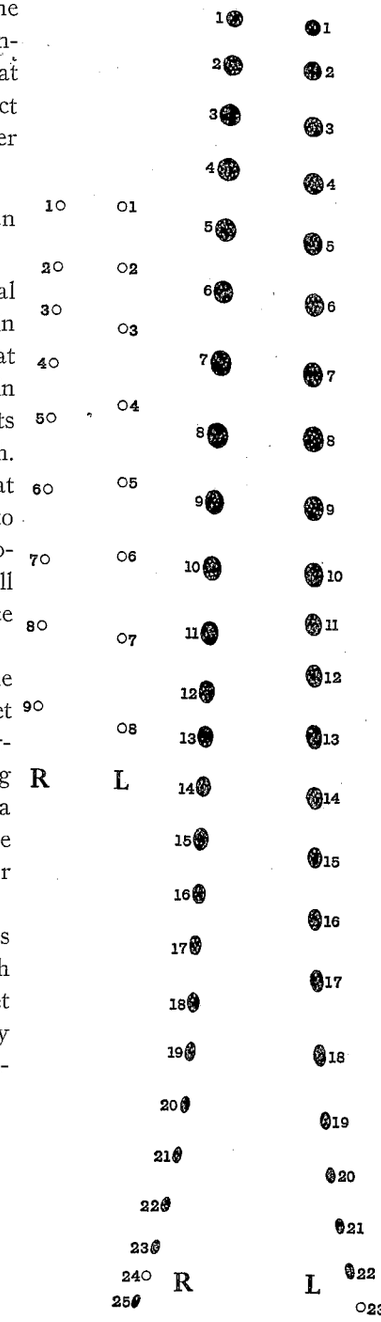


Fig. 15. Diagram of the dentition of the smaller specimen. The two rows of circles at the left represent the maxillary teeth, the two rows at the right the places where the mandibular teeth come into contact with the palate. The circles indicate teeth which remain covered by the gum, the black spots represent functional teeth.

Another mandibular tooth with a polished facet is the fourteenth of the left side (fig. 16 e). As is shown in fig. 14, this tooth corresponds with the fourteenth left maxillary tooth, on which, however, not a distinct facet can be found although there is a slightly polished ridge which might have arisen as a result of rubbing against the mandibular tooth. This fourteenth maxillary tooth is functional, it projects for about 20 mm above the gum.

Three neatly polished facets are found on the top of the fifteenth right mandibular tooth (fig. 16 f). Fig. 14 shows that this tooth made a pit in the palate at the place where the thirteenth maxillary tooth is found. The latter (fig. 8), however, did not protrude from the gum, its top shows a large amount of decay by caries and it was found surrounded by an abscess. So the facets of the mandibular tooth cannot be explained as a result of friction against the maxillary tooth as it is now. It is possible, however, that previously the maxillary tooth did cut the gum and was in contact with the mandibular tooth when the mouth was shut. Afterwards the top of the maxillary tooth may have broken and secondarily become covered by the gum again.

The facets described above are of very small size. Much larger facets are found on two teeth in a lower jaw which has been for long years in the collections of the Rijksmuseum van Natuurlijke Historie. The symphysial part of this jaw has a length of 111 cm. In the lower jaw of the smaller specimen of February 1937 the symphysial part is 244 cm long, in the larger specimen 290 cm. This proves that the lower jaw referred to belonged to an adult female or a young male [1]). The gum has been removed from this jaw to the surface of the bone, so that the alveoli remain filled with dried soft parts and the teeth remain with their fangs in the original places. A number of the teeth, in the posterior part of the jaw, have become lost (probably taken out), so that holes remain in their place. Each half of the jaw originally possessed 25 teeth. On each side of the jaw the ninth tooth is worn out to a considerable degree, undoubtedly by friction against a functional tooth of the upper jaw.

In the left jaw the ninth tooth shows a shallow groove with a smoothly polished surface at a short distance from the top (fig. 17), in the ninth tooth of the right jaw a similar, though somewhat deeper depression is

1) That really the jaw belonged to an adult female could be ascertained by the extraction of a tooth from the middle region. The fang of this tooth is distinctly contracted, the depth of the pulp cavity is reduced to 25 mm. Consequently the tooth had reached its maximum size, and therefore the animal from which the jaw was taken was adult. Owing to the comparatively small size of the jaw it cannot have been anything else but a female.

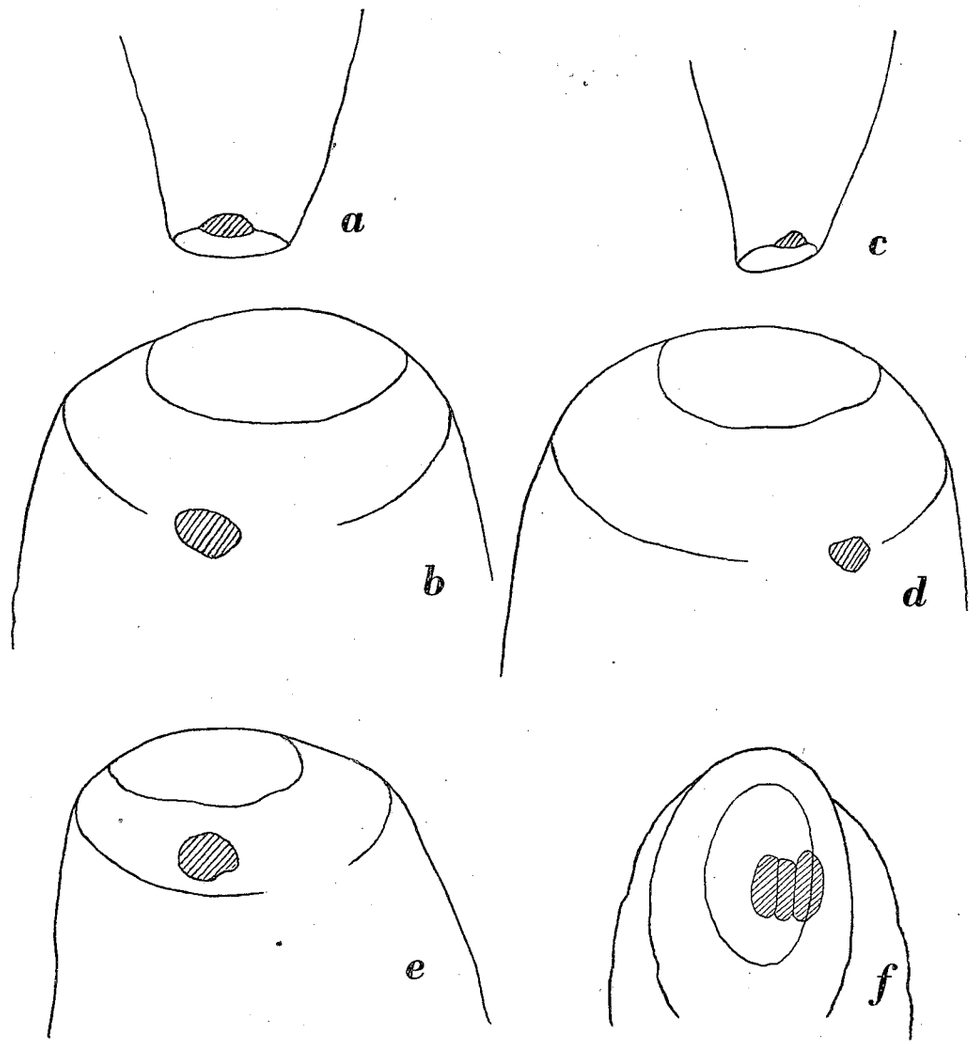


Fig. 16. Tops of teeth of the larger specimen. a, labial side of the tenth right maxillary tooth; b, lingual side of the eleventh right mandibular tooth; c, labial side of the eleventh right maxillary tooth; d, lingual side of the twelfth right mandibular tooth; e, lingual side of the fourteenth left mandibular tooth; f, upper view of the crown of the fifteenth right mandibular tooth. The facets are represented by shading. Natural size.

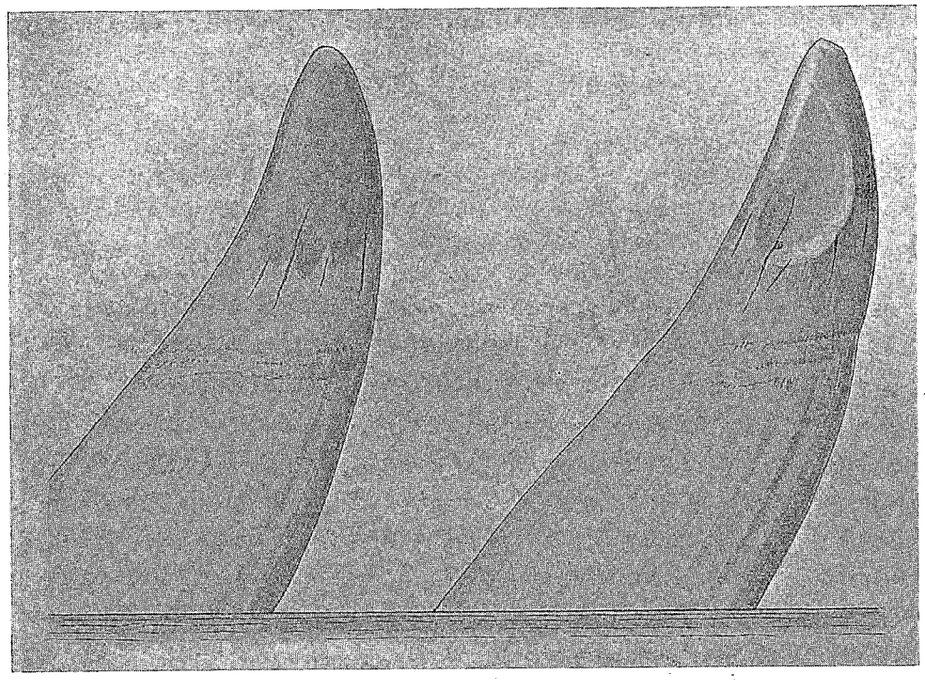


Fig. 17. The tenth and the ninth left mandibular teeth in the jaw of an adult female. The lingual surface is represented. Natural size.

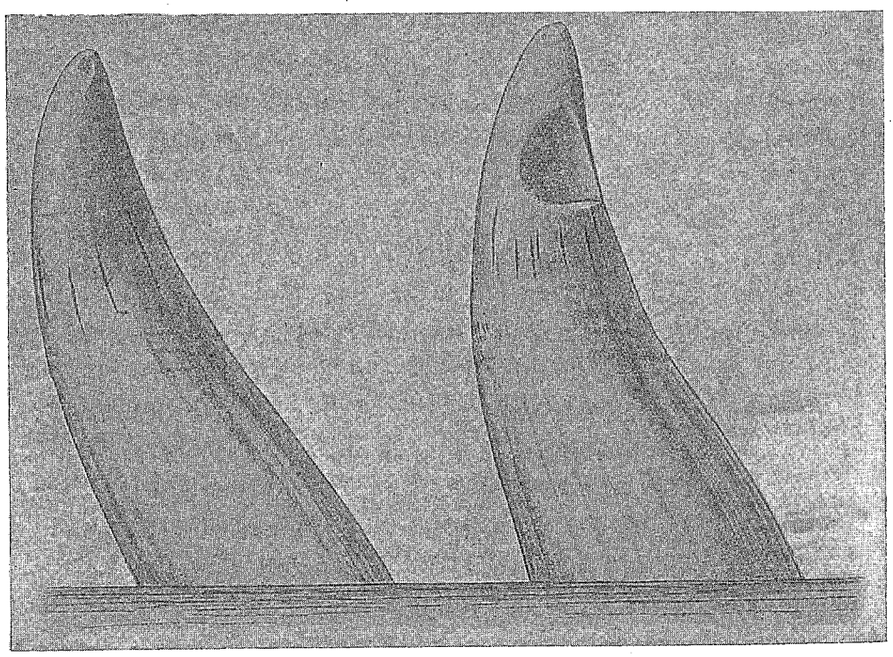


Fig. 18. The eighth and the ninth right mandibular teeth in the jaw of an adult female. The lingual surface is represented. Natural size.

found (fig. 18). Here too the surface of the groove is smoothly polished. Some other teeth of the same mandible possess small facets which may be caused by contact of these with functional maxillary teeth, as, e.g., the eighth tooth of the right jaw (fig. 18).

The figured teeth projected for about 4 or 5 cm above the jaw, as is indicated by the transverse lines, due to small quantities of tartar.

Similar instances of large facets on the crown end of sperm whale teeth have been described and figured by Neuville (1932, pl. XIV and figs. 52

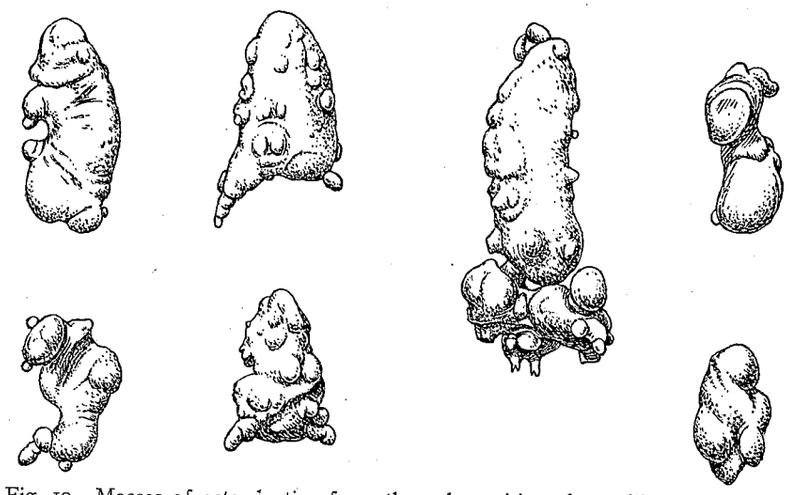


Fig. 19. Masses of osteodentine from the pulp cavities of mandibular teeth of the larger specimen. Natural size.

and 53). It proves that cases of contact between maxillary and mandibular teeth are not of very rare occurrence.

9. The osteodentine.

In the pulp cavities of the larger mandibular teeth of the smaller specimen no osteodentine was found, but it does occur in the hindmost teeth, often in large quantities, so that the whole of the pulp cavity is filled with this material. In the smallest teeth it even protrudes as irregular masses from the base of the fang (fig. 13, upper row of figures).

In most of the teeth of the lower jaw of the larger specimen lumps of osteodentine were found. Many of these were present in the soft tissues of the pulp cavity as isolated masses. These lumps of osteodentine usually have an irregular shape as they are the result of the fusion of several smaller nodules. A few of these are represented in fig. 19. Other lumps

of osteodentine had already grown on to the dentine or are partially embedded in this material.

As remarked in the previous pages the fang of a great number of the maxillary teeth of the larger specimen contains a large amount of osteodentine. In all the maxillary teeth of the smaller specimen the pulp cavity is completely filled with this material.

Not in every tooth of the sperm whale osteodentine is formed. It usually is not found in young mandibular teeth, and it is nearly always present in teeth of old specimens, especially when the fang is narrowing or obliterating. Of the two specimens of which the teeth are described in the present paper one did not possess osteodentine in most of its mandibular teeth, whilst in those of the other it occurred in large quantities. The occurrence of osteodentine in the teeth of sperm whales is described by White (1861, p. 224/225) as follows: "... isolated nodules of this material are often found imbedded in the early-formed dentine tissue. Generally, however, it is in more mature teeth, and when the vital powers of the matrix begin to flag, that this is more abundantly formed, and often the remnant of the pulp is converted into it, and thus fills up the cavity of the contracting fang".

Several instances of teeth in which the pulp cavity is entirely filled with osteodentine are referred to on previous pages, particularly many maxillary teeth and the smaller mandibular teeth at the posterior part of the toothrow show this phenomenon. A very striking example of this kind is figured and briefly described by Moodie (1923, pl. XLVI b and fig. 21). Especially the longitudinal section of this tooth (l.c., fig. 21) shows the irregular masses of osteodentine ("pulpstones") which have closed the whole of the pulp cavity.

Sections of sperm whale teeth often reveal masses of osteodentine embedded in the dentine. A well known example of this kind is the figure of Owen (1840—1845, pl. 89 fig. 2; 1866—1868, vol. 1 fig. 239). Here an isolated nodule of osteodentine is seen near the top of the tooth and larger coalescent masses in the central part of the lower half. In a figure published by van Beneden and Gervais (1868—1880, pl. 20 fig. 7) a few nodules of osteodentine are represented in the axis of the dentine, and in one of the figures of Neuville (1932, pl. I) small nodules of a similar shape are visible.

By the kind permission of Dr. A. B. van Deinse figures are given here (Pl. XIII) of a sperm whale tooth from his collection, which has been sawn into two halves longitudinally. The polished surfaces of these two halves show the outer layer of cement, covering the dentine which forms the bulk

of the tooth, and, enclosed in the dentine, several masses of osteodentine. The latter has a pronounced yellow colour and appears rather dark in the photographs, so that the difference between this matter and the dentine is decidedly more accentuated than in the object itself. The tooth has a length of 16 cm, the topmost part is broken so that about half a cm is missing here, the maximum breadth is 6 cm. Of one of the halves (right hand figure of Pl. XIII) the flat surface is approximately the median plane of the tooth; the surface of the other half (left hand figure of Pl. XIII) is at some distance from the median plane, as some material has vanished in the process of cutting and polishing.

The manner in which the osteodentine in this tooth is enclosed is extremely interesting. In the sections the osteodentine appears as strings of pearls separated from each other so that in the whole length of the tooth at least six successive groups of osteodentine are found. The direction of the "strings" of osteodentine is parallel to the layers of the dentine.

The complete history of the tooth is evident from these sections. At a certain time a mass of osteodentine, consisting of small isolated nodules, was formed in the pulp cavity in the neighbourhood of the last layer of dentine. Gradually the osteodentine came into contact with the dentine and it was covered with new layers of dentine. After several new layers of dentine were formed so that the original group of osteodentine was completely embedded in the dentine, a second group of nodules of osteodentine was secreted. This process continued regularly, so that periods in which dentine only was formed alternated with periods in which an amount of osteodentine was formed. The last group of osteodentine is much larger than the previous groups, so that the top of the pulp cavity now is filled with an irregular mass of comparatively large conglomerates of this matter.

How can this regular succession of formation of pure dentine and of osteodentine be explained? As a possible explanation I venture the following. The regularity in the whole process reminds of the winter-rings in the scales of fishes which are excellent indicators of age and growth. Now it is possible that the formation of osteodentine in the teeth of sperm whales is favoured by a change in external circumstances, e.g., differences in temperature or food. Especially the latter may be an important factor for the process. There are several data on the annual migration of the sperm whale (van Musschenbroek, 1877; Collett, 1911—1912; Tomilin, 1936), and it is not improbable that the sperm whale from which the described tooth was taken developed osteodentine during a certain time of the year which was spent under different (possibly unfavourable) conditions as compared to the rest of the year. The last mass of osteodentine is of an irregular

shape and much larger than the previous masses, it is partially embedded in the dentine, but not yet covered with dentine at the outside. Probably therefore the animal was still living under conditions which furthered the formation of osteodentine. Now the sperm whale from which the tooth was taken was killed in the Antarctic, where conditions are different from those in warmer seas.

There is no proof whatever for the supposition set forth above, but the regular manner of secretion of successive masses of osteodentine is too obvious to be regarded as purely accidental. If really each mass of osteodentine was formed during a certain time of the year the topmost part of the tooth must have been at least seven years old. The animal itself then was older, as the top of the tooth is distinctly abraded.

V. NOTES ON DISTRIBUTION

The data compiled in the following pages have been arranged according to the countries in which the animals stranded or were captured. For a number of countries there are complete lists of all the sperm whales which have been observed there, for other countries the data are compiled from the literature which was available to me, and which in many cases must have been far from complete.

There are several records of the occurrence of sperm whales on the Dutch coast, although the remains of these animals are very scanty in our country. Two teeth of *Physeter macrocephalus* from prehistoric time are described by van Giffen (1913), the specimens came from a mound near Eenum in the province Groningen. The next oldest record of the occurrence of the sperm whale in the Netherlands is found in the book of Albertus Magnus (1651). After a description of sea monsters fitting in with the figures by Olaus Magnus (1567) and by Gesner (1558) the author continues: "Et tempore meo plures capti sunt: unus quidem in Phrisia circa locum qui Stauria vocatur, cuius cum caput per oculum cuspide punctum esset, undecim lagenis sagiminis emisit, quarum quaelibet vix portabatur ab homine uno: & hoc sagimen & lagenas ego vidi: & est sagimen valdè lucidum & purum postquam defaecatum est. Alter captus fuit ultra traiectum versus Hollandiam, cuius caput quadraginta reddidit sagiminis lagenas." (Albertus Magnus, 1651, p. 650). The strandings of the whales quoted above occurred in the thirteenth century (Albertus Magnus lived from 1193 to 1280), the locality Stauria obviously is Stavoren. As far as concerns the other locality "ultra traiectum versus Hollandiam" we find in the later literature (Cuvier, 1823; Mulder, 1836; Killermann, 1919) the

record "near Utrecht". In all probability this is incorrect. In Albertus Magnus' time the Zuiderzee was not in widely open connection with the North Sea, it was a kind of lake (Lake Flevo) which communicated with the North Sea by an estuary, the Vlie. Stavoren was situated on the east side of the Vlie, and the second specimen mentioned by Albertus Magnus in all probability was captured on the west side of the Vlie. With the sentence "Alter captus fuit ultra traiectum versus Hollandiam" Albertus Magnus evidently meant "The other specimen was taken at the other side of the estuary between Friesland and Holland". As the author states that he has seen the oil, the stranding of the animals must have occurred between 1254 and 1257, as he visited the monasteries of the Netherlands in this time (cf. van Deinse, 1933). That the whales referred to really were sperm whales results from the account quoted above in which the spermaceti is mentioned. As remarked by Pouchet (1888) the account of Albertus Magnus undoubtedly is the first record of the stranding of whales which can be specifically identified.

A list of strandings of whales on the Dutch coast is given by Houttuyn (1762). Later papers containing particulars of stranded whales in the Netherlands are those of Loosjes (1812), Nyenhuis (1836), Mulder (1836), and van Bemmelen (1864). Muller (1863—1877) comments upon numerous plates of sperm whales stranded on the Dutch coasts. Afterwards van Deinse (1918, 1931) critically sifted the data and added some strandings which had remained unnoticed in the previous literature. According to van Deinse's last complete list of strandings (1931, p. 178—183) the number of known cases (including a few of uncertain value) amounts to 41. Not included in this list are the two strandings referred to by Albertus Magnus, and, as a matter of fact, the two animals of 1937. In a later paper van Deinse (1933) comments upon the stranding of sperm whales mentioned by Albertus Magnus. In 1897 the last stranding of a sperm whale on the Dutch coast had occurred more than a hundred years ago (in 1781 or 1788), so that Maitland (1897) lists the sperm whale as exterminated in the Netherlands.

Anderson (1747) gives an account of the stranding of 17 sperm whales, about as many females as males, in the mouth of the Elbe in 1723, and mentions a specimen stranded at St. Peter in 1738. Besides these data six more strandings of sperm whales on the German North Sea coast are recorded by Mohr (1935), occurring in the years 1575, 1604, 1721, and 1762.

According to Winge (1904, 1908) an almost completely decayed skeleton of a sperm whale, from the Littorina-period, i.e., the stone age, was found at the island Læsø in the Kattegat. Winge (1908) moreover mentions the

stranding of a sperm whale in 1770 at Hjarnø off Horsens Fjord. The latter is the only record of the occurrence of the sperm whale in the Baltic in recent time, as such it is mentioned too by Japha (1907, 1908). This stranded whale was one of the two specimens which in 1770 had penetrated into Horsens Fjord (cf. Collett, 1911—1912, p. 628). Another record, probably at least of prehistoric time, is made known by Malm (1871), who gives the measurements of a tooth of a sperm whale which undoubtedly came from the upper jaw. It had been found on one of the islands of the "skärgarden" and had been in the ground for a considerable time.

For the Norwegian waters there are several records of stranded, captured, or observed sperm whales. Linné (1746, 1761) states already concerning the sperm whale: "Habitat in mari norwegico". Collett (1877, 1883, 1911—1912) gives several data concerning the occurrence of sperm whales on or off the Norwegian coast. In two different localities a tooth was found in the ground, one of these had a length of 21 cm and a width (in the laterally compressed basal region) of 10 cm. Strandings of sperm whales on the Norwegian coast occurred in 1713 and in 1780, in 1849 a dead specimen was found floating near the coast, in different localities living sperm whales were observed in 1818, 1845, 1865, and 1894. In 1896 there was a herd of 10—12 specimens off East Finmarken, two of these were captured. Some of the data referred to above are found too in a publication by Grieg (1890). Harmer (1928) mentions the capture of 2 sperm whales off the West coast of Norway in 1926.

Especially in his publication of 1911—1912 Collett gives important data on the distribution of the sperm whale. From these the following may be mentioned here. Every year in July small herds of male sperm whales, comprising about half a dozen specimens, or single specimens, appear from the south and arrive at the Hebrides, the Faroes, and at the east coast of Iceland. In the years between 1903 and 1907, 17 specimens were captured off the Shetland Islands and the Hebrides, in 1911 again 17 specimens were taken at the Hebrides. Near Iceland in 1908 eight specimens were captured, and five in 1909. Guldberg (1901) remarks that in 1895 a sperm whale was captured off the north west coast of Iceland, and another off the Faroes (these records are also mentioned by Collett in his book of 1911—1912). In the same paper Guldberg publishes some other data on sperm whales killed or observed in Norwegian waters or off the Faroes, in Collett (1911—1912) the same data are given. In the Stockholm Zoological Museum there is a skeleton of a sperm whale from the Faroes (Anon., 1924). In 1926 two sperm whales were captured off the Faroes (Harmer, 1928), in 1928 or 1929 six specimens in the North Sea (Harmer, 1931).

Nougaret (1869) records the capture of a sperm whale between the island Jan Mayen and the east coast of Greenland.

Fabricius (1780) records the sperm whale as a representative of the Greenland fauna, three of Linné's species of *Physeter* are mentioned by him. According to Holböll (1849) the sperm whale is extremely rare off the west coast of Greenland, as only once a specimen was observed by him. Brown (1868) too points to the scarcity of the sperm whale in this region, only one instance of the capture of this animal (in 1857) had come to his notice. Zorgdrager (1728) remarks that in 1718 and 1719 some sperm whales were taken in the waters off Greenland an the North Cape. As a rare occurrence Loosjes (1812) regards the capture of one sperm whale off Greenland and four in Davis Strait by Dutch whalers in 1750.

Low (1813) remarks that the sperm whale is often caught about the Orkneys. According to Thompson (1912, 1928 a) the sperm whale is seldom caught at Shetland, but the Hebridean whaling-station got no less than seven individuals in 1909. In the Annual Reports of the Fishery Board for Scotland for the years 1910—1912 (Anon., 1911—1913) the following numbers of catches of sperm whales in Scottish waters are given: 7 in 1909, 1 in 1910, 18 in 1911, 9 in 1912, therefore for the whole period 35 specimens. According to these Annual Reports one specimen captured in 1912 was a female, only on one former occasion (in 1905) a female was recorded from Scottish waters, although 55 males had been taken since whaling started here. The total number of sperm whales taken during the ten years 1904—1913 in Scottish waters according to Jenkins (1921) is 66; Thompson (1928 a) gives as total catch for the period 1904—1914, 53 specimens. In another paper (Thompson, 1928 b) many important details are given. Between 1908 and 1914, 42 sperm whales were landed at Scottish stations, between 1920 and 1927, 33 specimens. Moreover Thompson states, after Haldane, that 23 sperm whales were taken between 1903 and 1907. It is interesting that the two specimens listed as females in reality were males. Thompson (1928 b) states that Haldane already proved that the specimen of 1905 was not a female. For the specimen of 1912 Thompson records a length of 56 feet, which is far too long for a female. Thompson therefore is right in his opinion that also this animal by mistake was regarded as a female. Jenkins (1932) mentions some of the data given by Thompson (1928 b).

Moreover there are several records of the stranding of sperm whales on the Scottish coasts or on the neighbouring islands. Turner (1871) mentions 8 of these strandings, and in a later paper (Turner, 1904) the strandings of 13 specimens are recorded, from the 9th or 10th century

to the year 1903. Among these there is the specimen from Thurso in the county Caithness of July 1863, the skeleton of which now is in the British Museum. The specimen referred to by Peach (1864) in all probability is the same animal, although the author states that it occurred near Wick in the same county in August 1863. Peach states that the skeleton of the specimen was purchased for the British Museum, so that there must be some confusion as far as concerns the localities and the dates. Johnston (1903) refers to one of the specimens listed by Turner in remarking that the last stranding of a sperm whale in Great Britain occurred in 1871. Later strandings were those of the specimens of 1897, 1901 and 1903 (Turner, 1904), and of 1917 (Harmer, 1918 a).

Several strandings of sperm whales on the English coasts are reported, but, as far as I know, no complete list of these has been published. Charlton (1668) remarks that about 20 years previously a specimen stranded near Norwich. In a later paper (Charlton, 1677) this fact must have occurred then about 30 years ago, but it is again recorded as having taken place before about 20 years. Probably the whale referred to was the specimen of 1646 recorded by Southwell (1881). This author mentions three more strandings of sperm whales on the English coast: one before 1606, one of 1626, and one of about 1646. Hunter (1829) and Woods (1829) refer to a sperm whale found at the South coast, Alderson (1827) and Thompson (1829) give particulars of a specimen stranded on the East coast. A specimen stranded on the Cornish coast is referred to by Couch (1878), and some particulars of strandings are given by Gray (1864), who mentions at least three cases not referred to by the authors cited above. The stranding of 12 specimens of sperm whales in the region of the mouth of the Thames in 1788 is mentioned by Gervais and van Beneden (1859) and by Gray (1864). Lydekker (1895) too gives a list of strandings, and mentions besides those referred to above one stranding of about 1652 at Yarmouth and one at Flimby in Cumberland. Moreover Lydekker remarks that in 1646 two specimens came ashore, both probably from a school of 8 or 9 specimens which entered the Wash.

The last specimen stranded on the English coast was the one of Bridlington, in the paper which contains a short description of this animal (Anon., 1937) the remark is found that about six strandings of sperm whales have occurred on the coasts of Great Britain in the last 25 years.

As far as concerns the Irish waters Barrett-Hamilton (1890) mentions the stranding of a sperm whale in 1889. Scharff (1900) records two more of the nineteenth century, and the following previous strandings on the Irish coast: 3 in 1695, 1 in 1750, and 1 in 1766. These data are taken from

Molyneux (1698) and Thompson (1856). The three specimens recorded for 1695 stranded before this year, as Molyneux (1698, p. 508) remarks: "There have been Three of this Kind taken to my Knowledge, in the Space of Six Years, all on the Western Coast of this Country; one near Colerane, in the County of Antrim: another about Ship-harbour, in the County of Donnegall; and a Third in August, 1691." As far as concerns the specimen of 1750, Thompson states that it stranded some years previously. Moreover in this time some sperm whales were captured off the west coast of Ireland: 1 in 1756, 3 in 1761, and in the following years every year some specimens (Thompson, 1856). Finally Thompson records a stranding of "*Physeter tursio*", which occurred about 15 years before 1837. Lillie (1910) remarks that in 1909 five bull sperm whales were captured west of Ireland. Jenkins (1921) states that during the years 1909—1913, 44 sperm whales were captured in Irish waters, Thompson (1928 b) gives the following numbers, after Scharff and Burfield: 1908, none; 1909, four; 1910, seven; 1911, at least two. In 1916 a young specimen (length 18 feet) came ashore in Co. Galway (Harmer, 1917).

In 1927, 11 specimens were taken off the British Islands by whaling companies (Harmer, 1928).

Paré (1604) and several later authors commented upon the stranding of a sperm whale in 1577 near Antwerp. This seems to be the only record for Belgium. As the animal had to pass the Dutch frontier before arriving there, this record is included in the lists of sperm whales of the Netherlands.

For the French Atlantic coast there are records of strandings of sperm whales in the years 1741, 1761, 1769, and 1784 (Despelette, 1744; Gervais and van Beneden, 1859; Fischer, 1872; Brasil, 1909). In 1784 a herd of 31 specimens, for the greater part females, came ashore on the coast of Brittany, the other data refer to single specimens. In 1875 two cachalots were seen in the coastal waters off the Basses-Pyrénées; one, a male of 11 m length, was captured (Anon., 1876). In 1890 a young male sperm whale stranded on the Ile de Ré near La Rochelle (Pouchet and Beauregard, 1890, 1891). According to newspaper reports two male sperm whales stranded near Dunkirk in July 1937. Both were males, as the size of the animals was mentioned as 18 and 22 m.

With some doubt as to the identity of the specimen a stranding is recorded by Nobre (1935) for the Portuguese coast. As, however, the animal had teeth in the lower jaw and had a length of 18 meters, it must have been a sperm whale. 47 sperm whales were captured in 1926 by Portuguese whaling companies (Harmer, 1928).

As far as concerns Spanish whaling companies Jenkins (1932) states

that the one at Algeciras killed 47 sperm whales in 1921. The number of sperm whales taken off the North coast of Spain is 30 for 1925, and 3 for 1926, whilst in the Straits of Gibraltar and surrounding waters 57 specimens were taken in 1926 (Harmer, 1928).

Numerous strandings of sperm whales in the Mediterranean have been reported. Gervais (1864) refers to a specimen stranded in 1856 on the Provençal coast, Frédol (1865) records a specimen stranded in 1862 in the same region. Already much earlier a stranded sperm whale was reported from this region (in 1726, cf. Baier, 1733), but later this animal was regarded as a species of dolphin (Risso, 1826).

In the course of years many specimens died on the Italian coasts. One of the earliest records is that of 1555 in the Adriatic near Trieste, commented upon by Gesner (1560). Some years previously there must have been another specimen, as Rondelet (1554) remarks that it was exhibited at Florence and soon had to be removed on account of its bad odour. This specimen undoubtedly was the one which stranded at Graviscae in Etruria (Tuscany), commented upon by Iovius (1561). The latter author moreover records another sperm whale which stranded some years before the appearance of his work near the mouth of the river Arno in Tuscany. A figure of a sperm whale stranded at Ancona (east coast of Italy) in 1601 is mentioned by Turner (1878). Six sperm whales were captured at Cittanuova near Trieste in 1853, a detailed account of the event is given by Heckel (1853), who in this paper moreover mentions four strandings of sperm whales on the coasts of Italy in ancient and mediaeval times. Lists of strandings of sperm whales on the Italian coasts are given by Cornalia (1870 ?) and de Sanctis (1881), here 14 cases are mentioned for the period between 1715 and 1874, among which the specimens of 1726 (Baier, 1733) and of 1853 are included. Moreover two strandings of uncertain dates are mentioned by de Sanctis, and the find of a lower jaw in the ground at Chioggia in 1810 is recorded by Cornalia and de Sanctis. In 1903 the body of a female specimen was found by Harmer on the island Lipari (cf. Harmer, 1917).

De Heldreich (1878) states that twice a sperm whale stranded on the Greek island Tenos, the last in 1840. The latter specimen was already referred to in a paper by Erhard (1858). Finally there is a record of a stranded sperm whale near Alexandria in 1838 (cf. Heckel, 1853).

For long years sperm whaling has been practiced in the Azores by the inhabitants of these islands. Pouchet and Beauregard (1889a, 1892), Pouchet and Chaves (1890), Monaco (1888, 1905, 1913) and Nobre (1935) give particulars of sperm whales caught off these islands. Van Beneden (1885) states that according to Droüt (Eléments de la Faune Açorienne,

1861; not seen by me) yearly about 150 sperm whales were caught at the Azores. Lindeman (1899) remarks that in 1898 on the Azores there were 29 whale companies each with a small number of rowing boats for the capture of sperm whales. According to Fraser (1937) the capture of these animals in the waters round the Azores in 1935 was 136 specimens (after data from the "Norsk Hvalfangst-Tidende" for August, 1936, cf. Fraser, 1937, p. 266. Some more of the data given below after Fraser, and many of the data in papers by Harmer (1928, 1931) are from the same journal).

Stafford (1669) states that sperm whales have been driven upon the shores of Bermuda and the Bahamas. A stranding of a young sperm whale at the Bermuda Islands is commented upon by Wheeler (1933), a recent stranding of a young specimen near New York gave occasion for the important paper by Raven and Gregory (1933). In 1842 a female specimen came ashore in Vineyard Sound, it was examined by Jackson (1845).

In former times sperm whales were not altogether rare in the waters off the New England coast (Goode, 1884). Dudley (1725) made some remarks on the sperm whale from this region, and Brisson (1756) even regarded the form occurring here as a distinct species which he named *Cetus novae angliae*. The first sperm whale killed by Nantucket whalemen was captured in or about the year 1712 (Starbuck, 1878; Hawes, 1924). This formed the beginning of intensive whaling chiefly by the Americans, who gradually hunted the sperm whales in all the seas of the world. According to Jenkins (1932) about 65.000 sperm whales were killed by American whalers in the period 1810 to 1880. The number of sperm whales captured during each year gradually increased till it reached its maximum in 1837, from this year the number diminished. Harmer (1928), who gives the number of gallons of sperm oil in periods of ten years from 1810 to 1880, remarks: "The decline from that year [i. e., 1837], to 1860 at least, must be attributed to a destruction of whales in excess of their rate of reproduction." (l.c., p. 64).

In recent times sperm whales have been captured off Newfoundland (Hentschel, 1910). In 1928 still 11 sperm whales were captured by Norwegian companies in Newfoundland waters (Harmer, 1931). There is at least one record of a sperm whale being taken in the Gulf of Mexico (Newman, 1910).

Smuts (1832) remarks that sperm whales are not rare in South Africa. The animal is mentioned as belonging to the fauna of this region by Sclater (1901), Fitzsimons (1920), and Haagner (1920). Some remarks on sperm whales captured at Durban are given by Chubb (1918). According to Harmer (1928) the following numbers of sperm whales were taken in the Cape Colony: 30 in 1923; 34 in 1924; 60 in 1925. The same author

gives the following data for Natal: 73 sperm whales captured in 1923; 256 in 1924; 511 in 1925; 466 in 1926; 408 in 1927. Jenkins (1932) gives the same numbers, but records for 1927 a number of 508 specimens. Fraser (1937) remarks that in the period of the southern summer 1934/35, 595 sperm whales were captured on the coast of Natal.

Lesson (1826) cites a statement by Marco Polo, showing that in former times sperm whales occurred in large numbers near Madagascar.

On the West African coast between 22° S. and the Equator 51 sperm whales were captured in 1925/26 (Harmer, 1928). In a later publication (Harmer, 1931) the number of 1.073 sperm whales is recorded as caught by Norwegian companies in the season 1928/29 in African waters. According to Tomilin (1936) near the Walfisch Bay 9 sperm whales were captured in 1926; off Angola 17 in 1924, and 27 in 1925; off French Congo 35 in 1926.

During the seven years from 1919/20 to 1925/26 the number of sperm whales killed in South Georgia and the South Shetlands was 170 (Thompson, 1928 a). Harmer (1928), Jenkins (1932), and Tomilin (1936) give a more detailed account, from which the following data may be taken. In the nine years from 1909/10 till 1917/18 the yearly catch in South Georgia varied from 0 in 1910/11 to 37 in 1917/18; the whole number taken during this period was 112. The number of sperm whales captured in the four successive seasons 1919/20 to 1922/23 was 3, 15, 0, and 16 respectively. In the four years from 1923/24 till 1926/27 the yearly number of sperm whales varied from 15 (in 1925/26) to 46 (in 1923/24); the whole number taken during this period was 102. Off the South Shetlands in the 11 periods from 1911/12 to 1922/23, 56 sperm whales were captured, the highest number for one season (1911/12) being 17; in the four years between 1923/24 and 1926/27, 113 specimens. One sperm whale was taken in the South Orkneys in 1925/26. In the 17 years for which the data are given by Harmer (1928) and Tomilin (1936) therefore 418 sperm whales were taken in the Antarctic region. In the season of 1928/29, 62 sperm whales were captured in the Antarctic by Norwegian companies (31 off South Georgia, 2 in the Ross Sea, and 29 by pelagic whaling in the West Antarctic, cf. Harmer, 1931, after data from the "Norsk Hvalfangst Tidende"). In later years this number became much higher, as may be seen from the following quotation from Fraser (1937, p. 266): "Attention may be drawn to the rapid increase in the number of Sperm Whales taken in the Antarctic in the last few years. From 1919—20 up to and including the season 1931—32 the Sperm catch was always less than 100 in any one season; in 1932—33 it reached 107; in 1933—34, 666; and in 1934—35, 577."

Blyth (1863) remarks that sperm whales are occasionally hunted at the

entrance of the Bay of Bengal, within sight of Ceylon, Sclater (1891) gives some particulars of a specimen which came ashore on the Madras coast, and Fernando (1913) records three strandings of sperm whales on Ceylon.

According to Quoy and Gaimard (1824) the sperm whale which they regarded as the distant species *Physeter polycyphus* was not rare in the seas around Timor. During a visit to the island Lomblem in the Timor archipelago Weber saw several skulls of sperm whales from animals captured by the inhabitants. One of these measured 193 cm, it was therefore from a young specimen (Weber, 1923). Turner (1878) mentions a lower jaw in the Edinburgh Museum, which came from Banda. Temminck (1849) comments upon the occurrence of the sperm whale in East Indian waters, but thinks that the capture of these animals hardly would be profitable owing to the rapid decrease in numbers. On the other hand van Musschenbroek (1877) expresses as his opinion that sperm whale hunting could be established successfully in the Moluccas. Van Musschenbroek gives several data on sperm whales in the Moluccas. The largest specimen which was accurately measured had a length of 84 English feet (= 25.6 m). Van Musschenbroek gives an account of the annual migration of the sperm whale in these regions. They enter the East Indian Archipelago from the south and migrate through the Banda and Celebes Seas northward to the Philippines and Japan, whence they return again. There are certain feeding grounds on which they stay for a long time. As such are mentioned by van Musschenbroek the grounds north of New Guinea and around the northern part of Halmahera and Morotai, and the region to the west of Ternate, Tidore, and Batjan.

Bourret (1928) mentions the sperm whale for the fauna of Indochina, Casto de Elera (1895) for the Philippines and the Mariana Islands.

Kaempfer (1729) already mentions the capture of sperm whales on the east coast of Japan, and de Lacepède (1818) describes a "new species" of sperm whale from Japanese waters after illustrations of these animals.

Jenkins (1932) gives the figures for the annual catch of sperm whales in Japan for the years 1910 to and including 1920. The total amount of sperm whales killed here during this period was 2.732; the average number per annum 248. The highest number was 588 in 1918, the lowest number 67 in 1910. In 1926 according to Harmer (1928) 364 sperm whales were taken in the seas off Japan and Korea, and 35 in Kamchatkan waters. A number of 606 sperm whales is recorded as taken in 1929 by Norwegian companies in East Asia (Harmer, 1931). Tomilin (1936) gives the following data for the number of sperm whales captured in Japan and Korea: 364 in 1923, 364 in 1925, 737 in 1926, 457 in 1927, 617 in 1928, 606 in 1929,

and 753 in 1930. Fraser (1937) remarks that in 1935 in Japan and Korea 479 sperm whales were captured. Peelle (1932) states that on the largest whaling station in Japanese waters, that in the Kurile Islands group, during 12 years 12 sperm whales were taken.

Zenkovič (1934) mentions that 57 male sperm whales were taken in 1933 in the Avatchinsk and Kronotsk Bays off Kamchatka in the Bering Sea. Tomilin (1936) gives for this region the following numbers: 57 in 1933, 71 in 1934, and 95 in 1935. Of the 128 sperm whales killed in 1933 and 1934, 20 specimens or 15 % had a length of 12—14 m, 89 specimens or 70 % a length of 14—17 m, and 19 specimens or 15 % a length of 17—19 m. Only two specimens were over 18 m long. Nearly all these animals were males, in three years' time only 3 females were taken. The data given here prove that hardly any of the killed specimens had reached its full growth. As far as concerns the migration of the sperm whale Tomilin (1936) remarks that in May and June they move northward along the Japanese waters and the Kuriles to the feeding grounds off Kamchatka; in September and October they migrate again in a southern direction.

Records of the occurrence of the sperm whale in Australia are given by Wall (1887, reissue of the edition of 1851), Aflalo (1896), and Iredale and Troughton (1934). A stranding of 36 male and one female sperm whales at Perkins Island, Tasmania, is briefly described by Lillie (1915). Hector (1873, 1878), and Hutton and Drummond (1904) mention the sperm whale for the fauna of New Zealand, whilst two instances of strandings of herds of these animals are recorded by Oliver (1922): in 1895 males, females, and young animals, altogether 27 specimens, and in 1918 a number of 25 sperm whales, measuring from 22 to 45 feet.

Near the coast of Chile in former times sperm whales occurred in large quantities (Hawes, 1924). In the summer of 1925/26 in the sea west of Chile 75 sperm whales were taken (Harmer, 1928); in the season of 1934/35 in this region 173 sperm whales were captured (Fraser, 1937). Moreover in 1925/26 off the coast of Peru 5 specimens were killed (Harmer, 1928).

Off Lower California 3 sperm whales were captured in 1926 (Harmer, 1928, Kellogg, 1931). In the four years 1925—28 a number of 12 was taken. According to Grinnell (1933) the sperm whale formerly was common off California, he remarks further that 4 or 5 were taken in Monterey Bay between 1918 and 1922. Kellogg (1931) records 7 specimens for California in the 5 years 1919—1923 and 3 in the two years 1925 and 1926.

In the five years 1919, 1920, and 1922—24 a number of 61 sperm whales were captured by whaling stations in Washington, for stations in

British Columbia in the 10 years 1919, 1920, and 1922—29 the total amount of sperm whales was 773 (the largest number, 146, in 1929, the smallest number, 35, in 1919) (data from Kellogg, 1931). In 1935 still more sperm whales were captured off British Columbia, Fraser (1937) gives 175 as the number for this year.

Nichols (1926, p. 609) remarks: "In summer the seas about the Aleutians are so little Arctic in character that an occasional warm-water sperm whale is taken at Akutan." In Alaskan waters, however, the sperm whale is not very rare, as numerous specimens have been taken in the 11 years between 1919 and 1929. After the data given by Kellogg (1931) the whole number of sperm whales captured here in this period was 361, the largest annual number was 95 (in 1919), the smallest number 1 (in 1921 and 1926).

In the region of the North Pacific bordered by British Columbia, Alaska, and Kamchatka, according to Tomilin (1936) between 1919 and 1929 the total number of sperm whales captured was 1217. The yearly number of sperm whales killed here in 1926 was 41, in 1933, 57, in 1934, 74, and in 1935, 95 (Tomilin, 1936).

As results from the data given above the sperm whale may be found in all the seas of the world, and in many textbooks the animal is characterized as ubiquitous (e.g., Hesse, 1924). Perhaps this is not altogether correct, and the statement made by Townsend (1935, p. 5): "The sperm whale is an inhabitant of tropical temperate seas — a straggler elsewhere." is nearer to the truth. In many publications the regions where sperm whales abound are listed, e.g., Beale (1839), Murray (1866). Moreover data on the distribution of the sperm whale are furnished by the whale chart in Maury (1854).

The best account of the distribution of the sperm whale, at least in the time of its abundance, is given in the important paper by Townsend (1935). The data in this paper are derived from logbooks of American whalers from the years 1761 to 1920, comprising a total catch of 36.908 sperm whales. Especially the two charts which accompany the paper are very instructive, here the localities are indicated in which one or more whales were taken. As one of the charts contains the records for the months April to September inclusive (the period of the northern summer), the other the records for the months October to March inclusive (the period of the southern summer) the charts give a good idea of the yearly migration of the sperm whale in connection with the change in temperature. In the equatorial region of the Pacific sperm whales occurred in abundance during the whole of the year. In the northern summer numerous sperm whales were taken in the region east of Japan and east of the United

States. In contradistinction to this the number of specimens caught east of the United States is small in the northern winter, and extremely small in the same season in the region east of Japan. A similar difference appears in the southern hemisphere. In the southern summer many specimens were taken between Australia and New Zealand, in the southern winter very few were caught here. Numerous sperm whales were killed during the southern summer off the east coast of South America, during the southern winter the animals were rarely taken in this region. The same applies to the region west of Cape of Good Hope. From these charts many more interesting particulars may be derived in relation to smaller areas. One instance may be noted here. In the period from October to March numerous sperm whales were killed in the seas north of New Guinea, and in the same period very few in the Sulu and Celebes Seas. On the other hand numerous sperm whales were captured in these seas from April to September, whilst hardly any were taken in the region north of New Guinea during the same period.

The data recorded by Townsend point to the fact that the sperm whale prefers the warm and temperate seas. The population in the equatorial region seems to remain more or less constant, there is a northward migration of sperm whales in the period from April to September and a southward migration in the period from October to March. This occurred at least in the times when sperm whales lived in great numbers. In the present time the animal may have become so much rarer that the ecological conditions (as such an abundance of food for the strongly diminished population in certain regions might be of influence) do not necessitate the regular migrations. The data given by Collett (1911—12), however, seem to indicate that at least in the beginning of the present century the annual migration of sperm whales in the North Atlantic regularly took place.

The present rarity of the sperm whale as compared with the common occurrence of this animal in former times is the result of the intensive hunting of this animal. This hunting resulted into a so striking decrease of sperm whales all over the world that in the years about 1880 it had become unprofitable. In later years, however, again sperm whales are caught in many regions of the world, so that in the year 1926 (for the southern region some of the data are of the southern summer 1925/26) 1603 sperm whales were killed (data for British Columbia and Alaska from Kellogg, 1931; data for other parts of the world from Tomilin, 1936). As long as this process goes on, unrestricted as it is, the sperm whale soon will become extremely rare. On a previous page already attention has been

drawn to the fact that 70 % of the sperm whales captured in 1933 and 1934 in the north east Pacific had a length of 14—17 m, whilst only 15 % of the whole catch had a length of 17—19 m. This shows that the majority of the specimens are caught before they reach their full growth. When this continues the animal must be on its way to extinction.

Some species of whalebone whales are protected, and the capture of others is prohibited when under a certain size limit. Something of the kind should be done to the sperm whale. If the method of protection suggested by Harmer (1928) could be enforced already much would be gained. Harmer refers to the fact that the sperm whale is polygamous so that the capture of many of the males would not severely influence the rate of reproduction, and remarks: "The imposition of a size limit of, say, 35 feet would protect nearly all the females (and, of course, the young of both sexes), leaving the pursuit of the more valuable males open to the whalers." (l. c., p. 91). If this could be established it would be of great help, though theoretically the extinction of the species could not be avoided by this rule. If regularly all the specimens of a length of 40 or more feet were captured, not a single male sperm whale would reach the stage of sexual maturity.

In reality, however, the establishment of a size limit would form an important means of protection of the species. Moreover the world wide distribution of the sperm whale is of advantage to the species to escape complete destruction. But notwithstanding this in the present time the sperm whale is rapidly diminishing in numbers owing to the reckless pursuit.

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NOTES

1) Cuvier (1836) cites an earlier edition of 1478, Allen (1881) an edition of 1495.

2) The first edition appeared in 1746. There are numerous later editions, Allen (1881) mentions eight or nine.

3) The complete title is: Versuch zu einer allgemeinen Naturgeschichte unter dem Titel: Angenehmes und lehrreiches Geschenk für die Jugend. Theils zum nüzlichen Zeitvertreib, theils zur Erweckung eines innerlichen Antriebs nicht nur die Naturgeschichte zu erlernen, sondern auch alsdenn in reifern Jahren durch eigene Untersuchung zu helfen dass dieselbe je länger je mehr zu grösserer Vollkommenheit gebracht und das Erlernte auch selbst geprüfte in eignen und andern Vorfallenheiten mit Nutzen gebraucht werden kann. Herausgegeben von der gemeinschaftlichen Handlung der kaiserl. privil. franziscischen Reichsakademie f. K. u. W. in Augsburg. 1783.

4) Allen, 1881, after Carus and Engelmann, cites Bajer as the author. The paper is editorial, based on communications from Vallisneri, for on a previous page, containing the list of authors of vol. 3, we read: "Anonymi quidam eruditi in Italia viri, quorum observationes nobiscum communicavit DN. D. VALLISNERIUS". The paper cited above is the first of these Observationes, it is signed at the bottom: "(Eugenianus I.)".

which, according to the above mentioned list, is an epitheton of Dn. D. Jo. Jacobus Baierus.

5) In the first edition of this work (1789—1795) no mention is made of the sperm whale. The volume cited above is the first of the second edition (1801—1809).

6) Allen (1881) cites the third edition of this work, which appeared in 1788.

7) In the English edition the name of the author is spelled by mistake "Crantz". The original German edition is from 1765; Allen (1881) cites five different editions.

8) This is the editio princeps of this work (cf. Allen, 1881, who besides this mentions later editions of 1829 and 1836).

9) Besides this edition (marked "Nouvelle Edition") Allen (1881) cites an edition in which the volume dealing with Cetacea appeared in 1825 ("Troisième Edition"). Romer (1933) cites a later edition (1834—1836), and remarks that the work was first issued in 1812.

10) Translated from the Danish edition of 1741 (cf. Allen, 1881, who mentions six different translations).

11) The first 77 pages of this work are in the library of the late Professor Max Weber. On the cover of this copy there is a note by A. Milne-Edwards: "Ce mémoire s'imprimait à Paris chez V. Masson quand la mort de Mr. Eschricht est venue l'interrompre. Il n'a jamais paru, aussi ces 77 pages sont elles fort rares." Eschricht died in 1863 (cf. Spärck, R., 1933. Dansk naturhistorisk Forening i København 1833—1933. Vidensk. Medd. Dansk naturh. Foren., vol. 95).

12) Neuville (1932, pls. XV, XVI) reproduces four figures from an edition of Gesner of 1555. Allen (1881) cites the editions of 1558, 1560, 1563, 1604, and 1620.

13) An earlier edition (1777) is cited by Allen (1881).

14) The complete title is: Wunderwerck Oder Gottes vnergründtliches vorbilden, das er inn seinen gschöpffen allen, so Geystlichen, so leyblichen, in Fewr, Lufft, Wasser, Erden, auch auss den selben vier vrhaben, ineingfügtem stuck dem Mentschen, in Gflügel, Vieh, Thier, Visch, Gwürm, von anbegin der weldt, biss zu vnserer diser zeit, erscheynen, hören, brieuen lassen. Zu gwiser anmhanüg seiner Herrlicheit, zu abschröckung sündtlichs lebens. Ober aber sonst verhängt hatt, den Ausserwölte zur übung vnd Christlichem nachsinnen, den bösen zur straaff jres vnglaubens, mit sonder wunderbarer geheymnus vnd bedeüttung. Alles mit schönen Abbildungen gezierdt, vnnd an den Leser einer Vorrede, in̄ dero, der entscheyd, hafft, betrug, fug vnd vrtel so hierinnen zu erlernen vnd zuhaben, in kurtze, eygentlich fürgeschribe vnd abgemalt. (vignet) Auss Herrn Conrad Lycosthenis Latinisch zusam̄en getragner beschreybung, mit grossem fleiss, durch Johann Herold, vffs treüwlichst inn vier Bücher gezogen vnnd Verteütscht. Mit Rd. Key. May. Freyheyt vnd Priuilegien.

15) This is a later edition of the work cited above as "Anon., 1784." Allen (1881) gives 1791 as the year of publication, and mentions a French translation of 1799.

16) Allen (1881) does not mention the edition cited above, but discusses a previous Latin edition of 1650, and mentions an English edition of 1657, the Dutch edition of 1660 (cited above), and the same work edited by Ruysch (cf. Ruysch, 1718).

17) The manuscript of this work was written in German. It was translated into English, the edition cited above is a Dutch translation of the English edition. There

is another Dutch edition of 1733, a Latin of 1727, a French of 1729, and a German of 1777.

18) A translation of Hasaeus, T., 1723 (or 1722?). De Leviathan Jobi et Ceto Jonae disquisitio. Bremae (not seen; title from Brandt and Ratzeburg, 1829). Important original parts are added by the translator.

19) A copy of this work is in the Leiden University Library. The title page reads: "Tableau des Divisions, Sous-divisions, Ordres et Genres des Quadrupèdes, des Cétacées et des Oiseaux, Par le Cen Lacepède. A Paris, Chez Plassan, imprimeur-libraire, rue de Vaugirard, no. 1195. L'An XII de la République."
On the reverse of the title page is found: "Cette nouvelle édition est augmenté du Tableau des Cétacées."
Page 1 contains an abridged new title: "Tableau des Divisions, Sous-divisions, Ordres et Genres des Mammifères."
On page 2 the following is found: "Plusieurs personnes qui possèdent les anciennes éditions des Œuvres de Buffon, et quelques uns des étudians qui suivent les cours de zoologie au Muséum d'histoire naturelle, ayant desiré de se procurer le *Tableau des mammifères et des oiseaux* décrits par Buffon, et rangés par F. M. Daudin d'après les méthodes établies par le professeur Lacepéde (Tableau qui termine le quatorzième volume de l'Histoire naturelle des quadrupèdes, *édition de Saugrain*), on en a imprimé à part un petit nombre d'exemplaires pour les vendre séparément.
Nota. La citation des volumes et des pages, qui termine chaque article, se rapporte à l'édition in-18 des Œuvres de Buffon, que l'on vient de citer."
Page 3 is the full title of the first part, reading:
"Tableau des Divisions, Sous-divisions, Ordres et Genres des Mammifères, Par le Cen Lacepède; Avec l'indication de toutes les espèces décrites par Buffon, et leur distribution dans chacun des genres, Par F. M. Daudin. A. Paris, Chez Plassan, imprimeur-libraire, rue de Vaugirard, no. 1195. L'An X de la République."
Page 4 is blank, page 5 to and including 62 contain the "Tableau des Mammifères". The next page contains the following title: "Tableau des Sous-classes, Divisions, Sous-divisions, Ordres et Genres des Oiseaux, Par le Cen Lacepède; avec l'indication de toutes les espèces décrites par Buffon, et leur distribution dans chacun des genres, Par F. M. Daudin." After this title the numbering of the pages is not continuous with that of the first part: pages 58 to and including 206 contain the "Tableau des Oiseaux".
Besides the work referred to above Engelmann (1846, p. 376) cites the following paper by de Lacepède: "Tableau des divisions, sous-divisions, ordres et genres des Mammifères, des Cétacés et des Oiseaux, in-4. Paris, an VII (1799.) Plassan. (38 pag.)".

20) The name of the author is not given in the paper. Nyenhuis (1836) remarks that Loosjes is the author; Bosgoed (1873) cites the paper with the name of the author as given above.

21) De Pauw and Willemsen (1905) cite an edition of 1635 of this work. Other editions are of 1611, 1614, 1618, 1623, and 1663 in the Dutch language, moreover there are translations in German and French.

22) The preface of this edition is dated "mars 1901".

23) Allen (1881) cites an edition of 1555 with slightly different title, and a Dutch translation of 1599.

24) There are several editions of Paré's works. The one cited above is a translation of the fourth (French?) edition. Turner (1878) cites a Latin edition of 1594, an English translation of 1634, and a French translation of 1652. Van Beneden (1888) cites a French edition of 1841, Thompson (1928 b) gives 1840 as the date of vol. 3 of the Œuvres complètes of Paré.

25) Allen (1881) cites an edition of 1793.

26) The first edition appeared in 1884.

27) Translated from the German work, of which a third ed., of 1829, is cited by Allen (1881).

28) The library of the Royal Zoological Society "Natura Artis Magistra" at Amsterdam contains two editions. The title of one is: "Naturgeschichte in Bildern mit erläuterndem Text von Dr. Fried. Strack", the title of the other reads: "Naturgeschichte in Bildern mit erläuterndem Text von Professor Dr. Strack". The two editions appeared in Düsseldorf, both are undated, but the catalogue of the Society gives 1820 as the year of publication. The figures in the two editions undoubtedly are made by different artists, though representing the same animals.

29) Allen (1881) cites an edition of 1775 and remarks that there is an earlier (1764) edition.

30) Gray (1866) cites this paper as follows: "W. S. MacLeay, New Sperm Whale, set up by W. S. Wall, 8vo., 1851". In the copy of 1887 which was at my disposal William S. Wall is mentioned on the title page as the author. In this paper the new species *Euphysetes grayi* (*Kogia grayi*) is described, and, on the plate which is added to the paper in the edition of 1887 MacLeay is recorded as the author of this species.

31) In the library of the Rijksmuseum van Natuurlijke Historie there is a reprint of this paper without other indication of the journal in which it appeared than vol. V no. XXVIII (pp. 404—419) and vol. V no. XXIX (pp. 534—554). As is indicated in pencil these numbers appeared in February and March, 1885. The journal is of a popular kind, but the paper by Wood contains good descriptions and excellent figures of different parts of sperm whales and other large Cetaceans.

32) Although indicated as second edition, in reality it is a reissue of the second edition with a new title-page, forming thereby the third Dutch edition. The first edition appeared in 1720. Moreover there are two German editions (cf. Allen, 1881).

EXPLANATION OF THE PLATES

PLATE X

The smaller specimen hanging in the steel wires just before it was laid down on the quay [1]).

PLATE XI

Fig. 1. Front view of the head of the larger specimen.
Fig. 2. Maxillary teeth in the gum of the larger specimen.

PLATE XII

Fig. 1. Dorsal fin and smaller humps on the back of the smaller specimen.
Fig. 2. Grooves at the throat of the smaller specimen.

PLATE XIII

Longitudinal sections of a tooth of a sperm whale in Dr. van Deinse's collection, showing successive masses of osteodentine. The two black spots in the lower part of the fang are holes for the screws with which the objects were mounted. Slightly reduced.

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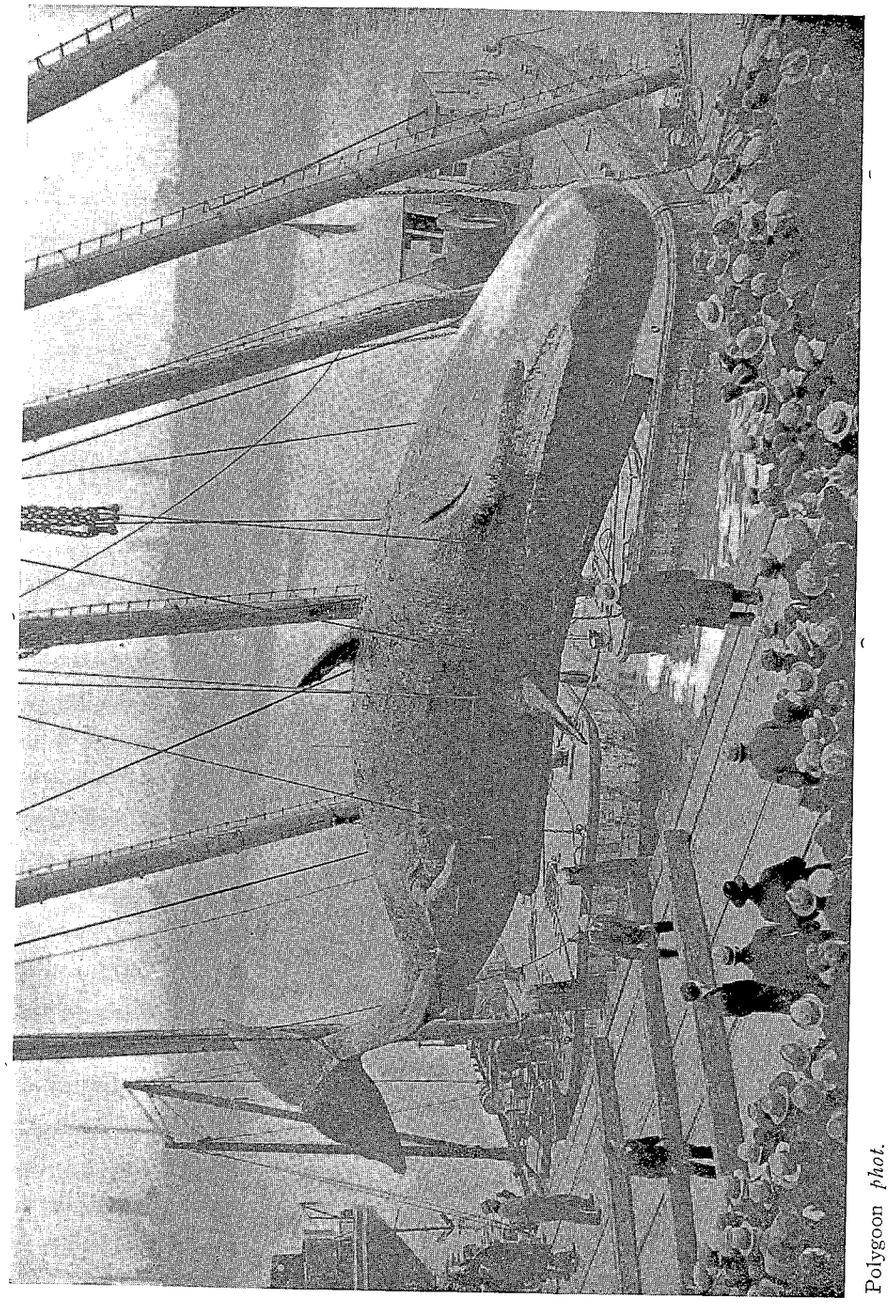
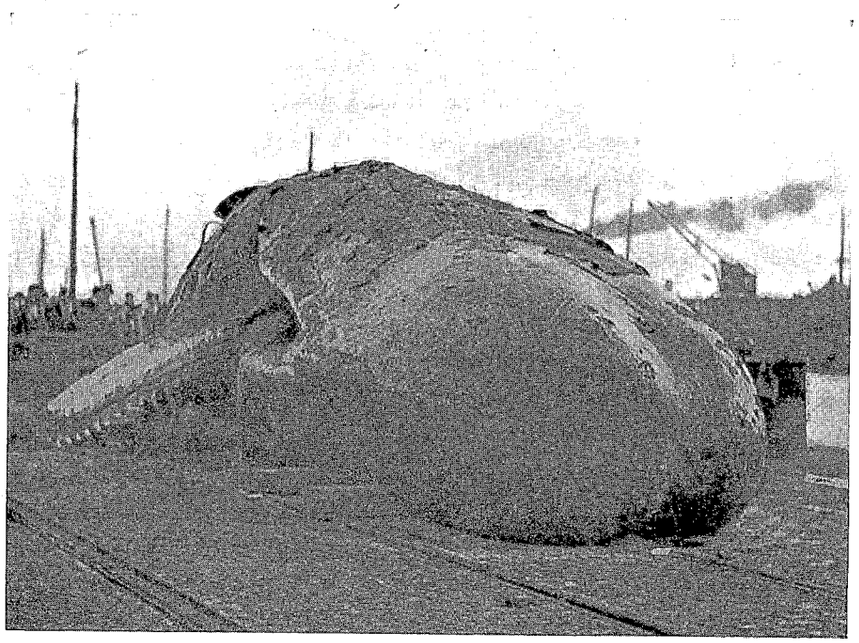
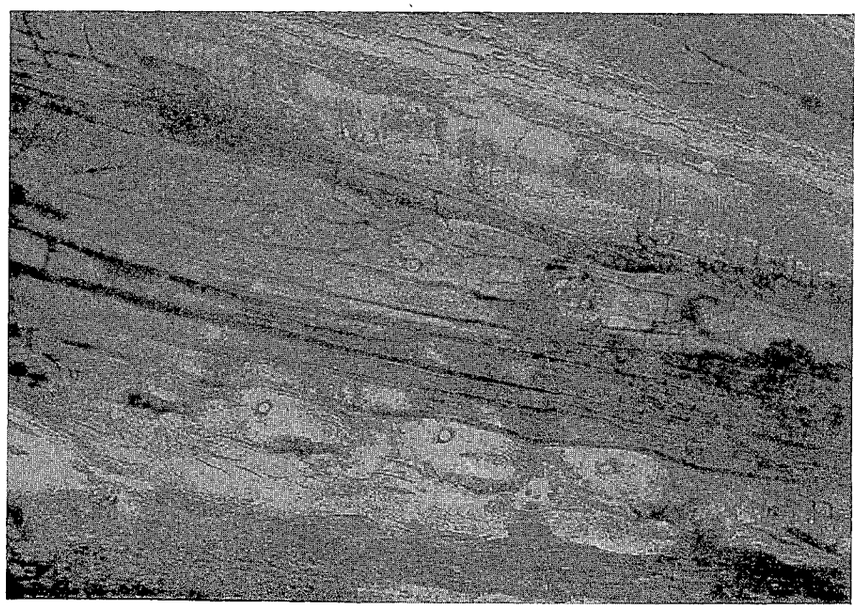
1) In March 1937 this photograph appeared in numerous newspapers and illustrated magazines. Moreover it is found in a recent book (Boulenger, E. G., 1937. World Natural History. London), the photograph is reproduced here from "Wide World". The legend of the figure (l.c., fig. 26) reads: "Bringing a Pot Whale ashore", in the text (l.c., p. 61) this uncommon English name is not mentioned.

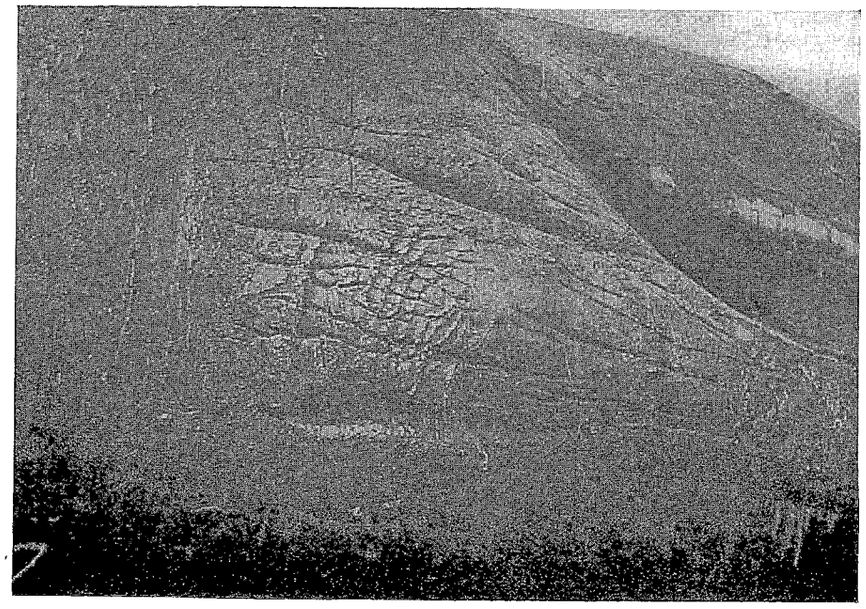


Polygoon *phot.*

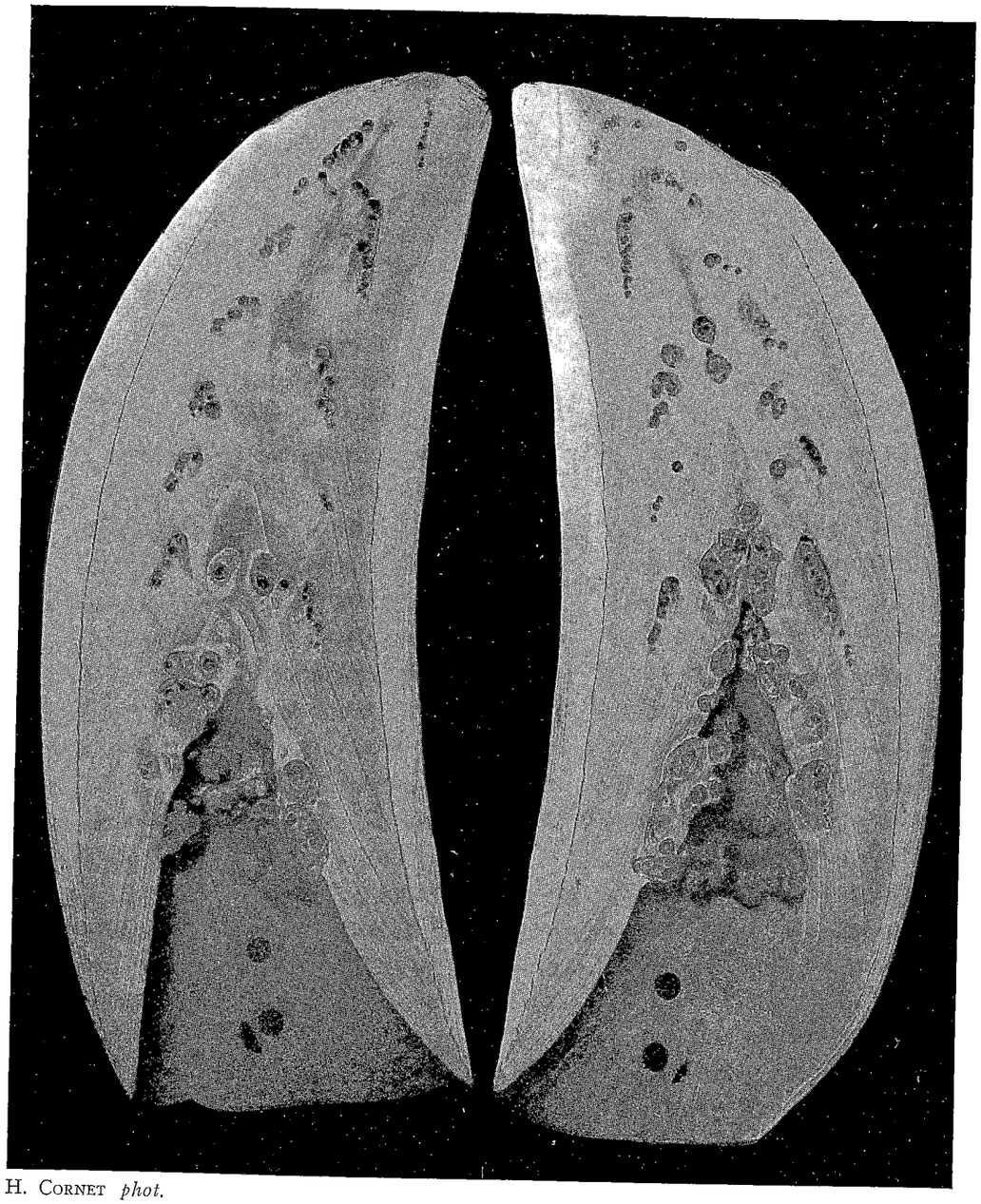




C. LEYENAAR *phot.*



C. LEYENAAR *phot.*



H. CORNET *phot.*