MEMOIRS

OF THE

AMERICAN MUSEUM OF NATURAL HISTORY

NEW SERIES, VOLUME I, PART V.

MONOGRAPHS OF THE PACIFIC CETACEA.

I.—THE CALIFORNIA GRAY WHALE (*RHACHIANECTES GLAUCUS* COPE).

BY ROY C. ANDREWS.

MARCH, 1914.

(*Continued from 3rd page of Cover.*)

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THE CALIFORNIA GRAY WHALE (*RHACHIANECTES GLAUCUS* COPE).

ITS HISTORY, HABITS, EXTERNAL ANATOMY, OSTEOLOGY AND RELATIONSHIP.

By Roy C. Andrews.

Plates XIX–XXVII and 22 Text Figures.

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HISTORY, HABITS AND EXTERNAL ANATOMY.

Foreword.

The present paper is the first of a series of monographs which are in course of preparation upon the large Cetaceans of the Pacific Ocean. The collection of specimens and field studies upon this group began in 1908 upon the coasts of Vancouver Island and southeastern Alaska and has since been carried on along the shores of Japan and Korea.

It was originally intended to embody all the results of these investigations in a single volume but continued field work and many interruptions have so delayed the assembling of the vast amount of data secured that it has seemed advisable to bring out the material upon each genus or species as fast as it is prepared for publication.

Acknowledgments.

It gives me the greatest pleasure to acknowledge the generosity and assistance of the President and Directors of the Toyo Hogei Kabushiki Kaisha (Oriental Whaling Co., Ltd.) of Osaka, Japan. Not only did these gentlemen freely extend the courtesies of their ships and stations but presented to the Museum the skeletons of the whale which forms the subject of the present paper. At all times the officers and employees of the Toyo Hogei Kaisha assisted me in every way possible, and it was entirely through their efforts that field studies and the collection of specimens was made possible.

To the untiring efforts of my friend Mr. D. Ogiwara, formerly an officer of the whaling company, much of the success of my two expeditions to Japan is due. Mr. Ogiwara, who is deeply interested in the advancement of science, not only rendered great practical assistance but always stood ready to give me the benefit of his sound advice and intimate knowledge of Japanese business methods.

Mr. T. Shibuya, Manager of the Shimonoseki branch of the Toyo Hogei Kaisha, was of the greatest assistance in many ways, especially in securing the two skeletons of *Rhachianectes* which were shipped to America.

Mr. Kondo, the station master at Ulsan, Korea, and Mr. T. Matsumoto, his assistant, deserve the greatest thanks not only for contributing materially to my study but also for making my stay in their home most enjoyable as well as profitable.

Thanks are also due to Messrs. Oto, Iku Kita, E. J. Kitson and S. Reed for assistance in various ways.

Captain H. G. Melsom of the S.S. 'Main' was my constant companion at Ulsan. Not only did he entertain me frequently upon his ship but contributed much information from his vast store of knowledge and long experience with Gray Whales. Captain Melsom was the first whaleman to learn to take "Devilfish" in Korean waters and it was he who laid the foundation for the winter fishery which has been so successfully prosecuted there by the Japanese for the last fifteen years. Captains Johnson and Hurum also entertained me frequently and gave me much valuable information.

Sincere thanks are due to Mr. Chas. L. Bernheimer of New York City for generous financial assistance during the field work upon which this paper is based.

During the years 1880–1882, Dr. J. A. Allen began work upon an extensive monograph of the Cetacea. A vast amount of material was examined and numerous plates were prepared by the well known artist, Mr. J. H. Blake. Because of ill health, however, this work was later abandoned and has remained in manuscript to the present day with the exception of the portion relative to *Eubalæna glacialis*, which was published in 1908.[1] Dr. Allen has very kindly offered me the use of this material and so far as possible it will be combined with the results of my own research. For the present paper the only available portion was that of the "general history" from the years 1868 to 1879. It is also a pleasure to acknowledge Dr. Allen's invaluable assistance and advice in preparing this paper for the press.

Dr. F. W. True has not only read portions of the manuscript but has devoted considerable time to an examination with me of the fossil genera of baleen whales in relation to *Rhachianectes*, and I was thus afforded the benefit of his thorough knowledge of this difficult material. For his never-failing kindness I wish to express my sincere appreciation. My thanks are also due to Dr. W. K. Gregory for much advice and many valuable suggestions.

My mother, Mrs. C. E. Andrews, kindly prepared the table of percentage measurements and assisted me in other ways, and to her my sincerest thanks are extended.

The photographs of the skull and skeleton were made by Mr. Julius Kirschner, the Museum photographer.

Introduction.

Knowledge of the habits and external anatomy of the California Gray Whale has rested almost exclusively upon the observations of Captain C. M. Scammon made nearly forty years ago. Shortly after the publication of his book 'The Marine Mammalia,' in 1874, the Gray Whale fishery began to decline and for several years was conducted only in a desultory manner by a number of Portuguese upon the shores of Lower California. During the past twenty years the species had been lost to science and many naturalists believed it to be extinct.

While studying Cetaceans upon the coast of Japan in 1910, the writer learned from the Japanese whaling company of the existence of an animal known as the *Koku kujira* or "Devil-fish," which formed the basis of their winter fishery upon the southeastern shore of Korea.

The descriptions indicated that the *Koku kujira* would prove to be none other than the lost California Gray Whale and I determined to investigate it at the earliest opportunity. Consequently, during the winter of 1911–12, I returned to the Orient and spent the months of January and February at the station of the Toyo Hogei Kaisha at Ulsan, a small village on the southeastern coast of Korea, forty miles north of Fusan.

During this time fifty or more Gray Whales were taken and it was possible to make a careful study of the habits and external characters of the species. Skeletons of two adult individuals were also secured, one of which was sent to the American Museum of Natural History in New York City and the other to the U. S. National Museum at Washington, D. C.

These are the first skeletons of this species to be preserved in any American Museum and are, moreover, the only *complete* specimens in the world.

The British Museum of Natural History, South Kensington, England, contains a skeleton and a second is to be found in the Imperial Museum of Tokyo, Japan. There is also one skull of the Gray Whale from California in the United States National Museum.

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[1] Bull, Amer. Mus. Nat. Hist., Vol. XXIV, Art. XVIII, pp. 277–329, pls. xix–xxiv.

The study of this animal has been especially interesting since it was almost an untouched field. The fact that the most diligent search of the literature of the subject discloses only 23 titles, and that the great majority of these papers are either short notices or compilations, indicates how little this whale, which is among the most remarkable of all large Cetaceans, has been studied.

General History.

"The California Gray whale was first introduced into scientific literature by Professor Cope in 1868 [1] under the name *Agaphelus glaucus*. For our first knowledge of its characters, however, we are indebted to Dr. W. H. Dall whose manuscript notes, outline figures and specimens of baleen transmitted by him to the Museum of the Essex Institute (now the Museum of the Peabody Academy of Science), Salem, Mass., formed the basis of Professor Cope's description. Dr. Dall's notes and figures were based upon an examination of two specimens, and though very incompletely indicating the characters of the species, were sufficient to show it to be one not previously described.

"Shortly afterward the external characters were quite fully given by Captain Scammon together with a detailed account of the habits, habitat and products, and of the California coast whaling of which it formed the chief basis. Captain Scammon's account was accompanied by two rough figures of the animal. At the same time the species was made the basis of a new genus (*Rhachianectes*) by Prof. Cope.[2] Captain Scammon's account was substantially republished in 1871 in the 'Overland Monthly' magazine,[3] and in 1874 was incorporated into his 'Marine Mammals' [4] with, however, much additional matter and new and creditable illustrations. In 1871 Pechuel-Losch gave a short account and figure of the animal in his 'Wale und Walfang' [5] but added nothing of importance to its history as given by Scammon in 1869. In 1870 Professor Van Beneden thus refers to the genus *Rhachianectes:* 'Si ce genre ne repose pas sur une balénoptère mutilée, c'est-à-dire qui a perdu sa nagoire dorsale, c'est une des plus belles découvertes qui aient été faites depuis bien longtemps en Cétotologie." [6]

"In view of Scammon's history of the species, the doubt here expressed has a strange aspect, but happily he later had abundant opportunity of satisfying himself that his doubt was groundless and it was also his good fortune to publish in 1877 the first description and figure [7] of the skull of the 'California Gray' from photographs, transmitted by Dr. O. Finsch." [8]

In 1879, Professor Cope examined at San Francisco, a "schooner-load of bones" of this species brought from Scammon's Lagoon, Lower California, to be ground up and sold as fertilizer and says: "Having examined a large number of the bones I can complete the characters of the genus *Rhachianectes*,[9] which have been but imperfectly known. The cervical vertebræ are all

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[1] Proc. Acad. Nat. Sci. Phila., 1868, pp. 225–227.
[2] *Ibid.*, 1869, pp. 15, 40–49, figs. 7, 8.
[3] Vol. VI, No. 2, Feb. 1871, pp. 118–125.
[4] The Marine Mammals of the North-western Coast of North America, by Charles M. Scammon, 1874.
[5] Das Ausland, 1871, pp. 1185–1186.
[6] Ostéographie des Cétacès, livr. 8, 1870, p. 235.
[7] Bull. de l'Acad. de Belgique, 2me Sér., T. XLIII, 1877, pp. 92–96, pl. 1.
[8] J. A. Allen, manuscript notes.
[9] Professor Cope's original reference to the genus, embraced in four lines, is as follows: "This genus is now first characterized. Its only known species I originally united with Agaphelus Cope, but the form of the scapula is so different that it must be distinguished. While that of Agaphelus is identical with that of Balænoptera, it is in the present genus quite like that of Balæna." — Proc. Acad. Nat. Sci. Phila., 1869, p. 15.

distinct, and the second and third at least enclose a vertebral canal. A first rib (the only one not broken up) has two heads; two other short ribs, perhaps first and second, are united distally into a broad sheet of bone. It is uncertain how far the union of these ribs is constant. The scapula has both coracoid and acromion. The orbital process of the frontal is of medium width, somewhat as in some species of *Megaptera*." [1]

A. W. Malm [2] described in 1883 fragments of the skeleton of *Rhachianectes* secured by the 'Vega' Expedition and figured parts of the skulls of several individuals.

In 1886 Charles H. Townsend published in the 'Bulletin of the United States Fish Commission' a brief report upon the condition of the Gray Whale fishery at that time along the coast of California and remarks: "Of the eleven whaling stations mentioned by Scammon as established along the coast ten or twelve years ago, only five remain...." In commenting upon the numbers of the Gray Whale, he says: "At the San Simeon station in December, 1885, I could see whales blowing almost every hour during the day. From the elevated 'look-out,' or observation station, on shore an extensive stretch of ocean could be examined with the telescope. During my stay, and for a short time afterward, covering a period of fully a month, Mr. Clark counted forty whales passing southward. Many of these were too far off shore to be pursued by the three boats that were daily cruising outside during the season, and a few may have been other species than gray whales, but counting the forty whales actually seen in December and doubling that number to include those that passed at night during the same period, we have eighty whales per month easily accounted for. Doubling this number again to include those which pass within sight of the lookout station in January (for the 'down season' lasts two months), we have one hundred and sixty whales as the number that may readily be seen at the present time from one point alone during the 'down season.' What proportion this number bears to the number passing off shore would be hard to say, but it is certainly less than half, since the whales near the coast are mostly females seeking bays and lagoons in which to bring forth their young, which would leave the males and young whales unaccounted for.

"These safe and obviously low estimates, and the above table showing the actual catch during the past three seasons, afford a very fair showing for a species so scarce in 1880 that only one individual could be captured, and indicate a tendency towards its re-establishment while unmolested in its breeding resorts." [3]

In the 'American Naturalist' for 1888, John Dean Caton [4] gave a popular compiled account of the Gray Whale and its habits, and twelve years later F. E. Beddard [5] very briefly described a skeleton of this species in the British Museum.

The last contribution to our knowledge of this interesting animal was made by Dr. F. W. True [6] in 1904. Dr. True summarized the existing facts relative to the external and internal anatomy of *Rhachianectes glaucus* with enlightening critical comments and also presented detail measurements and photographs of the Monterey skull in the National Museum.

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[1] American Naturalist, Vol. XIII, Oct. 1879, p. 655.
[2] Bihang K. Sven. Vet. Akad. Handl., Vol. VIII, No. 4, 1883, pp. 17–37.
[3] Bull. U. S. Fish. Comm., Vol. VI, 1886, pp. 346–350, pls. vi, vii.
[4] American Naturalist, Vol. XXII, 1888, pp. 509–514.
[5] A Book of Whales, 1900, pp. 168–170.
[6] Smiths. Contrib. to Knowledge, Vol. XXXIII. The Whalebone Whales of the Western North Atlantic, 1904, pp. 287–292, pl. 47 and pl. 49, fig. 3.

Life History.

Migration.— The Gray Whales begin to appear at Ulsan, southeast Korea, about the end of November on their southward migration. Single pregnant females come first and a little later both males and females are seen but the latter considerably outnumber the former. About January 1, schools of from ten to fifteen males, with perhaps one or two females, appear, the female always leading. From the 7th to the 25th of January, when the migration is completed, only males are present, the females all having passed.

In November and December, when the females are taken, almost every individual will be found to be carrying young nearly ready for birth. As these would necessarily be delivered within two or three weeks after passing Ulsan, the birth must occur in the bays among the numerous small islands at the extreme southern end of the peninsula. Indeed Captain H. G. Melsom, who has hunted Gray Whales for fifteen years along the Korea coast, has often observed them in this vicinity, but because of the abundance of other and more valuable species, they are not killed at this time by the Japanese. When travelling southward the whales are always hurrying straight ahead as though anxious to arrive at the breeding grounds and are never accompanied by small calves; upon the northward migration, however, young have been seen following their parents.

The "Devilfish" again arrives at Ulsan, travelling north, about the middle of March and by the 15th of May they have all passed by. Although the greater portion of the herd goes straight northward, Captain Melsom reports that during the end of April and first week of May he has observed many Gray Whales in Broughton Bay, Korea; these animals seemed to be feeding and had apparently broken the migration by a sojourn in the bay.

A comparison of these observations upon the Korea whales and those made by Scammon on the California coast is interesting. It shows that the breeding grounds of the two herds are in very nearly the same latitude and that their migration dates correspond closely. In regard to this Scammon writes: "The California Gray whale is found only in north latitudes, and its migrations have never been known to extend lower than 20° north. It frequents the coast of California from November to May. During these months the cows enter the lagoons on the lower coast to bring forth their young, while the males remain outside along the seashore. The time of gestation is about one year. Occasionally a male is seen in the lagoons with the cows at the last of the season, and soon after both male and female, with their young, will be seen working their way northward, following the shore so near that they often pass through the kelp near the beach. It is seldom they are seen far out at sea. This habit of resorting to shoal bays is one in which they differ strikingly from other whales. In summer they congregate in the Arctic Ocean and Okhotsk Sea. It has been said that this species of whale has been found on the coast of China and about the shores of the island of Formosa, but the report needs confirmation.[1]

"In October and November the California Grays appear off the coast of Oregon and Upper California, on their way back to their tropical haunts, making a quick, low spout at long intervals; showing themselves but very little until they reach the smooth lagoons of the lower coast, where, if not disturbed, they gather in large numbers, passing and repassing into and out of the estuaries,

[1] From personal observation and the statements of the whalers, I doubt if the Gray Whales migrate far south of the peninsula of Korea. During my own travels along the China and Formosa coasts, I have neither seen nor heard of Gray Whales. R. C. A.

or slowly raising their colossal forms midway above the surface, falling over on their sides as if by accident, and dashing the water into foam and spray about them. At times, in calm weather, they are seen lying on the water quite motionless, keeping one position for an hour or more. At such times the sea-gulls and cormorants frequently alight upon the huge beasts. The first season in Scammon's Lagoon, coast of Lower California, the boats were lowered several times for them, we thinking that the animals when in that position were dead or sleeping, but before the boats arrived within even shooting distance they were on the move again" (*l. c.*, pp. 22–24).

As yet it is impossible to state whether or not the Korea and California herds mingle in the north during the summer. Information gathered from the whalers tends to show that a large part of the former herd summers in the Okhotsk Sea and the latter in Bering Sea and further north. Individuals of the two herds may mingle and interbreed during their sojourn in the north, but it is probable that whales which have been born near either the Korea or California coasts will find mates among the members of their own herd during the southward migration and return annually to their birth place. It is quite conceivable that the case of the Gray Whale may be analogous to that of the Fur Seal where it has been shown conclusively that members of the American and Japanese herds do not mingle in the north although separated by comparatively few miles of water at certain times of the year.

Period of gestation and rate of growth.— Because of its regular annual migrations the period of gestation of this species can be more nearly determined than in the case of most other large whales, and appears to be about one year. Mating probably takes place in the south during December or early January, and the calf is ready for delivery the following year.

As stated above (see 'Migration'), the females which appear at Ulsan, Korea, travelling southward are nearly all bearing calves almost ready for birth. Upon the return journey the females are accompanied by young calves, and Capt. H. G. Melsom writes that he killed on March 13 and 14, 1912, at Chan Chien Dogo (near Broughton Bay), Korea, upon their northward migration, two females bearing fœtuses 7 and 10 inches long, respectively. These fœtuses were probably not more than $2\frac{1}{2}$ months old, which would indicate that the mating had taken place late in the previous December and that the calves would be delivered the following December or January when the whales returned to the south. A female 1300 cm. (42′ 8″) in length taken at Ulsan, Korea, on January 8, 1912, contained a fœtus 476 cm. (15′ $7\frac{1}{2}$″) long, and ready for birth; it would certainly not have been carried more than a week or ten days longer.

Whether or not the females again mate immediately after giving birth to their young it is impossible to state, but from Scammon's observations, quoted below, I believe it to be unlikely and that calves are born but once in two years.

Scammon says that the period of gestation is about one year, and remarks: "This statement is maintained upon the following observations: We have known of five embryos being taken from females between the latitudes of 31° and 37° north, on the California coast, when the animals were returning from their warm winter haunts to their cool summer resorts, and in every instance they were exceedingly fat, which is quite opposite to the cows which have produced and nutured a calf while in the lagoons; hence we conclude that the animals propagate only once in two years" (*l. c.*, p. 23, note).

Mr. C. H. Townsend, writing in 1886 of the San Simeon (Cal.) station, says: "Unlike Monterey, this station depends almost entirely for its business upon the gray whales, which pass southward with great regularity from December until February. The 'up season,' lasting until

April, is also profitable at San Simeon, but the catch there consists chiefly of males, the females keeping farther off shore when passing northward with their young. During the last ten years Captain Clark has seen but one female accompanied by young in the vicinity of his station. At San Simeon, and all the whaling establishments situated south of it, females exceed the other sex in numbers during the 'down run' and most of them contain well-developed young. At this place and at San Luis Obispo, the nearest neighboring station, I saw four young whales lying on the beach, which had been taken from females killed in the vicinity during that season (December, 1885). Their average length was about 12 feet; the largest, which I sketched, being 17 feet long, and from an adult nearly 40 feet in length. They were probably within two weeks of the time of birth when the parent animals were killed" (*l. c.*, pp. 347–348).

From the above data it may be safely affirmed that the length at birth of the majority of Gray Whales is between 12 and 17 feet. When the females go north in March on the Korea coast, the calves which have been born near the end of the previous December accompany them, and by the time they reach Ulsan are about twenty-five feet in length, This makes a growth of nine or ten feet during a little less than three months. This may seem extraordinary, but it is quite in accord with what apparently takes place in all baleen whales. Without doubt the rate of growth for the calf is very rapid during the first few months after birth and until sexual maturity is reached.

Thirty-two feet is the minimum length for Gray Whales taken at Ulsan, and individuals of this size must certainly have been born during the previous winter. Thus, accepting 14 feet as the average length at birth, we get a growth of 18 feet during a little less than one year.

How long the young nurse is problematical but it must be considerably less than one year because, so far as I am aware, nursing calves or females have not been taken at Ulsan on the southward migration, and some would certainly have been brought in if the suckling period was not over before the animals reached that point upon the coast.

Spouting and diving.— The height and form of the spout varies with conditions. Normally the vapor rises vertically ten or eleven feet in a thick column having the width at the summit about twice that at the base (Plate XXIV, Fig. 7). It may, however, reach a height of fifteen feet if the whale is large and has been submerged for a considerable period. The spout is single in the majority of cases, but Captain Melsom asserts positively that at times it is divided like that of a Right Whale. As in all Cetaceans the initial spout after a period of submergence is generally the highest and fullest.

The number of respirations between the dives is fairly regular. When the whale has been below for several minutes upon rising to the surface it will usually blow two or three times before again going down.

When cruising along the shore the animal generally remains submerged seven or eight minutes and blows three times when it reappears. Captain Melsom assures me that when a large female is taking a straight course it will remain below four or five minutes and rise to make three spouts very regularly; at other times a single whale will remain down ten minutes and a school between fifteen or twenty minutes, depending upon circumstances.

When travelling straight ahead and unmolested the Devilfish swim under water for a distance of 300 or 400 fathoms quite regularly and rise to spout three times.

Under normal conditions the animals 'sound' much as do Humpbacks. As soon as the spout has been delivered, the body begins to revolve and as the dive progresses the flukes are

lifted out of the water and drawn slowly under. The flukes are not invariably shown, however, even when sounding; some animals will almost always 'fluke out' and others, not at all. Under no circumstances do the Gray Whales arch the back as strongly as do the Humpbacks nor do the animals raise themselves so far out of the water.

During the 'surface' or 'intermediate' dives only a small part of the back is shown, the motion is forward and downward, and the flukes are never exposed.

Speed.— The Gray Whales are slow swimmers and cannot exceed seven or eight knots per hour even when badly frightened and doing their best to get away. Ordinarily when 'travelling,' and unmolested, they make about three or four knots, and when cruising along the shore perhaps two or three knots per hour.

The Gray Whale is essentially a shore-loving species and on its annual migration always prefers to swim along close to the beach. At times the whales will go in so close to the shore that they are actually rolling in the surf and seem to enjoy being pounded by the breakers. Scammon has observed the same habit in the California animals and says: "About the shoals at the mouth of one of the lagoons, in 1860, we saw large numbers of the monsters. It was at the low stage of the tide, and the shoal places were plainly marked by the constantly foaming breakers. To our surprise we saw many of the whales going through the surf where the depth of water was barely sufficient to float them. We could discern in many places, by the white sand that came to the surface, that they must be near or touching the bottom. One in particular, lay for half an hour in the breakers, playing, as seals often do in a heavy surf; turning from side to side with half extended fins, and moved apparently by the heavy ground-swell which was breaking; at times making a playful spring with its bending flukes, throwing its body clear of the water, coming down with a heavy splash, then making two or three spouts, and again settling under water; perhaps the next moment its head would appear, and with the heavy swell the animal would roll over in a listless manner, to all appearance enjoying the sport intensely. We passed close to this sportive animal, and had only thirteen feet of water" (*l. c.*, p. 24).

Frequently when being hunted the Korea whales would escape by swimming into water so shallow that the ships could not follow them and remaining there until the men had given up the chase.

Food.— Although the stomachs of a great number of Gray Whales were examined carefully I could never discover what constitutes their food. In every case the stomach was more or less filled with dark green water in which the only solid materials were bits of kelp, a little sea weed, and small masses of a light green gelatinous material. The stomachs of two individuals contained a number of small water-worn pebbles and several masses, six to eight inches long, of what appeared to be finely shredded raw meat still connected by its fibers; this was certainly not fish. It is probable that the kelp and sea weed had been taken in with other material, as in the case of the pebbles. The excrement of all the whales had about the consistency of thick cream and was dark green like the water in the stomach.

All the gunners asserted that when the Gray Whales appear at Ulsan on their migrations they are invariably travelling straight ahead and apparently not stopping to feed. This information, combined with the fact that little except water could be found in the stomachs, lends strong support to the theory that upon their annual migrations the Devilfish feed but very little, if at all. If feeding is indulged in, it would seem extraordinary that no specimens have been brought to the station having food, or its remains, in their stomachs. The presence of fæces in the intes-

tines may be due to the fact that these organs had not entirely emptied themselves since the last period of feeding in the north. The green color of the water in the stomach and of the excrement is probably due to bileary secretions.

It is possible that while upon their migrations the whales eat quantities of the jelly fish which are so frequently seen near the kelp fields just off shore. These animals, consisting largely of water, would be very quickly acted upon by the digestive fluids and the lack of solid material in the stomach be thus explained. Captain Melsom has seen Gray Whales in the Okhotsk Sea during the summer which were not travelling but were swimming slowly about.

It is interesting to note that neither Scammon nor Townsend could get any definite information as to the food of the Gray Whales of the California coast. Scammon remarks: "To our personal knowledge, but little or no food has been found in the animal's stomach. We have examined several taken in the lagoons, and in them we found what the whalers called 'sedge' or 'sea-moss' (a sort of sea-cabbage), which at certain seasons darkens the water in extensive patches both in and about the mouths of the estuaries. Whether this was taken into the stomach as food some naturalists doubt, giving as a reason that the whale, passing through the water mixed with this vegetable matter, on opening its mouth would of necessity receive more or less of it, which would be swallowed, there being no other way in which it could be disposed of. The quantity found in any one individual would not exceed a barrelful.

"From the testimony of several whaling-men whom we regard as interested and careful observers, together with our own investigations, we are convinced that mussels have been found in the maws of the California Grays; but as yet, from our own observations, we have not been able to establish the fact of what their principal sustenance consists" (*l. c.*, pp. 24, 25, note).

Townsend says in regard to the food: "The opinion of the men with whom I talked is that it does not feed to any great extent outside of its arctic habitat. It is certainly much thinner on the northward than on the southward run, a male that would yield 30 or more barrels of oil in the down season yielding less than 25 two months later. Whalers admit their ignorance of what constitutes the food of this animal, and can find nothing in its stomach during the breeding season" (*l. c.*, p. 349).

Affection.— The male Devilfish at all times shows strong affection for the female and Captain Melsom tells me that during the migration, when a school of males led by one or two females is found, if one of the latter is wounded, often the former will refuse to leave until she is dead. One day when hunting a pair he wounded the cow and the bull would not leave, keeping close alongside and pushing his head over her body. Later he struck the male with a harpoon but did not get fast and even then it returned and was finally killed. Captain Melsom assures me, however, that if the male is killed the female will seldom remain.

Scammon has recorded instances of the female's love for her young and it was because of her vigorous defense when attacked on the breeding grounds that the name "Devilfish" was gained. The whalemen in Korea, however, where the hunting is done from small ships by the Norwegian method, do not regard the animals as especially dangerous. They seldom lance one from the 'pram,' as is frequently done with Finbacks because the Gray Whales seem to be very sensitive to pain, and as soon as the iron penetrates the body the animal will raise itself in the water, throwing its head from side to side and sometimes lashing about with its flukes and fins.

Attacks by Killers (Orca orca).— The Gray Whales seem to be objects of continual persecution by the Killers; much more so than any of the other large whales. Among the first

eight or nine Devilfish which I examined at Ulsan, three attracted my attention at once because the entire anterior part of the tongue had been torn away. Teeth marks plainly showed in the remaining portion and upon consulting the gunner, Captain Hans Hurum, who had killed them, he told me that it had been done by Killers at the time he shot the whales. Seven Gray Whales were in the school, and shortly after he began to hunt them fifteen Killers appeared. The whales became terrified at once and he had no difficulty in killing three of the seven. When the Orcas gathered about, the whales turned belly up and lay motionless, with fins outspread, apparently paralyzed by fright. A Killer would put its snout against the closed lips of the Devilfish and endeavor to force the mouth open and its own head inside. This extraordinary method of attack was corroborated by Capt. Johnson who had been hunting the same school of Gray Whales, and, moreover, by all the whalemen at the station who had witnessed it upon many other occasions.

Out of the thirty-five Gray Whales which I examined especially, seven had the tongues eaten to a greater or less extent and one had several large semicircular bites in the left lower lip. The Killers do not confine their attention entirely to the tongue for almost every whale which was brought in had the tips and posterior edges of the fins and flukes more or less torn; in several specimens fresh teeth marks were plainly visible where the fin had been 'shredded' as the whale drew it out of the Orca's mouth.

Although none of the Gray Whales exhibited teeth marks on other parts of the body undoubtedly some of them are killed by the Orcas. A female Killer which was brought to the station had several pieces of flesh in its stomach besides a strip of whalebone three inches long; I could not positively identify the latter but believe it to have been from a small Devilfish. A male Killer was taken at the same time by Captain Hurum who told me that in the animal's death flurry it had thrown up two great chunks of flesh.

Captain Melsom brought a Gray Whale to the station one day and I was interested to find the tongue almost gone. He said he had passed a school of Killers in the morning and later, after steaming about fifteen miles, had killed the Devilfish. A short time afterward, a long distance away, he saw the fins of a school of Killers which were coming at full speed straight for the ship. They circled about the vessel and one of them forced open the mouth of the dead whale to get at the tongue. When Captain Melsom fired at the Killer with his Krag rifle the animal lashed out with its flukes, smashing the ship's rail, and disappeared.

As soon as Orcas appear if the Gray Whales are not paralyzed by fright they head for shore and slide in as close as possible to the beach where sometimes the Killers will not follow them. The Devilfish will actually go into such shallow water as to roll in the wash and even try to hide behind rocks. The Orcas are not afraid of the ships and will not leave the whales they are chasing when the vessels arrive, thus giving much assistance to the human hunters.

Captain Johnson, of the 'Rex Maru,' brought to the station at Ulsan a Gray Whale which had been shot in the breast between the fins. He had first seen Killers circling about the whale which was lying at the surface, belly up, with the fins outspread, being absolutely paralyzed by fright. The vessel steamed up at half speed and Johnson shot at once, the iron striking the whale in the breast.

Such is the fear of the Gray Whale that when, as frequently happens, porpoises are playing about a single animal, it will sometimes become terrified, thinking that the Killers have appeared.

I have never personally witnessed it but the gunners tell me that a pod of Gray Whales can

be stampeded much as can a herd of cattle. If three or four ships are near each other when a school of Devilfish are found, they draw together, each vessel going at full speed and making as much noise as possible. The whales at once sound, but as soon as they rise to spout the ships steam at them again. The Devilfish go down once more but do not stay under long, ascending at shorter intervals until finally they are ploughing along at the surface. The animals are 'scared up' as the gunners say, and become terrified to such a degree that everything is forgotten except the desire to get away. It is not always possible to stampede a herd, and often the whales will disappear at the first sound, not rising again until a long distance away. If Killers are about at the time a herd of Gray Whales are being hunted it is very easy for the ships to stampede them.

Even if the Devilfish do exhibit considerable stupidity when danger from Killers threatens, at other times they are the cleverest and most tricky of all large whales. One day the S. S. 'Main,' Captain Melsom, was hunting a Gray Whale in a perfectly smooth sea. The whale had been down for fifteen minutes when suddenly a slight sound was heard near the ship and a thin cloud of vapor was seen floating upward from a patch of ripples which might have been made by a duck leaving the surface. The whale had exposed only the blowholes, spouted, refilled the lungs and again sunk, doing it almost noiselessly. The gunners assert that this is quite a usual occurrence when a single Gray Whale is being hunted.

Diseases.— Most whales are subject to diseases of various kinds and the Devilfish is no exception. One specimen was brought to the station at Ulsan, with all the flesh on the left side of the head badly decomposed and in some places entirely gone, leaving the bone exposed; what remained hung in a soft, green, evil-smelling mass. The whale had evidently suffered considerably from the disease for it was very thin and the blubber dry.

A second specimen had a large swelling on the ventral ridge of the peduncle, which upon being opened, proved to be a large capsular tumor about one foot in depth and of a like diameter.

The skin upon the snout of a third individual was drawn into small circular patches leaving large sections of the blubber exposed.

Size.

The available material relating to the size of *Rhachianectes glaucus* consists of the following: From Korea, records of one hundred and twenty-two specimens taken by the whaling company during 1909–10, and of twenty-three measured by myself in 1912; from California, the measurements given by Scammon and Dall of two specimens taken in Monterey Bay, and the record by Pechuel of one from the Bay of San Simeon.

My own measurements of the total length were taken from the notch of the flukes to the tip of the snout, either along the side of the belly as the animal lay in the water or as each section was drawn upon the cutting wharf. Every whale was also measured by a representative of the company, and as the total length was secured by the Japanese in a way similar to mine it may be assumed that all the Korean specimens are directly comparable.

In the following tables measurements of both males and females are arranged according to size.

Table I. Measurements of 53 females.

Place	Date	Total Length Feet	Total Length Cm.
Ulsan	Dec. 5, 1909	45	1371
"	" 9, "	"	"
"	" 17, "	"	"
"	Jan. 9, "	"	"
"	" 15, "	"	"
"	Dec. 5, "	44	1340
Chan Chien Dogo	" 6, "	"	"
Ulsan	" 28, "	"	"
"	" 18, "	43	1310
"	" 23, "	"	"
"	" 25, "	"	"
"	Jan. 6, 1910	"	"
"	" " "	"	"
"	" 15, "	"	"
"	Dec. 1, 1909	42	1279
"	" 2, "	"	"
"	" 7, "	"	"
Chan Chien Dogo	" 10, "	"	"
Ulsan	" 11, "	"	"
"	" 18, "	"	"
"	" 19, "	"	"
Hidokatsu,	Dec. 20, 1909	42	1279
Chan Chien Dogo	" 22, "	"	"
Ulsan	" " "	"	"
"	" 24, "	"	"
"	" 26, "	"	"
"	Jan. 6, 1910	"	"

Place	Date	Total Length Feet	Total Length Cm.
Chan Chien Dogo	Dec. 8, 1909	41	1249
" " "	" 13, "	"	"
" " "	" 15, "	"	"
" " "	" " "	"	"
Ulsan	" 21, "	"	"
"	" 27, "	"	"
"	Jan. 6, 1910	"	"
"	" " "	"	"
"	Dec. 26, 1909	40	1218
"	" 4, "	"	"
Chan Chien Dogo	" 7, "	"	"
" " "	" 11, "	"	"
" " "	" 16, "	"	"
Ulsan	" 26, "	"	"
"	" 28, "	39	1188
"	Jan. 1, 1910	"	"
"	" " "	"	"
Chan Chien Dogo	Dec. 17, 1909	38	1158
" " "	" 19, "	"	"
Ulsan	" 31, "	37	1127
"	Jan. 3, 1910	34	1036
"	" 5, "	33	1005
"	" 1, "	32	975
Ulsan, (R. C. A.)	Jan. 9, 1912	43′3″	1317
" "	" 8, "	42′8″	1300
" "	" 10, "	38′1″	1160

Table II.—Measurements of 95 males.

Place	Date	Total Length Feet	Total Length Cm.
Ulsan	Dec. 9, 1909	43	1310
"	" 17, "	"	"
"	" 30, "	"	"
"	Jan. 3, 1910	"	"
"	Dec. 1, 1909	42	1297
"	" 18, "	"	"
"	" 27, "	"	"
"	" 27, "	"	"
"	" 30, "	"	"
"	Jan. 9, 1910	"	"
"	Dec. 1, 1909	41	1249
"	" 4, "	"	"
"	" 22, "	"	"
"	" 29, "	"	"
"	" " "	"	"
"	" 3, "	40	1218
"	" 4, "	"	"
Chan Chien Dogo	" 6, "	"	"
Ulsan	" 8, "	"	"
Chan Chien Dogo	" 15, "	"	"

Place	Date	Total Length Feet	Total Length Cm.
Chan Chien Dogo	Dec. 18, 1909	40	1218
" " "	" 18, "	"	"
" " "	" 19, "	"	"
" " "	" 20, "	"	"
Ulsan	" 21, 1909	"	"
"	" 27, "	"	"
"	" 29, "	"	"
"	" " "	"	"
"	" " "	"	"
"	" 30, "	"	"
"	" 31, "	"	"
"	" " "	"	"
"	" " "	"	"
"	Jan. 1, 1910	"	"
"	" 12, "	"	"
Oshima, Japan	Feb. 9, 1910	"	"
Ulsan	" 25, "	"	"
"	Dec. 9, 1909	39	1188
"	" 15, "	"	"
"	" 16, "	"	"

Table II.— Continued.

Place	Date	Total Length Feet	Total Length Cm.
Ulsan	Dec. 17, 1909	39	1188
"	" 23, "	"	"
"	" 26, "	"	"
"	" " "	"	"
"	" 29, "	"	"
"	" 30, "	"	"
"	" 30, "	"	"
"	" 31, "	"	"
"	" " "	"	"
"	Jan. 6, 1910	"	"
"	" 9, "	"	"
"	" " "	"	"
"	" 12, "	"	"
"	Feb. 20, "	"	"
Chan Chien Dogo,	Mar. 14, "	"	"
Ulsan	Jan. 6, "	38	1158
"	" 8, "	"	"
"	" 9, "	"	"
"	" " "	"	"
"	" 21, "	"	"
"	Mar. 2, "	"	"
"	Dec. 15, 1909	37	1127
"	" 20, "	"	"
"	" 31, "	"	"
"	Jan. 3, 1910	"	"
"	" 4, "	"	"
"	" 7, "	"	"
"	Feb. 13, "	"	"
"	Dec. 17, "	36	1097
Ulsan	Jan. 5, 1910	36	1097
"	" 7, "	"	"
"	" 7, "	"	"
. . .	. . .	. . .	. . .
Ulsan (R. C. A.)	Jan. 13, 1912	41′½″	1250
" "	" 19, "	"	"
" "	" 8, "	40′8½″	1240
" "	" 10, "	"	"
" "	" 21, "	"	"
" "	" 24, "	40′6½″	1235
" "	" 20, "	40′2½″	"
" "	" 9, "	39′5½″	1202
" "	" 11, "	39′1″	1190
" "	" 17, "	"	"
" "	" 16, "	38′9″	1180
" "	" 17, "	"	"
" "	" 8, "	38′5″	1170
" "	" " "	38′1″	1160
" "	" 13, "	"	"
" "	" 9, "	37′6½″	1143
" "	" 14, "	35′7½″	1085
" "	" 10, "	35′3½″	1075
" "	" " "	34′5½″	1050
" "	" 16, "	32′2″	980
. . .	. . .	. . .	. . .
Monterey, Cal. (Scammon)		1865	42	1280
" " (Dall)		——	48	1462
San Diego, Cal. (Pechuel)		——	32	975

Like all baleen whales, the female *Rhachianectes* is larger than the male. The maximum size of the 123 specimens measured by the whaling company was 1371 cm. (45′); this length was reached by four females. The maximum for males was 1310 cm. (43′). A female 1317 cm. (43′ 3″) long and two males each 1250 cm. (41″ ½′) were the largest of the 23 specimens which I measured in 1912. Dall has recorded an unsexed individual 1554 cm. (51′) and a male 1462 cm. (48′) in length. If these measurements are correct Dall's specimens must have been of unusual size for the whalers in Korea assured me that examples longer than 1371 cm. were extremely rare. Measurements of his 1462 cm. whale show such a remarkable disagreement with all other specimens that there must have been some error in either taking or recording the dimensions. My friend Capt. H. G. Melsom, who has spent nearly fifteen years hunting Gray Whales in Korea, tells me that he killed two female whales 49 and 47 feet long, respectively; these are the largest specimens he has ever known killed.

The average length for all females measured by the whaling company and by myself agrees closely and is respectively 1254 cm. (41′ 2″) and 1259 cm. (41′ 4″); for all males it is 1188 cm. (39′) and 1172 cm. (38′ 6″). There can be little doubt that specimens larger than 1371 cm. (45′) are exceedingly rare.

It is difficult to arrive at a satisfactory conclusion as to the length at which *Rhachianectes glaucus* becomes sexually mature, for at present there are few data relative to this subject. Town-

send took a fœtus 518 cm. (17′) long from a female, "about forty feet long," and the only pregnant female which I examined was a specimen 1300 cm. (42′ 8″) in length. The condition of the skeleton proved this animal to be fully adult.

The measurements of length are arranged in tabular form in the following table (Table III).

Table III. Summary of Measurements.

Locality	Average for all specimens of both sexes		Average for all females		Average for all males		Maximum for females	Maximum for males	Minimum for females	Minimum for males
	No. of Whales	Length	No. of Whales	Length	No. of Whales	Length	Length	Length	Length	Length
Korea, measured by R. C. A.	23	cm. 1184 ft. 38′9½″	3	cm. 1259 ft. 41′4″	20	cm. 1172 ft. 38′6″	cm. 1317 ft. 43′3″	cm. 1250 ft. 41′1″	cm. 1160 ft. 38′1″	cm. 980 ft. 32′2″
Korea, measured by Whalers	123	cm. 1213 ft. 39′10″	50	cm. 1254 ft. 41′2″	73	cm. 1188 ft. 39′	cm. 1371 ft. 45′	cm. 1310 ft. 43′	cm. 975 ft. 32′	cm. 1097 ft. 35′5″
California, measured by Scammon, Dall, and Pechuel	4	cm. 1318 ft. 40′8″		—	3	cm. 1239 ft. 40′8″	—	cm. 1462 ft. 48′	—	cm. 975 ft. 32′

Proportions.

In the following tables detail measurements of Korea and California representatives of *Rhachianectes glaucus* will be found. It was possible to take a fairly complete series of measurements of some of the Korea specimens while of others only a few could be secured but all have been presented with the hope that they may be of aid to future students of this species.

In the second table certain of the most reliable measurements have been selected, and their ratios to the total length given, to ascertain the degree of individual variation and to facilitate comparison.

It will be seen upon examination of the table of ratios that there is a greater or less variation in almost all the proportions. The question at once arises as to whether or not this can be due wholly to individual differences or in part to inaccuracy of measurement. The lengths of all specimens were secured while the animals were lying in the water or else were the totals of the different sections as the whales were being "cut in." The length was never taken over the back but usually along the side or breast, and in most cases I believe it to be accurate. In Nos. 2, 9, and 11 there is a possibility of doubt, but none of the ratios of these specimens show unusual variation.

All the measurements, except the total length and the distance from the tip of the snout to the axilla, were secured without difficulty after the sections of the whale had been drawn upon the wharf.

I have included in the table, measurements of the fully grown fœtus No. 1*a*, for as these were taken at leisure with the greatest care there is no doubt as to their accuracy and they furnish a valuable standard for comparison with the adult individuals.

Table IV.— Detail Measurements of Korea and California specimens.

	ULSAN, KOREA																								CALIFORNIA		
	No. 1 Jan. 8 ♀	Foetus No. 1a Jan. 8 ♂	No. 2 Jan. 8 ♂	No. 3 Jan. 8 ♂	No. 4 Jan. 8 ♂	No. 5 Jan. 9 ♂	No. 6 Jan. 9 ♀	No. 7 Jan. 9 ♂	No. 8 Jan. 10 ♂	No. 9 Jan. 10 ♀	No. 10 Jan. 10 ♂	No. 11 Jan. 10 ♂	No. 12 Jan. 11 ♂	No. 13 Jan. 13 ♂	No. 14 Jan. 13 ♂	No. 15 Jan. 14 ♂	No. 16 Jan. 16 ♂	No. 17 Jan. 16 ♂	No. 18 Jan. 17 ♂	No. 19 Jan. 17 ♂	No. 20 Jan. 19 ♂	No. 21 Jan. 20 ♂	No. 22 Jan. 21 ♂	No. 23 Jan. 24 ♂	Seamon Monterey 1865 ♂	Dall Monterey Jan. 1866 ♂	Pechuel San Diego ♂
	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.
Total length snout to notch of flukes	1300	435	1160	1240	1170	1143	1317	1202	1240	1160	1050	1075	1190	1250	1160	1085	1180	980	1190	1180	1250	1225	1240	1235	1280	1462	975
Tip of snout to eye	250	81	220	227	222	218	244	250	240	....	200	220	225	245	210	220	220	175	232	232	230	230	240	225	229	315	....
" " " " blow-hole (center)	224	74	....	220	210	205	220	....	207	....	....	210	205	232	196	208	215	165	....	210	220	210	235	210	183	145	244
" " " " axilla	....	152	....	....	....	366	390	....	390	365	320	380	....	440	....	350	....	310	....	400	....	415	410	....	335	....	....
Notch of flukes to anus	410	141	370	370	....	363	377	346	335	....	350	355	....	375	335	360	325	280	350	345	355	370	360	365	366	442	....
" " " " dorsal "hump"	485	177	....	450	....	413	....	....	405	373	425	375	350	....	....	....	....	350	....	....	405	....	....	....	....	....	....
Anus to clitoris or penis	....	45	....	....	....	....	....	....	120	....	125	....	....	....	....	....	....	....	....	....	....	....	....	....	142	61	....
" " umbilicus	....	75	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Flukes tip to tip	310	103.5	320	302	....	290	306	....	330	275	300	300	....	302	310	300	320	....	320	....	....	290	320	....	305	267	274
Length right lobe of flukes axially	150	62	....	....	....	155	....	....	....	....	....	175	....	....	....	....	....	....	....	....	....	150	....	....	....	....	....
" left " " " "	....	60	....	....	....	160	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Greatest thickness of flukes at insertion	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	22	23	....	....
" breadth " " ant. post	....	40	....	....	....	....	....	....	....	....	106	112	....	....	105	100	95	....	110	....	118	90	....	....	104	....	....
Depth of peduncle just ant. to flukes (on curve)	80	29	76	70	....	68	....	....	75	70	....	80	....	70	....	....	70	....	78	....	....	75	80	80	46	....	....
" " " midway between flukes and anus	....	49	110	....	....	140	....	....	127	135	126	....	....	126	115	114	135	....	130	....	....	150	....	150	....	....	....
Length of pectoral, tip to head of humerus	228	....	240	230	220	222	220	225	230	....	224	220	....	230	....	218	235	180	218	228	240	220	220	235	....	....	....
" " " " " post. insertion	137	67	165	160	145	150	140	160	160	....	156	155	....	165	....	148	155	120	150	160	175	160	150	170	....	....	....
" " " " " ant. "	205	94	....	190	....	190	190	185	180	....	....	....	....	....	....	....	190	....	....	....	....	....	....	....	198	183	153
Greatest breadth of pectoral	75	33	90	94	79	83	85	89	90	....	85	85	....	92	....	82	....	68	85	88	90	85	90	95	87	....	61
Distance from eye to ear	56	24	55	....	....	....	....	....	53	....	52	....	53	62	50	....	50	....	....	50	....	50	....	....	....	....	....
" eye above ear	2[1]	1[1]	....	....	....	....	....	....	5	....	5	....	5	6	5	....	5	....	....	5	....	2	....	....	....	....	....
Length of right blowhole (straight)	25	9	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	21	....	....
" " left " "	25	9	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Dist. apart of blowholes anteriorly	7	4.5	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
" " " " posteriorly	23	9	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Length of row of baleen (straight)	220	....	203	....	198	190	210	215	....	....	182	200	204	219	185	190	183	155	200	....	200	210	....	200	....	....	....
Longest plate baleen (inside)	40	....	48	....	....	40	46	40	....	....	....	45	....	....	38	36	45	32	45	....	40	38	....	42	46	36	31
Number plates of baleen (one side)	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	158	162	148	....	....	....	154	....	....	....	....	....
Number of throat furrows	2	2	2	3	3	2	2	2	2	....	2	2	....	2	3	2	3	2	2	2	4	2	2	2	....	....	....
Length of longest throat furrows	....	59	140	150	165	160	170	....	150	....	165	153	....	165	150	145	150	130	155	160	....	170	170	....	....	....	....
Distance apart anteriorly	15	6	22	....	32	....	....	....	....	....	....	....	....	....	....	19	....	....	....	....	....	....	20	....	....	....	....	....
" " posteriorly	....	16	47	....	50	....	....	....	....	....	....	....	....	....	....	55	....	....	....	....	....	....	50	....	....	....	....	....
Tip of mandible to ant. end of furrows	65	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	75	....	....	....	....	....

[1] Nos. 1 and 1a had the ear *above* the eye.

It will be seen from the table that the greatest variation appears in the distance from the notch of the flukes to the dorsal "hump" amounting to 11%; this will be discussed later.

The variation of 5.3% in the width of the flukes from tip to tip may in great measure be accounted for by the fact that the tips of the flukes were very frequently injured. The same can be said of the measurement of the pectoral from the tip to the head of the humerus, but in a less degree, for usually one of the flippers, at least, was uninjured and the correct length could thus be secured.

The measurements of the California examples neither conform to each other nor to those from Korea. In Scammon's specimen the distance from the tip of the snout to the blowholes is 14.2% of the total length. This is much less than in any of the Korea whales and, moreover, gives a difference of 3.6% between the measurements from the tip of the snout to the eye and to the blowhole. This can hardly be correct. The same discrepancy is apparent in Dall's figures, but to a greater degree. The ratio to the total length of the tip of the snout to the eye is greater than in any of the Korea specimens, and that from the tip of the snout to the blowholes is much less, the difference between the two being 11.6%. One, or both, of these measurements is certainly incorrect.

Pechuel's figures give the distance from the snout to the blowhole as 25% of the total length, while the greatest in the Korea specimens is 19.5%. It is impossible to account for this discrepancy.

Scammon's measurements from the snout to the axilla, of the flukes from tip to tip, and of the depth of the peduncle just anterior to the flukes, are all at such variance with the Korea specimens that they must either be incorrect or have been taken in quite a different manner from my own. The same is true of Dall's measurements of the flukes from tip to tip and of the length of the fin. These data in reference to the California specimens are, therefore, of little value either for comparison with the Korea examples or with each other.

Table V. — Proportional Measurements of Korea and California specimens.

	ULSAN KOREA													
	No. 1 ♀	No. 1a Fœtus ♂	No. 2 ♂	No. 3 ♂	No. 4 ♂	No. 5 ♂	No. 6 ♀	No. 7 ♂	No. 8 ♂	No. 9 ♀	No. 10 ♂	No. 11 ♂	No. 12 ♂	No. 13 ♂
	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.
Total length, snout to notch of flukes	1300	435	1160	1240	1170	1143	1317	1202	1240	1160	1050	1075	1190	1250
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Tip of snout to eye	19.2	18.6	18.9	18.3	18.9	19.0	18.5	20.7	19.3	—	19.0	20.4	18.9	19.6
" " " " blowhole	17.2	17.0	—	17.7	17.9	17.9	16.7	—	16.6	—	—	19.5	17.2	18.5
" " " " axilla	—	34.9	—	—	—	32.0	29.6	—	31.4	31.4	30.4	35.3	—	35.2
Notch of flukes to anus	31.5	32.3	31.9	29.8	—	31.7	28.6	28.7	27.0	—	33.3	33.0	—	30.0
" " " " dorsal "hump"	37.3	40.6	—	36.2	—	36.1	—	—	32.6	32.1	40.4	34.8	29.4	—
Flukes, tip to tip	23.8	23.6	26.0	24.3	—	25.3	23.2	—	26.6	23.7	28.5	27.9	—	24.1
Depth of peduncle just anterior to flukes	6.1	6.6	6.5	5.6	—	5.9	—	—	6.0	6.0	7.6	7.4	—	5.6
" " " midway between flukes and anus	—	11.2	9.4	—	—	12.2	—	—	10.2	11.6	—	—	—	10.0
Fin, tip to head of humerus	17.5	—	20.7	18.5	18.8	19.4	16.7	18.7	18.5	—	20.9	20.4	—	18.4
" " " anterior insertion	15.8	21.6	—	15.3	—	16.6	14.4	15.3	14.5	—	—	—	—	—
" greatest breadth	5.7	7.5	7.7	7.5	6.7	7.2	6.4	7.4	7.2	—	—	7.9	—	7.3

Table V. — Continued.

	ULSAN KOREA												CALIFORNIA		
	No. 14 ♂	No. 15 ♂	No. 16 ♂	No. 17 ♂	No. 18 ♂	No. 19 ♂	No. 20 ♂	No. 21 ♂	No. 22 ♂	No. 23 ♂	Amount of variation in ratios	Average of ratios	Scammon ♂	Dall ♂	Pechuel ♂
	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.
Total length, snout to notch of flukes	1160	1085	1180	980	1190	1180	1125	1125	1240	1235			1280	1462	975
	%	%	%	%	%	%	%	%	%	%	%[1]	%[1]	%	%	%
Tip of snout to eye	18.1	20.2	18.6	17.8	19.4	19.6	18.4	18.7	19.3	18.2	2.9	19.0	17.8	21.5	——
" " " " blowhole	16.8	19.1	18.2	16.8	——	17.7	17.6	17.1	18.9	17.0	2.8	17.6	14.2	9.9	25.0
" " " " axilla	——	32.2	——	31.6	——	33.8	——	33.8	33.0	——	5.7	32.4	26.1	——	——
Notch of flukes to anus	28.0	33.1	27.5	28.5	29.4	29.2	28.4	30.2	29.0	29.5	5.8	30.4	28.5	30.2	——
" " " " dorsal "hump"	——	——	——	35.7	——	——	32.4	——	——	——	11.0	34.7	——	——	——
Flukes, tip to tip	26.7	27.6	27.1	——	26.8	——	——	23.6	25.8	——	5.3	25.6	23.8	18.2	28.1
Depth of peduncle just anterior to flukes	——	——	5.9	——	6.5	——	——	6.1	6.4	6.4	2.0	6.3	3.5	——	——
" " " midway between flukes and anus.	9.9	10.5	11.4	——	10.9	——	——	12.2	——	12.1	2.8	10.9	——	——	——
Fin, tip to head of humerus	——	20.0	19.9	18.3	18.3	19.3	19.2	17.9	17.7	19.0	4.2	18.9	——	——	——
" " " anterior insertion	——	——	16.1	——	——	——	——	——	——	——	1.3	15.4	15.4	12.5	15.6
" greatest breadth	——	7.5	——	6.9	7.1	7.4	7.2	6.9	7.2	7.6	2.2	7.1	6.7	——	6.2

Color.

Plates XIX and XX.

None of the published descriptions of the color of *Rhachianectes glaucus* which I have been able to find occupy more than three or four lines, or give other than the vaguest impression of the animal's appearance. Scammon says: "The California Gray is unlike other species of baleen whales in color, being of a mottled gray, very light in some individuals, while others, both male and female, are nearly black" (*l. c.*, p. 20). Scammon's figure (*l. c.*, plate ii, fig. 1) shows a rather slender whale, gray, and irregularly marked with white on the entire upper half of the body from the head to the flukes; the lower half is represented as almost plain.

This type of coloration is just the reverse of what was observed in Korea specimens. It is true that several examples were seen which had the back more or less heavily marked, but in every case where this occurred the lower half of the body was so thickly covered with white and gray patches that there was a great preponderance of the light color. Unless the California specimens are very different from those of Korea, which is highly improbable, Scammon's figure is incorrect. This view is strengthened when the drawing of *Balænoptera sulfurea* (*l. c.*, plate xiii) is examined for it is quite unlike a Pacific Sulphurbottom in coloration. Scammon's first figure of *Rhachianectes*, published in 1869,[2] although very crude, gives in the side view a really better suggestion of the color of the animal than does the plate in his 'Marine Mammalia.' In his first figure the markings are shown evenly distributed over the entire body from the head to the flukes and not confined to the dorsal surface as in the later drawing.

In Cope's article on the Gray Whale (1868), Mr. W. H. Dall's description of two specimens seen by him at Monterey, Cal., is quoted, as follows: "Color above and below, black, with a gray bloom like a plum. This distinguishes this species from the known Balænæ of the Pacific, which are more or less white on the belly and fin" (*l. c.*, p. 226).

Pechuel's figure of *Rhachianectes* is diagrammatic and there is little attempt at coloration.

[1] This does not include fœtus No. 1a.

[2] Proc. Phil. Acad. Nat. Sci. Phil., 1869, fig. 8.

PLATE XIX.

PLATE XIX.

RHACHIANECTES GLAUCUS.

Fig. 1. Lateral view of peduncle showing white markings, mostly cirriped scars.
Fig. 2. Lateral view of peduncle showing normal gray and white markings and total absence of cirriped scars.
Fig. 3. Head, pectoral fin and section of back blubber.
Fig. 4. Direct lateral view of peduncle showing dorsal crenulations.
Fig. 5. Dorsal view of peduncle showing normal gray markings and flukes.
Fig. 6. Peduncle lying upon the wharf.
Fig. 7. Posterior portion of body showing inferior outline.

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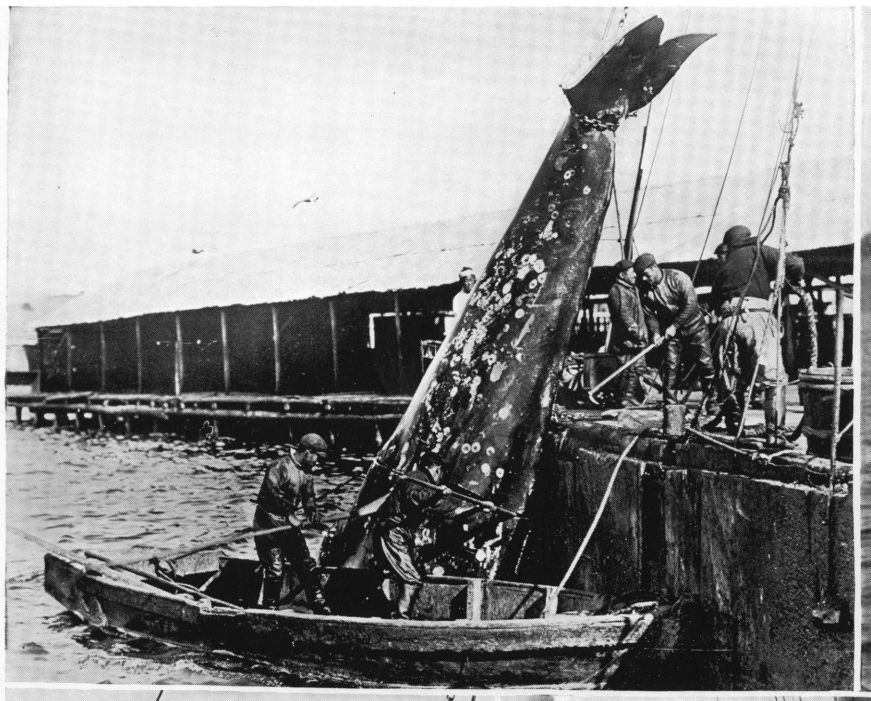

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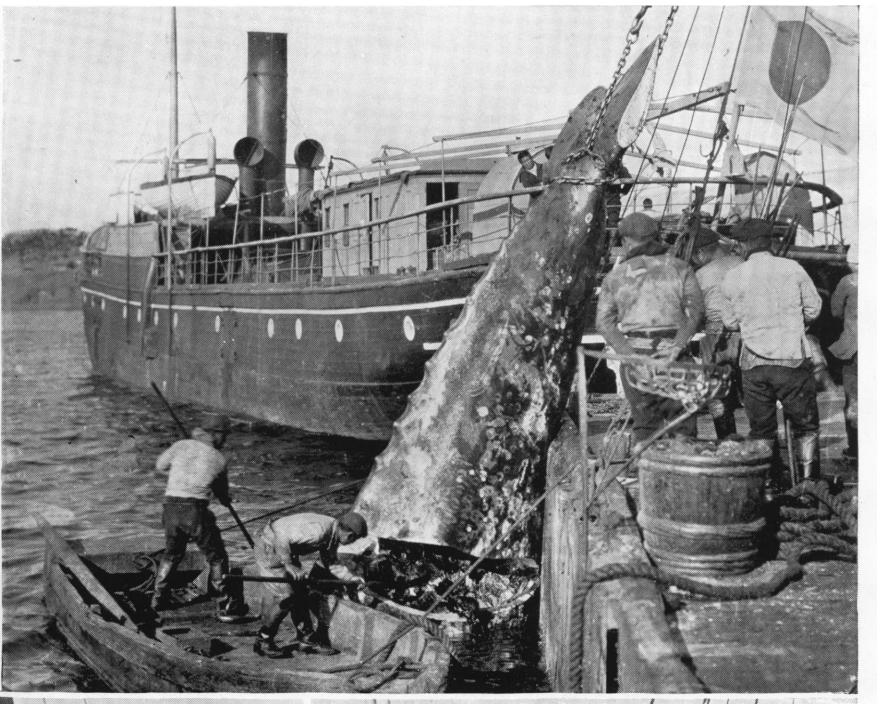

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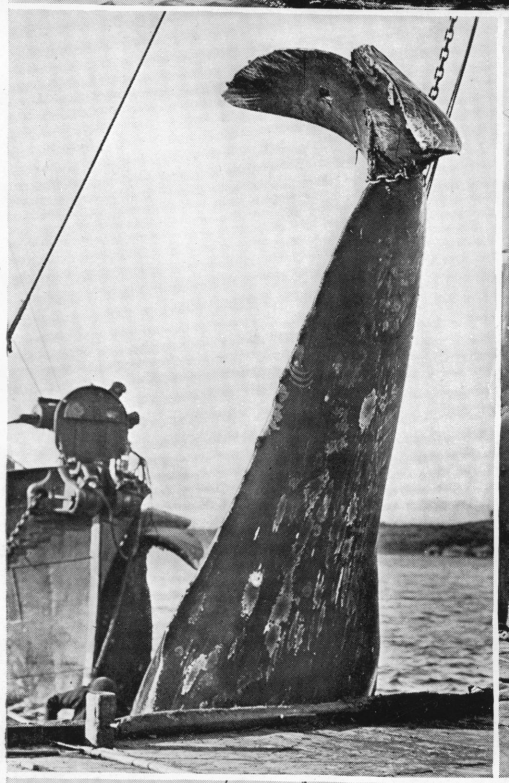

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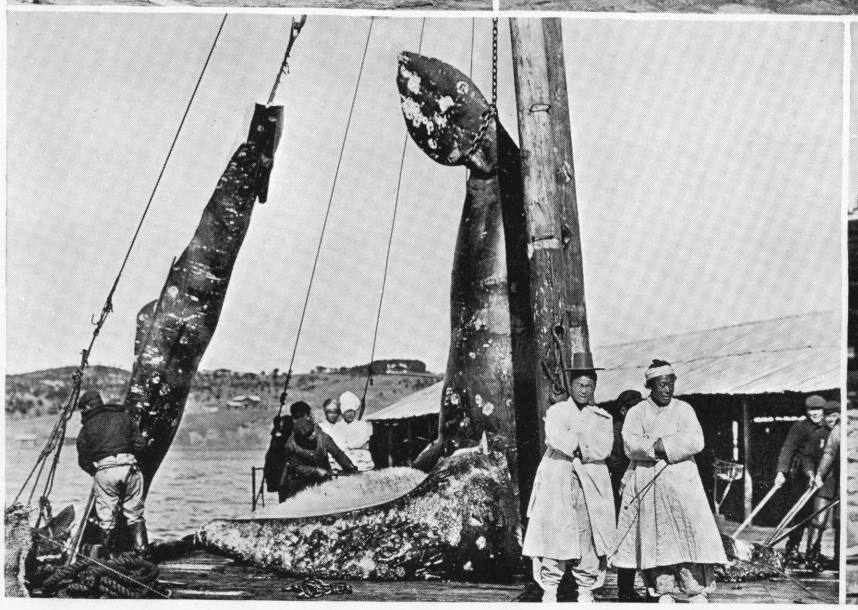

7

RHACHIANECTES GLAUCUS.

He says in regard to this: "Abweichend von allen anderen Walen ist seine Farbe ein melirtes grau, Manche sind ganz fleckig, selten sieht man gleichmässig dunkel gefärbte." [1]

The following description of Korea examples is, therefore, the only detailed account of the color of the Gray Whale that has thus far been published.

There seems to be quite as much individual color variation in *R. glaucus* as in other baleen whales, some examples being abnormally dark with but few gray markings while others are very light, the entire body being so thickly covered with blotches of white and gray that there is a preponderance of the light color. It is obvious, therefore, that no description which will apply to all individuals can be given, but between the light and dark extremes there was a certain type of coloration possessed by a majority of the examples which came under my observation. This may be described as follows: The head, throat, back, and the dorsal and ventral ridges of the peduncle are black, or very dark slate, and are usually unmarked. On the dorsal and lateral surfaces of the distal half of the rostrum there is considerable white and light gray in flecks and small spots; this is frequently true of the chin, lower lips, and both mandibular rami. On the under side of the rostrum just exterior to the bases of the baleen rows, there is a band of flesh pink, or white, about three inches wide. The amount of white on the rostrum and lips varies greatly with individuals but it is seldom entirely absent. The throat and sides to the pectorals are usually unmarked. From the fins to a point opposite the anus, on the sides, breast and belly, are many roughly elliptical and circular markings with irregular edges. These markings have gray centers shading to very light gray, or white, on the edges and are broken by small round, or oval, black spots (Plate XX, Fig. 6). They follow the long axis of the body and generally closely approximate each other.

On the sides of the peduncle the gray markings become scattered and are generally smaller and darker. The whole body from the head to the flukes has many white or light gray circular scars of varying sizes, apparently left by parasitic cirripeds; on some individuals these almost obscure all other markings.

The pectoral fins are dark slate like the body. Above, on the posterior half, there are a few scattered white circles and spots. Below, the white circles are more numerous and on the distal half are two more or less broken bands of white, or very light gray, about 8 cm. wide and 45 cm. long between the 2nd and 3rd and 3rd and 4th fingers; the band between the 2nd and 3rd fingers is usually the longer. The posterior edge of the fin is very frequently white.

The flukes are black or dark slate like the body, a few white circles and spots being scattered over both surfaces, generally more on the lower. Frequently the posterior edges and tips are white.

In connection with the preceding description it is interesting to refer to the color of fœtus No. 1*a*, described below. This specimen was almost ready for birth and gives an excellent idea of the disposition of the markings on the Gray Whale before the body has been scarred by parasites and by contact with rocks. The general color must become much darker after birth than it is during fœtal life.

Color Variations.— There are striking variations from the type of coloration described above. Three specimens out of the twenty-one on which color notes were taken were exceptionally light colored. One (No. 8, male) had the entire rostrum, lips and mandibular rami dotted and specked

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[1] Pechuel-Loesche, Wale and Walfang. Ausland, Vol. 44, 1871, p. 1186.

with gray and white. The sides of the breast and throat, from the fins forward, were streaked longitudinally with long gray lines, and the center of the throat thickly splashed with white. The back was heavily marked with oblong blotches of white. The only portion of the whale unmarked was the dorsal and ventral ridges of the peduncle.

A second whale (No. 11, male) had almost no white on the lips, rostrum or throat, but the sides of the body and peduncle, from the fins to the flukes, were so thickly washed, circled and blotched with gray and white that there was much more light than dark color.

No. 19, female, had the lower lips and distal portion of the mandible finely dotted and flecked with gray and white. The sides, belly, and the entire peduncle were so thickly covered with small light gray patches, that there was more light than dark color. The ground color of this whale was dark gray and not slate, or black, as usual.

No. 3 was a dark whale and No. 5 exceptionally so. The body was black and had only a few small and rather indistinct gray markings on the sides, back and lower half of the peduncle.

No. 6, female, was black. On the left side of the throat were a few long stripes of white, which seemed to be scars. The remainder of the throat, breast and belly was unmarked save for a single large, irregular, light-gray patch on the belly; the entire peduncle was plain except for a little white along the dorsal ridge. No. 14, male, was much like No. 6; No. 17, male, although a very dark individual, had the rostrum, lips and mandibular rami mixed white and gray, and the sides of the peduncle, body and back streaked with long, narrow gray lines.

There seems to be a tendency among the whalers to believe that all individuals which show a preponderance of light color are of the greatest age. Averages and comparisons of the lengths of the very dark, very light, and normal examples of *R. glaucus* shows but little difference between them and gives no basis for believing that the animals become lighter with increasing years. Only three of the whales which I examined were females, one of these being exceptionally dark and the other somewhat lighter than normal. The males presented both light and dark extremes and every variety of intermediate coloration. I believe, therefore, that the color differences have nothing whatever to do with sex or age, or that they are other than purely individual.

For reference the field descriptions of twenty-one individuals examined at Ulsan, Korea, are given below:

Field color descriptions of 23 Korea specimens.

No. 1. Female. Length, 1300 cm. General color dark slate. Much white on the distal half of the rostrum, snout and upper lips just above the bases of the baleen rows. Many fine, grayish lines on the back, and numbers of irregular white streaks over the entire body; the latter appeared to be scars from old wounds. Inferior half of peduncle from genitalia to flukes thickly marked with irregular elliptical patches of light gray.

Pectoral fins dark slate above, having both margins and tips whitish, the light color extending far up on the superior surface of the fin.

Flukes above dark slate with many white dashes and circles, the latter undoubtedly caused by parasitic cirripeds.

No. 1*a*. Fœtus. Male. Length, 476 cm. General color gray. The entire head and throat to the posterior insertion of the pectoral fins is light gray. A line of small, dark gray spots and dashes extends from the eye to a point a short distance above the pectoral. On the throat are a few small patches of very light gray, almost flesh white, and several large irregular markings of dark gray.

PLATE XX.

PLATE XX.

Rhachianectes glaucus.

Fig. 1. Direct lateral view of head showing few parasite scars.
Fig. 2. Three-quarters posterior view of head showing many parasite scars.
Fig. 3. Dorsal view of head and blowholes; note the barnacles *Cryptolepas rhachianecti* embedded in the skin, and the masses of *Cyamus scammoni*.
Fig. 4. Front view of head.
Fig. 5. Direct lateral view of head and mandible of fœtus No. 1*a*.
Fig. 6. Section of peduncle showing normal gray and white markings.

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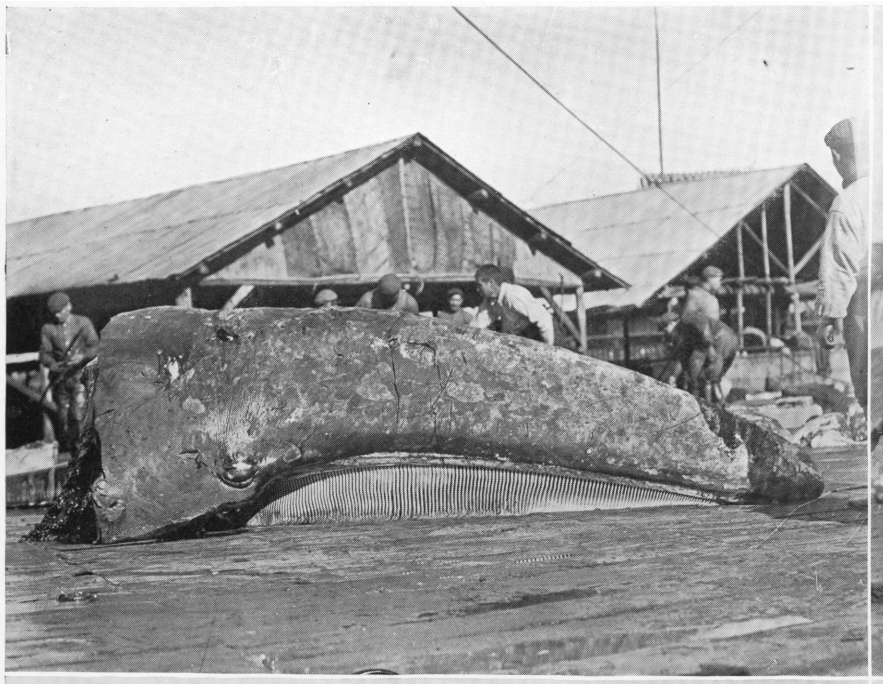

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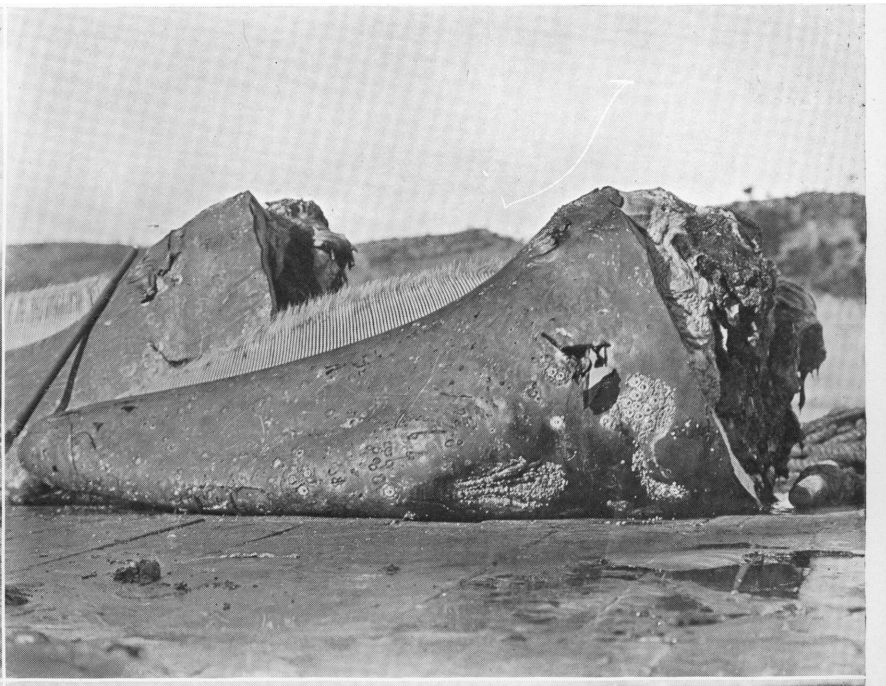

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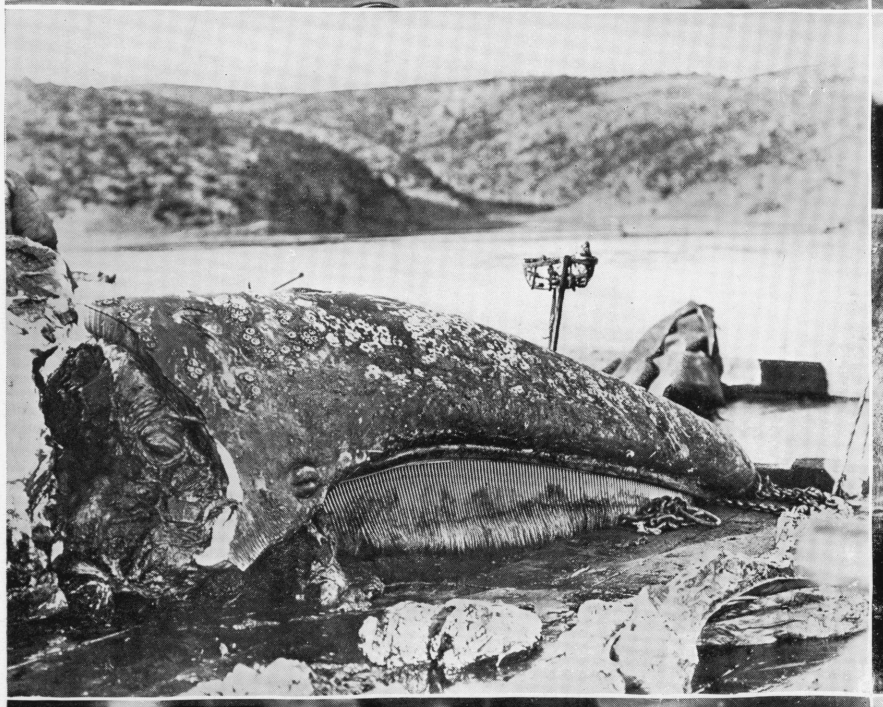

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RHACHIANECTES GLAUCUS.

On the sides a slight ridge is formed by the ends of the vertebral transverse processes below which the lateral and ventral surfaces of the body, forward almost to the pectoral fins, bear many irregular oblong and elliptical patches of very light gray; the markings are longitudinal, follow the long axis of the body and are so thick that there is more of the light than of the dark color. The back, above the line of the transverse processes, is light gray thinly marked with irregular, dark gray oval and oblong patches. On the right side, just posterior to the tip of the pectoral laid back, is a circular, pure white spot about 4 centimeters in diameter and a second smaller one above the posterior insertion of the fin.

The pectorals are plain dark gray on both surfaces but have light posterior and anterior edges.

The flukes are plain light gray above with dark anterior and posterior margins. Below, the ground color is light gray but coarse, broken whitish lines run transversely across each fluke from the anterior edge and curve inward toward the notch; this gives more white than dark color to the inferior surface.

No. 2. Male. Length, 1160 cm. Many fine white spots and flecks on snout, symphysis of mandible, and on both rami, but the remainder of the head is plain dark gray. Posterior to the genitalia both sides of the body have many large irregular patches of light gray about thirty cm. long by twelve cm. wide, and numerous blotches, circles and spots of white. There is a large patch of light gray about 150 cm. long by 45 cm. wide on the right side of the back and a large white spot just posterior to the tip of the pectoral fin laid back. The mid-dorsal region has either very few gray markings or none at all. The lower half of the peduncle is covered with rather fine dashes and circles of white.

The pectoral fins are alike on both surfaces. On the distal two-thirds between the second and third and the third and fourth digits there are two broad parallel bands of white. The remainder of the fin is so dotted, barred and circled with white that there is more white than dark.

Both surfaces of the flukes are dark slate thickly covered with irregular bands, spots and dashes of white. The left lobe has the inferior surface of the distal end almost entirely white.

No. 3. Male. Length, 1240 cm. A dark individual. The general color is dark slate, almost black. On the dorsal and lateral surface of the rostrum there is considerable light gray, but except for numerous cirriped scars, especially on the sides of the peduncle, the body has comparatively few light markings.

On both surfaces of the pectoral fins there is a broad longitudinal band of white between the fingers, and a few circles and spots of white on other parts of the flipper. The posterior edges are also white.

No. 4. Male. Length, 1170 cm. General color of body dark slate. The entire rostrum is clear light gray, shading into darker on the head, but does not show much white; neither is there white on the lips or mandibular rami. The dorsal region of the peduncle and body forward to the pectoral fins is unmarked dark slate but the sides have many small spots, dashes, and circular scars of white.

The pectoral fins are dark slate above and have a whitish longitudinal band between the fingers; also a few large cirriped scars. The anterior edge of the fin is dark slate and the posterior edge white.

No. 5. Male. Length, 1143 cm. A very dark individual. Head, back, sides and upper

half of peduncle, black. Lower half of peduncle has a few small, light gray markings and on the back and sides near the pectorals are several rather indistinct, gray patches; scattered over the body are a few large, white circular scars. Mucous membrane in the roof of the mouth light pink as are the lips just above the bases of the baleen rows.

The pectoral fins are black, above, except for two or three large white circles. Below, there is one large oblong patch of white between the fingers.

Both surfaces of the flukes are plain, unmarked black.

No. 6. Female. Length, 1317 cm. A very dark whale. Throat, breast and belly plain black except for a few long white stripes (apparently scars) just above the furrows and a large, irregular, light gray patch on the belly. The back and sides are black, almost unmarked, and on the peduncle *there are no gray patches* and only a few cirriped scars; along the dorsal ridge is a little white.

The superior surface of the pectoral fins is black with a few white circles; inferiorly both flippers are marbled and circled with white.

No. 7. Male. Length, 1202 cm. The entire distal third of the rostrum and the dorsal ridge to the blowholes is greatly roughened, or "cornified," thickly infested with parasitic *Cyamus*. There is no white on the rostrum.

The superior surface of each pectoral fin has but little white. On the inferior surface two broad bands of white run between the fingers to the tip of the fin and there is a large white patch near the base.

No. 8. Male. Length, 1240 cm. The lightest colored specimen which has been brought to the station. The dorsal ridge of the rostrum is almost entirely white having but few gray specks; the left side of the rostrum is like the dorsal surface but the right side is covered with fine gray and white flecks and dots giving a "pepper and salt" effect (apparently many small barnacles had fastened here). From chin to pectorals the sides of the throat and breast are streaked with long, longitudinal gray lines about five mm. wide and the center of the throat is thickly splashed with white. The rami of the mandible and the lower lips are mixed white and gray ("pepper and salt"). The entire back is thickly marked with small white circles and dots and the sides of the body, posterior to the fins, and of the peduncle are covered with blotches of white, fairly regular in size and about 25 cm. long by 10 wide; the edges of the blotches are irregular. The mid-dorsal and mid-ventral regions of the peduncle are plain black except for a circular patch of white about 30 cm. in diameter.

On the inferior surface the pectorals have two broad longitudinal bands between the digits, that nearest the posterior edge being the longest; there are also many smaller patches and scars on the lower surface. Above, the pectorals have much less white, only one band being present.

The flukes are black, above, thinly circled with white but below have much white.

No. 9. Female. Length, 1160 cm. Sides of body and of the peduncle blotched with light gray; the markings are heavier on the body. Ventral region almost plain.

No. 10. Male. Length, 1050 cm. A dark individual. Throat and lips plain dark slate with practically no lighter color. On the sides backward to a point opposite the anus are a good many large, gray, oval and oblong markings having irregular margins; the sides are also thickly studded with barnacles. The dorsal and ventral regions of the peduncle are plain but there are a few white circles and spots on the sides. The dorsal "hump" has patches of light gray, almost white, on either side and a large white spot on the right side; just anterior to the penis is a gray blotch.

Above, the pectoral is black with only one white spot.

The flukes are black on both surfaces save for a few white circles; the distal half of the posterior edge is all white.

No. 11. Male. Length, 1075 cm. A light individual. There is almost no white on the rostrum, lips, or throat. Sides of body and of peduncle so thickly washed, circled and marked with gray and white that there is much more light than dark color present.

No. 13. Male. Length, 1250 cm. Sides of body from the fins to a point opposite the anus, have many large gray and white markings and an extensive area of clear light gray. The peduncle has few gray markings on the sides but many white barnacle scars (many barnacles are still in position).

On the inferior surface, both fins are black but have a number of white spots joining to form a band about 60 cm. long between the second and third fingers. There are a good many other white spots and circles along the posterior edge, the remainder of the fin being unmarked. The superior surface is almost like the inferior but shows somewhat less white.

No. 14. Male. Length, 1160 cm. An exceptionally dark whale. The head is black showing practically no white or gray markings and but few parasites. On the chin and throat and on the breast between the fins there are many white flecks and circles but the remainder of the breast and belly is plain. On the left side from the fin to a point opposite the penis is an area of clear light gray about 60 cm. wide; on the right side its place is taken by a number of rather dark gray, roughly oblong, markings. The peduncle is almost entirely black but has a few gray patches on the inferior half.

No. 15. Male. Length, 1085 cm. The head shows a little white on the dorsal surface of the rostrum and on the sides a good many white barnacle scars. The sides of the body from the pectoral fins to a point opposite the anus have numerous light gray patches with white edges which almost join each other; these also cover the belly but do not extend on to the back. The superior half of the peduncle is plain black and the remainder thinly covered with rather small gray markings.

No. 16. Male. Length, 1180 cm. A light individual. The head, lips, throat and back are black except for a few gray patches just posterior to the blowholes and a white spot on the lips. The sides of the body from the fins to a point opposite the anus are covered with rather small gray patches which become larger and more numerous on the lateral surfaces of the peduncle. (These patches are gray in the center shading to white on the edges and broken by small black spots or dashes). The dorsal and ventral regions of the peduncle are unmarked.

The pectoral fins are black, above, circled with white. The inferior surface has fewer circles but is washed with white in several places. The flukes are black below with a few white circles. (In coloration the tail resembles that of *Megaptera*).

No. 17. Male. Length, 980 cm. A dark whale. The sides of the rostrum, lips and mandibular rami are mixed gray and white ("pepper and salt"). The back, sides of body and peduncle are marked with long gray lines which resemble scratches but seem to be normal.

The flukes are very light colored on the inferior surface and have whitish lines running transversely across each lobe and curving inward toward the notch.

No. 18. Male. Length 1190 cm. The dorsal and lateral surfaces of the rostrum are very light gray; the entire mandible is dark but shades into very light gray about 60 cm. from the symphysis. The sides of the body from the pectoral fins to a point opposite the anus has many,

rather dark gray markings a few of which are present on the proximal half of the peduncle; the remainder of the peduncle is very dark slate. The back is unmarked save for a few small barnacle scars.

No. 19. Male. Length, 1180 cm. A very light whale. The ground color of the body is dark gray and not the usual slate, or black. Distal half of mandible gray and white mixed. The sides of the body, belly and entire peduncle are thickly covered with small gray patches, irregular in shape, but having their longitudinal axes following the axis of the body. The gray markings are about 15 cm. long by 8 cm. wide and coalesce so that there is more of the light gray and white than the darker ground color.

No. 20. Male. Length, 1215 cm. Ground color dark gray. Sides of rostrum and head to the eyes very light gray; just above the bases of the baleen rows is the usual narrow pinkish band. Sides of body to the fins have many gray markings, and the back, belly and, in fact, the entire body is thickly covered with white cirriped scars. The dorsal and ventral regions of the peduncle are unmarked, but the sides have a number of gray patches which become smaller posteriorly and cease about 120 cm. from the flukes.

The pectorals are dark on the superior surfaces with only a few white flecks. There is a considerable quantity of white flecks, spots and circles scattered over the inferior surfaces and the posterior edges are white.

The flukes are dark above and below showing but few white circles and spots.

No. 23. Male. Length, 1235 cm. A light individual. The head, lips and jaws are mostly light gray with flecks of white. There is much light gray on the sides of the body in small patches, bars, dashes and flecks. The sides of the peduncle show some light gray markings and the ventral surface a few irregular white lines resembling scratches.

External Anatomy.

Plates XX–XXIV.

Outline of Body.— The rostrum is strongly convex, the highest point being just anterior to the blowholes. Directly behind the spiracles there is a shallow concavity about sixty cm. long, and from that point to the "hump" the dorsal outline is regularly convex. From the hump the upper ridge of the peduncle slants very gradually downward to the flukes. The throat is rather flat but opposite a point midway between the eye and the anterior insertion of the fin, the breast and belly swell outward in a gradual curve to the anus broken only by a slight bulge at the penis. At the anus there is an abrupt dip and from that point to the flukes the ventral outline of the peduncle is slightly convex; the greatest convexity is just anterior to a point midway between the anus and flukes. The body is deepest opposite the tip of the pectoral fin laid back.

The outline of the body in Scammon's figure of *Rhachianectes* needs some correction. From the blowholes to the end of the peduncle crenulations the back is straight when it should be convex and there is little indication of a hump. The breast and belly are hardly full enough, the prominent dip just posterior to the anus is not shown, and the ventral outline of the peduncle should be slightly convex.

Head.— The head of *Rhachianectes* is distinctly characteristic and differs strongly from that of all other baleen whales. Its shape, in some respects, is intermediate between that of the

PLATE XXI.

PLATE XXI.

RHACHIANECTES GLAUCUS.

Fig. 1. Eye and ear.
Fig. 2. Inner view of baleen.
Fig. 3. Blowholes and *Cyamus scammoni*.
Fig. 4. Three-quarters view of tongue.
Fig. 5. Lateral view of anterior portion of snout showing cornified areas due to the action of parasites.
Fig. 6. Inferior view of anterior portion of snout.
Fig. 7. Fœtus No. 1*a*.

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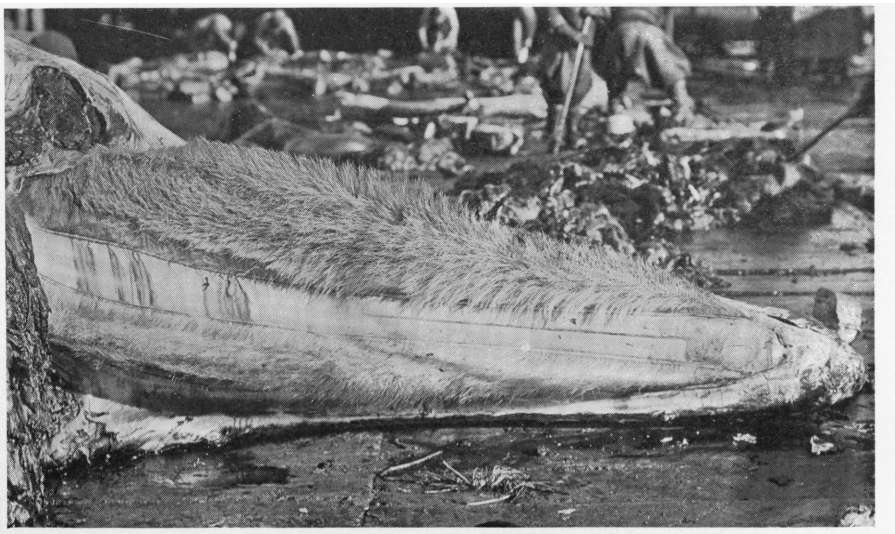

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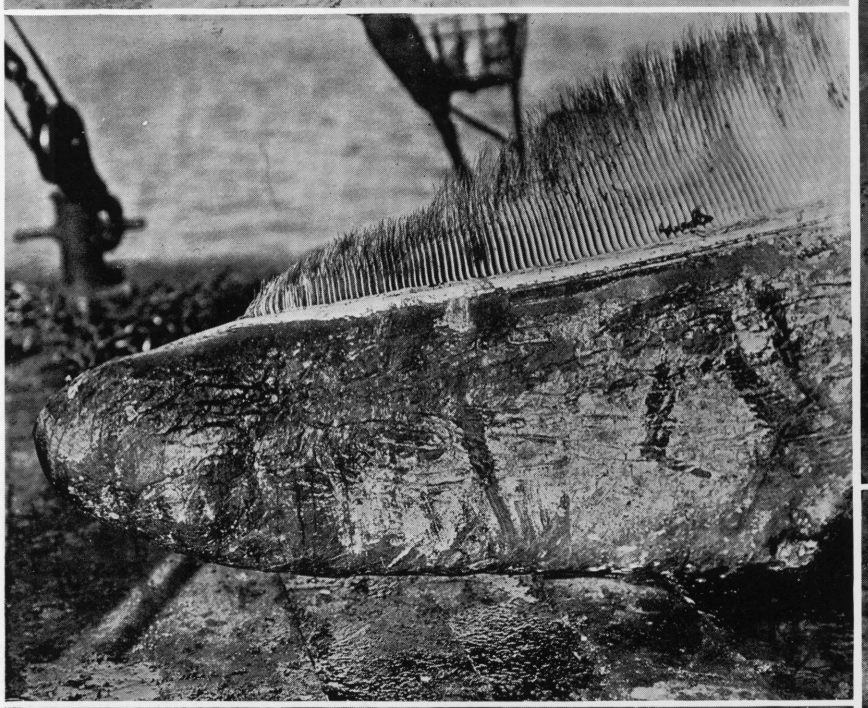

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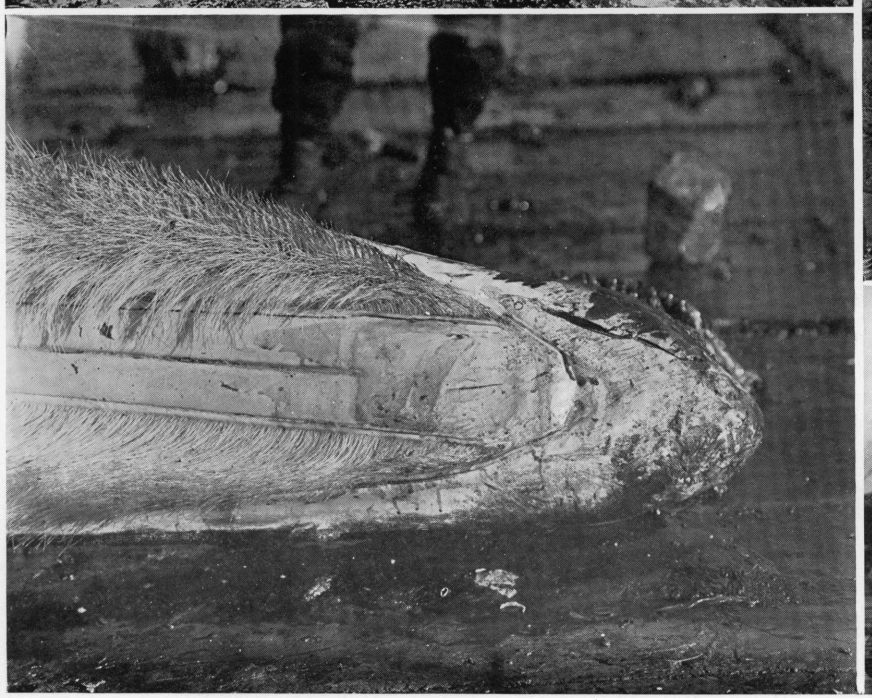

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RHACHIANECTES GLAUCUS.

Balæninæ and the Balænopterinæ. It is not so large proportionately, and the rostrum is neither as narrow nor as curved as in the former, but is much narrower and deeper than in the latter.

The rostrum is convex dorsally, narrow and very deep, especially so just anterior to the blowholes. On either side of the rostrum just anterior to, and below, the spiracles is a prominent swelling about forty-five cm. wide which runs forward, narrows, and gradually becomes lost. Immediately below this swelling is a shallow depression extending for the entire antero-posterior length of the rostrum.

The head is deep vertically and in whale No. 3, male, 1240 cm. in length, the distance from the eye to the summit of the head over the curve of the side was 94 cm.

The blowholes are situated in a slight depression just behind the highest point of the rostrum, the anterior ends being slightly higher than are the posterior. They appear as two slightly curved slits, the convexities inward, having a long and rather shallow furrow between them. In whale No. 1, 1300 cm. in length, the blowholes were 25 cm. long, the anterior ends being 7 cm. apart and the posterior ends 23 cm.

In Cope's description from Dr. W. H. Dall's note there is the following statement: "....the blowholes are entirely concealed by four dermal plicæ, which accounts for the small misty spout peculiar to the species" (*l. c.*, 1868, p. 226). I am at a loss to know what is meant by the "four dermal plicæ," as the blowholes of all the specimens which I examined were open and did not differ greatly from those of other baleen whales.

The region immediately about the spiracles was usually thickly infested with parasitic *Cyamus scammoni*.

Eye.— The eye forms a rather prominent swelling above, and a little behind, the corner of the mouth and is surrounded by two furrows the anterior and posterior ends of which almost meet. In some cases the ends of the furrows actually join thus forming a complete circle about the eye but in the majority of individuals the ends stand a short distance apart. The upper lid is considerably fuller and more prominent than is the lower. On whale No. 21, male, 1225 cm. in length, the furrows about the eye were each 18 cm. long, and the eye opening itself 5 cm. from the anterior to the posterior commissure.

The eyeball from an adult male 1158 cm. in length had a circumference of 205 mm. after it had been trimmed of adhering fat. The iris was 26 mm. long and 17 mm. in vertical diameter. The pupil was 10 mm. long and 6 mm. in diameter, oval, with the superior edge somewhat flattened.

The iris was a clear, dark brown band 6 mm. wide, the outer edge of which shaded into a narrow whitish ring. Encircling the iris was a band of light gray, 4 mm. in width, which shaded off gradually into very dark gray.

Auricular orifice.— The ear opening varies in size, as in all large whales, but is usually about 18 mm. in longitudinal diameter and directed upward at an angle of nearly 30 degrees. The meatus is a little larger than a good sized pencil.

The position of the ear is somewhat variable. In whale No. 1, female, 1300 cm. in length, the ear was 56 cm. behind the eye and 20 cm. *above* it. In fœtus No. 1*a*, male, from the same whale, the ear was 24 cm. behind the eye and 1 cm. above it. In none of the other twenty-three specimens on which notes were taken was the ear above the eye, it usually being from 2 to 5 cm. below it.

Scammon remarks in this connection: "The ear, which appears externally like a mere slit

in the skin two and one half inches in length, is about eighteen inches behind the eye, and a little above it" (*l. c.*, p. 20). In the table of measurements the distance from the eye to the ear of eleven specimens will be found.

Tongue.— The tongue of *Rhachianectes* is narrow, thick and solid, resembling that of a Right Whale much more strongly than it does the soft, shapeless tongue of *Megaptera* or any *Balænoptera*. The dorsal surface is regularly convex except at the distal end where it becomes concave, and the tip is upturned and deeply cleft. There is a narrow flattened strip on the top which runs from the proximal to the distal end. A cross-section of the tongue would be a semicircle with a slight dorsal compression. The color is usually flesh-pink becoming bluish gray at the tip.

Whale No. 17, male, 980 cm. in length, had a tongue 145 cm. long, 78 cm. wide over the curve and 50 cm. thick in the center. The tongue of No. 18, male, 1190 cm. in length, was 170 cm. long and 110 cm. wide over the curve.

Baleen.— The baleen plates of *Rhachianectes* differ from those of all other whales in being very thick and heavy, in the almost complete absence of transverse ridges, in having the outer edges thick and rounded instead of thin and sharp, and in the coarseness of the bristles. The baleen rows are not joined anteriorly by a narrow strip of small bristle-like plates as are those of the Balænopterinæ, in this respect resembling the Balæninæ.

The basal half of each plate is regularly concave, but in the distal half the concavity gradually disappears and the plate becomes flat. The color of the laminæ is yellowish white, or light yellow.

There are decidedly fewer baleen laminæ in each row than in any other large whale, the number varying from 138 to 174 on each side, the distance between the plates at the bases is from 5 to 10 mm. Following is a record of the number of baleen plates, *on one side only*, of different individuals, counting in every case the first and last lamina which was more than 50 mm. long and 5 mm. wide; the plates were all counted while *in situ:* 174, 168, 164, 162, 160, 158, 154, 148, 138.

The anterior ends of the baleen rows of whale No. 21, male, 1225 cm. in length were 35 cm. from the tip of the snout and 15 cm. apart; the posterior ends at the bases were 14 cm. apart and at the widest point the tips of the two rows diverged 65 cm.

The mucous membrane in the roof of the mouth between the bases of the baleen rows is white or flesh-pink.

The bristles of the proximal half of each plate are about 13 cm. in length but gradually elongate reaching a length of 25 cm. near the tips; they are round, very coarse and contrast strongly with the finer bristles of all other baleen whales. When seen *in situ* the bristles give the effect of a mat of thick, coarse fibers.

The baleen bristles are either entirely yellowish white like the plates themselves, or those of the posterior section may be gray, or dark gray, and the anterior portion yellowish white. The color of the bristles of twelve individuals was recorded showing that seven had some portion gray and five entirely yellowish white. Following is a list of the specimens in which the color of the bristles was noted:

PLATE XXII.

PLATE XXII.

RHACHIANECTES GLAUCUS.

Fig. 1. Throat showing two grooves.
Fig. 2. " " " "
Fig. 3. " " three "
Fig. 4. " " " "
Fig. 5. " " " "
Fig. 6. Tongue in position.

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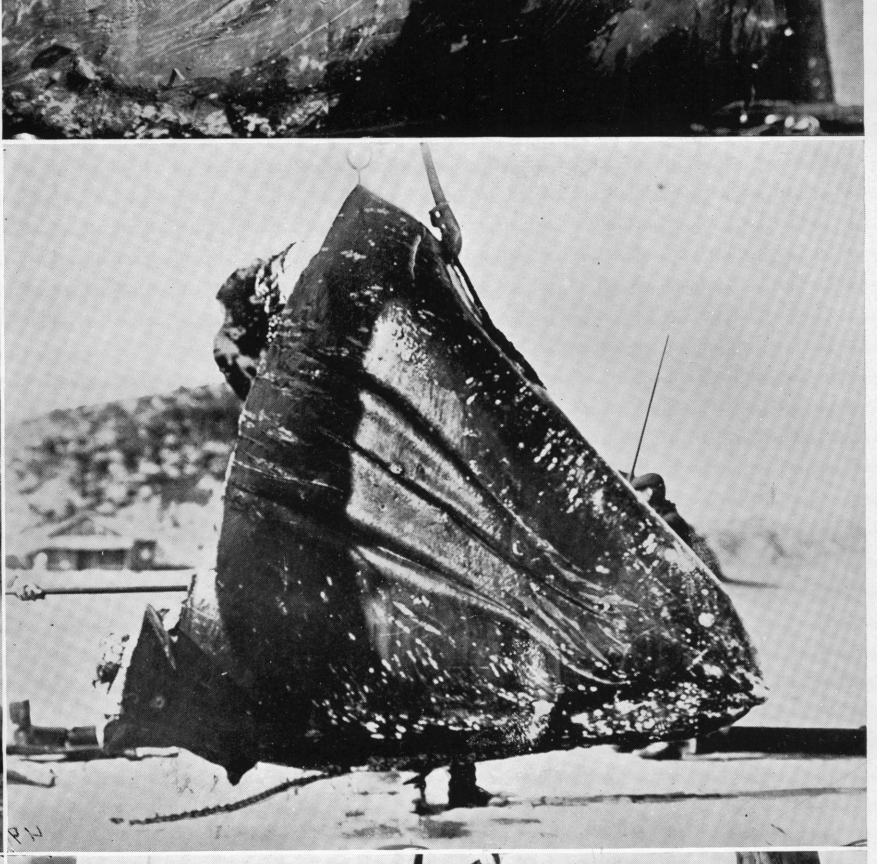

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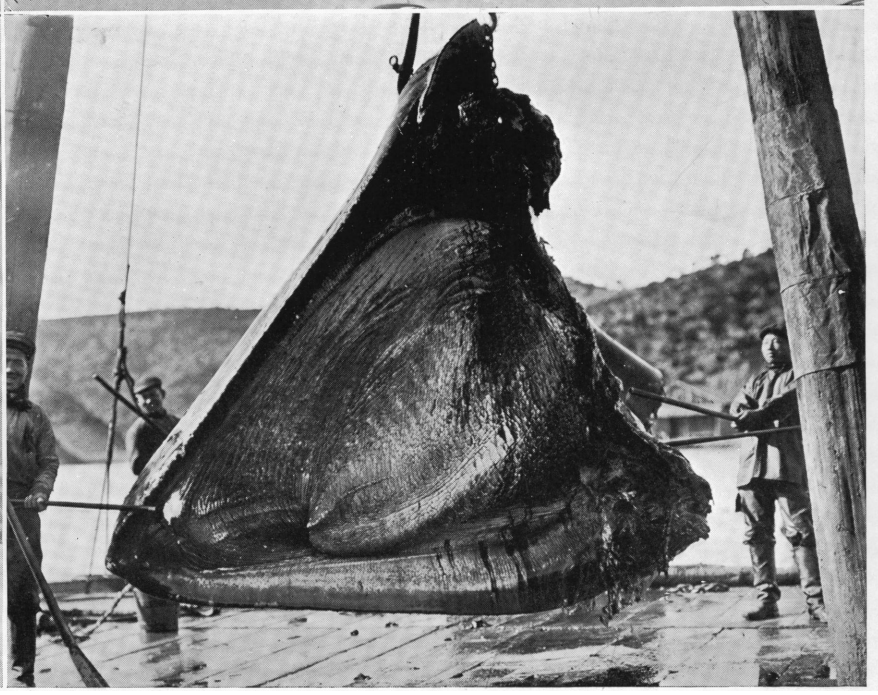

RHACHIANECTES GLAUCUS.

Color of bristles.

Capture Number	Sex	
4	♂	Posterior half gray, anterior half yellowish.
5	♂	" " " " " "
6	♀	All yellowish.
7	♂	Posterior half dark gray, anterior half yellowish.
8	♂	" two-thirds gray, anterior one-third yellowish.
11	♂	All yellowish.
13	♂	Posterior two-thirds gray, anterior one-third yellowish.
14	♂	All yellowish.
18	♂	" "
20	♂	Posterior three-fourths gray, anterior one-fourth yellowish.
21	♂	All yellowish.
23	♂	Posterior half gray, anterior half yellowish.

The descriptions given above of the baleen and bristles were written at the whaling station in Korea with fresh specimens at hand. I find upon examination of the set of baleen which was shipped to the Museum that both the bristles and laminæ are now very much darker than when fresh. This is due both to the drying of the plates and from soiling with dirt and grease. The bristles are now a strong brown and the plates yellowish-brown. I believe that in the great majority of cases any light colored baleen while being shipped from the field to a museum will be more or less soiled in transit and consequently the only reliable descriptions of such material are those that have been taken from fresh specimens.

Dall says that *Rhachianectes* has 145 laminæ of baleen on each side and that it is "light yellow," while Scammon describes it as "light brown or nearly white." Van Beneden speaks of the baleen in the Vienna Museum as being pale like that of *Balœnoptera acuto-rostrata*. The baleen in the U. S. National Museum from San Louis Obispo, Cal., is stated by Dr. True to be yellowish-white except at one end of the series where for a distance of about eight inches the blades and bristles are dull chocolate-brown. He says: "The largest plates measure 18 in. in length without the bristles, and 6 in. at the base. The longest bristles measure $9\frac{1}{2}$ in., and were perhaps originally a little longer" (*l. c.*, p. 290).

Throat furrows.— On either side of the median gular line *Rhachianectes glaucus* has two or more deep furrows. Their anterior ends closely approach each other and stand parallel for a short distance but gradually spread apart posteriorly. The furrows begin about 165 cm. from the tip of the mandible and end opposite a point half way between the eye and ear; the posterior ends are generally almost three times as far apart as are the anterior. Whale No. 24, male, 1225 cm. in length, had furrows 170 cm. long, the anterior ends being 20 cm. apart and the posterior ends 50 cm.; the anterior ends were 75 cm. from the tip of the lower jaw.

Although two furrows seem to be the usual number for *R. glaucus*, three are not infrequently present, and one individual which I examined possessed *four*. Whale No. 3, male, had three grooves, the left being 150 cm. long and the right 116 cm.; between their anterior ends was a shorter furrow 100 cm. in length. No. 4, male, also had three furrows, the two outer being 165 cm. long and the median 130 cm. The two outer furrows of No. 14, male, were 120 cm. in length and the one between them 154 cm. long; this was the only individual in which the median furrow was the longest of the three. In No. 16, male, the median furrow was 62 cm. in length while the two outer measured 150 cm.

No. 20, male, had *four* distinct furrows; the median and two outer ones were of about the

same length and between the middle and left near the *posterior* end was a fourth short groove. Out of the twenty-one specimens in which the number of gular furrows were recorded fifteen had two, and six three, or more. Several whales were brought in which were not measured or described and among them were four or five individuals showing three throat furrows. The grooves are almost 5 cm. in depth and have rounded edges.

The gular furrows of *Rhachianectes* seem to be a specialization in the direction of the throat and breast grooves of the Balænopterinæ. Since in *Rhachianectes* they are presumably present to increase the throat capacity they throw light upon the origin of the folds in the Balænopterinæ and tend to substantiate Prof. Kükenthal's theory that their purpose is to allow the short-headed members of this subfamily to take into the mouth a greater quantity of water containing their food.

The grooves of the Balænopterinæ in their early development were probably few in number and confined to the gular region, as in the case of *Rhachianectes*. As specialization of the entire body continued the furrows increased in number and in length extending backward upon the abdomen to give the greater thoracic expansion made necessary by the extraordinary development of the lungs.

It is well known that the sternum in all baleen whales is reduced to a vestige, and that the proximal ends of the ribs articulate loosely with the vertebral column, the distal ends of all but the first pair being free. Thus the frame-work of the thoracic cavity is capable of great lateral movement. In conjunction with the skeletal changes the lungs become greatly enlarged and adapted to retain the air during a considerable period of submergence. The increased power of lung expansion called for external as well as internal modification of the breast and the furrows which had already developed upon the throat became more numerous and prolonged posteriorly. The greatest number of furrows and their most frequent branching is between the pectoral fins, as might be expected.

In the existing Balænopterinæ, when the lungs are filled with air the whole thorax expands laterally and with it the flexible skin between the folds. Thus the furrows, besides their original function of increasing the throat capacity during the feeding operation, are also of use during respiration. *Rhachianectes* being a shallow water whale and a relatively primitive form, has not as yet developed the furrows upon the breast and abdomen.

In the case of the Balæninæ extensive specialization of the entire head has taken place and it has become of such a proportionately great size that there has been no necessity for increasing the throat capacity by the development of furrows; like the head, the entire thorax has become enormously enlarged by the great thickening of the body and has thus accommodated itself to the processes of respiration.

The Odontoceti, because of the nature of their food and the manner of securing it, are not under the necessity of increasing their throat capacity by the development of furrows.[1] In this group, moreover, which are not as extensively specialized as are the baleen whales, the sternum is long and the "thoracic box" is relatively immobile.

Pectoral limb.— The pectoral fins of *Rhachianectes* are distinctly individual being intermediate in shape between those of the Balæninæ and the Balænopterinæ. They are much broader and thicker proportionately and not so pointed as the fins of the latter subfamily, but are more lanceolate, and not as heavy, as thick or as broad as the pectorals of the Balæninæ.

[1] This is not literally true since the Ziphioides have two throat furrows.

PLATE XXIII.

PLATE XXIII.

RHACHIANECTES GLAUCUS.

Fig. 1. Superior surface of uninjured pectoral fin.
Fig. 2. Pectoral fin injured and infested with parasitic *Cyamus scammoni*.
Fig. 3. Superior surface of slightly injured pectoral fin.
Fig. 4. Inferior surface of pectoral fin showing usual type of coloration (slightly injured).
Fig. 5. Inferior surface of pectoral fin.
Fig. 6. " " " " "
Fig. 7. " " " " " (injured).
Fig. 8. " " " " " "

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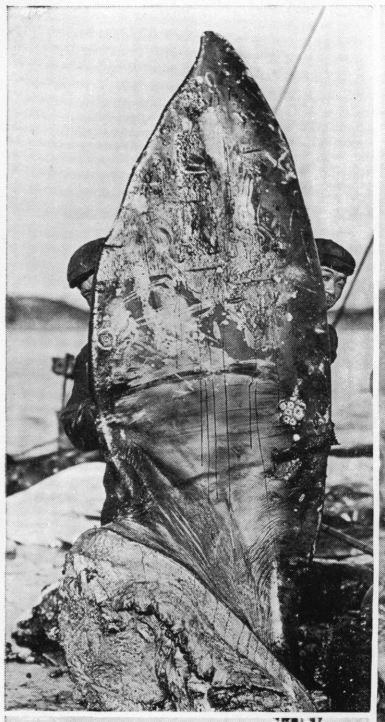

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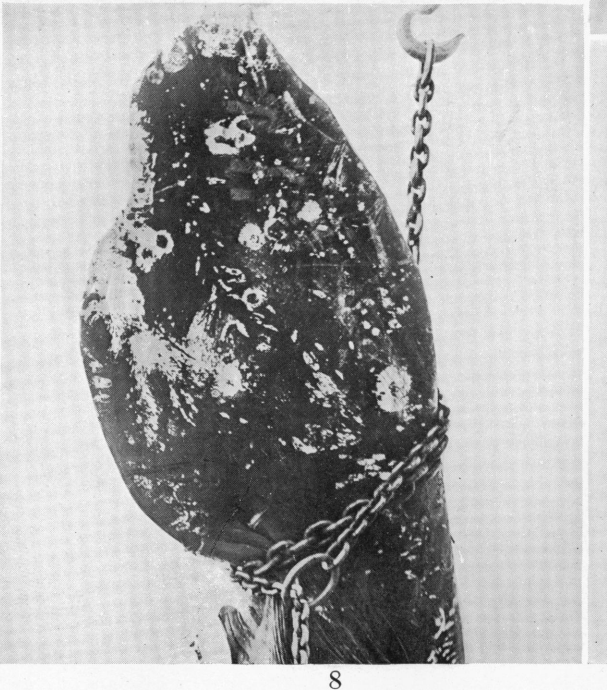

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RHACHIANECTES GLAUCUS.

If photos of the pectoral of *Rhachianectes* are compared with those of a Right Whale or of any *Balænoptera* it will be seen at a glance that its shape is intermediate between the two types.

The flipper of *Rhachianectes* is broadly lanceolate. The posterior edge is about 3 cm. thick and strongly convex except just behind the rather blunt tip where a shallow concavity is formed; the anterior edge is regularly convex. The greatest breadth of the fin is at a point almost midway between the tip and the axilla, and the four digits are so prominently outlined that each may be traced for almost its full length before the fin has been stripped of blubber. There is considerable variation in the breadth of the pectoral among different individuals due to a greater or less convexity of the posterior border. Out of the twenty-three specimens on which notes were taken all but two had at least one of the flippers more or less injured on the posterior edges or tips. This, I believe, was mainly the work of Killers (*Orca orca*) which apparently keep the Gray Whales in a continual state of terror when upon their annual migrations. It may also be due, in some degree, to contact with rocks, as this species is generally to be found close in shore and frequently rolls about in the surf in very shallow water. Wherever the edges or tips of the fins were injured they were invariably thickly covered with parasitic crustaceans, *Cyamus scammoni*, and frequently the hard barnacle *Cryptolepas rhachianecti* was embedded on both surfaces.

Scammon's figure is hardly an accurate representation of the flipper of *Rhachianectes glaucus*. The outer edge is too straight, the tip is too blunt, and the fin is not broad enough.

In color, the pectorals are dark slate like the body. Above, on the posterior half, are a few scattered white circles, spots and flecks; below, the white circles and spots are more numerous and there are two, more or less broken, bands of white, or very light gray, about 8 cm. wide and 45 cm. long between the 2nd and 3rd, and 3rd and 4th fingers; the band between the 2nd and 3rd digits is usually the longer. The posterior edge of the fin is generally white.

There is much variation in the amount of white on the pectorals. Some individuals had the two bands between the fingers present on both surfaces and the entire fin thickly covered with spots, circles, dashes and flecks of white. Others had the distal third of the flipper washed with light gray, or white, while in still other cases white was practically absent on both surfaces. In almost all cases, however, there was more of the light markings on the lower surface than on the upper. A large proportion of the white circles and spots seemed to be scars left by parasitic cirripeds and were exactly similar to those on the flippers of *Megaptera*.

Flukes.— The flukes of *Rhachianectes glaucus* are quite unlike those of any other large whale. In shape they resemble most closely those of *Physeter macrocephalus* but both the anterior and posterior edges are more convex than in the latter species and the notch is more open and shallower. They are strikingly different from the slender, graceful flukes of *Balænoptera* and equally so from *Balæna* and *Eubalæna*. The resemblances to *Megaptera* are only superficial.

When either lobe of the flukes of *Rhachianectes glaucus* is viewed singly it is strongly suggestive of the pectoral fin in shape. The anterior margin is slightly convex becoming more so near the distal end. The posterior edge for the proximal two-thirds is strongly convex, but the distal third just behind the tip is slightly concave. Since the tips of the flukes in all adult specimens are more or less injured the concavity generally does not show and the posterior edge is evenly convex from the notch to the tip. The posterior edge, instead of being extremely thin as in *Balænoptera*, is almost three cm. in thickness and is broken by shallow, rounded emarginations. These crenulations must be normal as they were present in a fœtus (No. 1*a*) which was almost ready for birth, and in nearly all the adult specimens. They are analogous to the emarginations on the

flukes of the *Megaptera* but are neither so numerous nor so deep and give a wavy effect rather than the scalloped appearance seen in the Humpback.

The entire posterior edge is frequently infested with *Cyamus*, which fasten themselves upon the slightest abrasion, and the posterior outline is often entirely changed by the attacks of these parasites or by other injuries. The notch is deep and usually open but varies considerably in this respect.

The flukes are black above and below like the body. A few circles, flecks and dashes of white are scattered over both surfaces, the lower usually being most heavily marked. As with the pectorals, the amount of white is extremely variable. The white circles and spots in many cases are the scars left by barnacles; two or three individuals had flukes exactly resembling those of a Humpback in color.

The flukes of a fœtus (No. 1*a*) on the inferior surface had wide, dark gray anterior and posterior borders and very light gray central portions. Many broken whitish lines curving inward toward the notch ran transversely across each lobe starting on the anterior edge. In a general way this was suggestive of the inferior surface of the flukes of *Balænoptera musculus*. One adult individual (No. 17) had flukes marked in exactly the same manner but as it was quite unlike all other specimens examined this must be considered to be an unusual type of coloration.

Dorsal crenulations of peduncle.— On the dorsal ridge of the peduncle, beginning about 100 cm. from the insertion of the flukes, is a series of low, rounded crenulations which end a short distance beyond a point opposite the anus in an evenly rounded bunch, or "hump," about 50 cm. long and 7 or 8 cm. high. The crenulations are about 30 cm. apart, those nearest the flukes being the least developed and those just posterior to the "hump" the most prominent. Their number and size are open to considerable variation, one individual having only 6 rather indistinct tubercles while another had 14, even the most posterior of the row being well developed; 9 or 10 is the usual number as shown by the following table:

Number of crenulations.

Capture Number	Sex	
5	♂	9
6	♀	6
8	♂	10
10	♂	10
11	♂	8
13	♂	10
14	♂	10
15	♂	7
20	♂	14
22	♂	9
23	♂	9

These crenulations are very similar to those on the dorsal ridge of the peduncle of the Humpback but are somewhat more prominent. They were noted by Dall, Scammon and Townsend. Dall says: "On the vertebral line, for fourteen feet from the caudal flukes, is a series of 18 ridges, like the teeth of a saw, which are altogether dermal in their character" (*l. c.*, 1868, p. 226). Out of some 30 individuals which I examined only one possessed as many as 14, the next highest being 10; it would appear, therefore, that 18 is rather an unusual number.

Scammon's statement that it "has a succession of ridges, crosswise along the back, from

PLATE XXIV.

PLATE XXIV.

RHACHIANECTES GLAUCUS.

Fig. 1. Flukes showing barnacle scars; posterior edges slightly injured.
Fig. 2. Flukes; posterior edges very slightly injured.
Fig. 3. Posterior edge of flukes.
Fig. 4. Peduncle of fœtus No. 1*a*.
Fig. 5. Section of blubber at end of peduncle crenulations ("hump").
Fig. 6. Gray Whale spouting blood.
Fig. 7. Normal spout of a Gray Whale.

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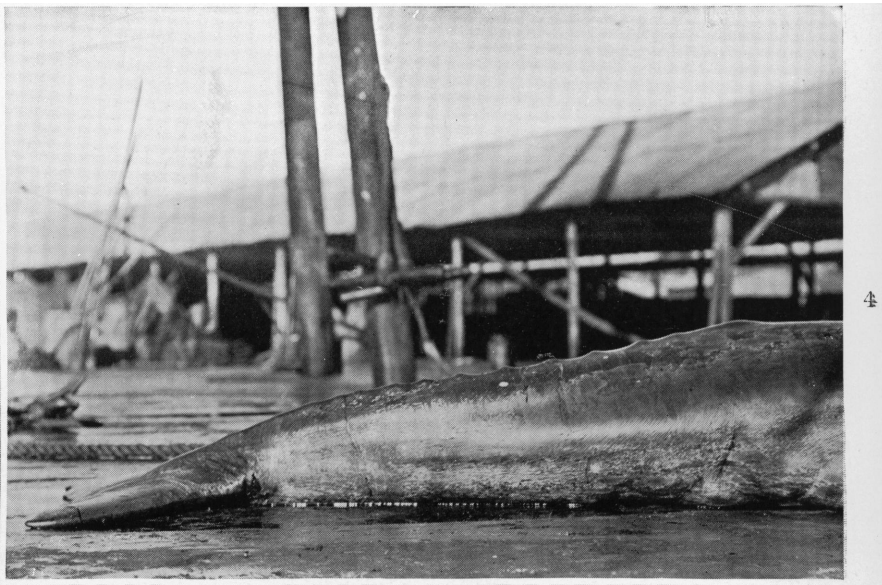

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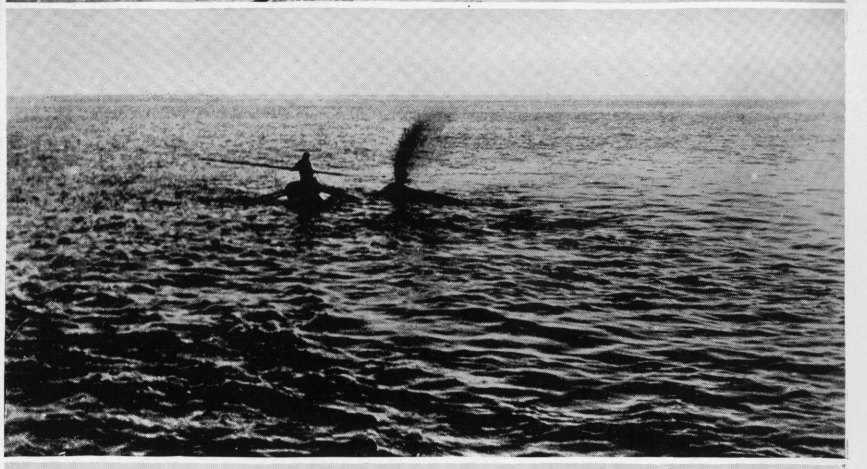

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RHACHIANECTES GLAUCUS.

opposite the vent to the flukes" is misleading for the ridges are certainly never transverse; although he figures them in their proper position he does not show the hump at the anterior end of the series.

Townsend speaks of the crenate ridge as being present in a fœtus but says he did not observe it in the adult. He may have seen a specimen in which it was so slightly developed as to have escaped his notice for it is probably never entirely absent.

In a fœtus 476 cm. long which I examined it was fully developed and 12 crenulations could be distinguished. Townsend's figure shows the crenate ridge as an elevated phlange which gives a somewhat erroneous idea of its true character for the dorsal ridge of the peduncle is not itself extended.

It seems somewhat remarkable that the presence of the hump or bunch, which ends the series of crenulations anteriorly, has not been previously mentioned, for in nearly all the individuals examined it was prominent and attracted my attention at once. By referring to the table of proportional measurements it will be seen that the relative position of the hump is decidedly variable, there being a difference of 11% between the highest and lowest ratios to the total distance from the notch of the flukes to the hump. Its average position relative to the length of the animal is the same as in the *Megaptera*, and by but little modification a dorsal fin similar to that of a Humpback could be derived from it. The fact that Humpbacks have the dorsal ridge of the peduncle distinctly crenulated from the flukes to the hump, in a way similar to that of the Gray Whales, is exceedingly interesting. There is a greater individual variation in the relative position of the dorsal fin in the *Megaptera* than in the *Balænoptera;* it is situated much further forward in the former genus than in the latter, and it has almost every possible shape between a prominent, falcate fin and a low rounded bunch.

Before the pectoral and caudal fins of the Humpback had reached their present high state of specialization it is very probable that the dorsal may have been much less prominent and that, as in the Gray Whales, it formed the terminal bunch at the anterior edge of the peduncle crenulations. As the specialization of the animal continued the dorsal hump increased in size, its shape became modified, and the crenulations in the remainder of the series grew less prominent.

It is possible, therefore, that we may see *Rhachianectes* developing a dorsal fin in a parallel way to the *Megaptera* and that, if specialization is continued, it may become as prominent as in the case of the Humpback and its relative position be more constant.

Hairs.— Both the fœtal and adult *Rhachianectes* possess longer hairs, and they are more widely and more uniformly spread over the entire head, than in any other baleen whale. The hairs were scattered in six irregular rows over the whole rostrum of fœtus No. 1*a*, and a line of 16 on the dorsal ridge extended from the blowholes to the snout. The most posterior hair was on the left side of the head opposite the posterior end of the blowholes.

On each rami of the mandible there were 21 hairs in three irregular rows, the most posterior being a little anterior to a point opposite the corner of the mouth. At the mandibular symphysis three irregular vertical rows, which closely approximated each other, contained 40 hairs. The areas most thickly covered with hirsute remains were the tips of the snout and mandible. Each hair was white, about 20 mm. long, and situated in a small pit surrounded by a dark ring.

On the head and lower jaw of the adult *Rhachianectes* the number and arrangement of the hairs is essentially the same as on the fœtus described above. The hairs are generally longer in the adult than in the fœtus, sometimes reaching a length of 40 mm.; on whale No. 18, male, in several places on the mandibular rami two hairs were found in a single follicle.

A careful examination was made of all parts of the body, both in the fœtus and adult, but in no place other than the head and jaws were there evidences of hair.

Blubber.— The blubber is very thick and fat, and varies in color from red to flesh-pink. Because of this, as noted by Dr. True, the Japanese recognize two kinds of Gray Whale, the "aosaki" (red blubber) and the "shirosaki" (white blubber). Although specimens with blubber strongly red, almost white, and of every intermediate shade, were taken during my stay at Ulsan, I could detect no differences, other than those purely individual, between them.

The blubber varies in thickness with individuals, and on different parts of the body, usually being from 20 cm. at the thinnest to 35 or 40 cm. at the thickest part.

The Japanese consider the meat and blubber to be of poorer quality for eating than those of any other baleen whale. In the winter, during the months of December and January when the price is at its highest, the blubber sells for about 4 sen (2 cents) per pound and the red meat 10 sen (5 cents).

In regard to the blubber Scammon says: "The coating of fat, or blubber, which possesses great solidity and is exceedingly sinewy and tough, varies from six to ten inches in thickness, and is of a reddish cast" (*l. c.*, p. 21).

Parasites.— The entire body of *Rhachianectes* is more or less thickly infested with the parasitic amphipod crustacean *Cyamus scammoni* Dall, and the hard barnacle *Cryptolepas rhachianecti* Dall. The barnacles embed themselves deeply on all parts of the body as well as on the flukes and pectoral fins.

The *Cyamus* are almost invariably to be found about the blowholes, the genital and anal openings, and on the tips and posterior edges of the flukes and flippers. Wherever a cluster of *Cryptolepas* have become embedded, *Cyamus scammoni* will also fasten and frequently cover a wide area having the barnacles as a nucleus; an injury or abrasion of the skin at once becomes the resting place of numbers of parasites. The snout of *Rhachianectes* for a distance of sixty or seventy cm. from the tip is usually cornified in a way similar to the "bonnet" of the Right Whale, and is produced, as in that species, by the action of the parasitic *Cyamus*. In some individuals the entire dorsal ridge of the rostrum from the snout nearly to the blowholes becomes cornified.

When a *Cryptolepas* detaches itself a circular grayish pit remains, which in time becomes white as the wound heals; these scars are exactly like those left by the barnacle *Coronula diadema* upon the *Megaptera*. No barnacles other than *Cryptolepas rhachianecti* were observed upon the Gray Whales, and it seems probable that none other infest this species.

A careful examination of the *Cyamus* taken from Korea specimens demonstrates that they are certainly identifiable with Dall's *Cyamus scammoni* described from the California examples of *Rhachianectes glaucus*. In any case it is doubtful if such highly specialized parasitic forms would show strong changes even if isolated for a long period and thus they furnish little information on the question as to whether or not the Gray Whales of the east and west sides of the Pacific actually mingle in the north.

Osteology.

The skeleton of *Rhachianectes*, other than the skull, has never been completely described, consequently a rather detailed account of its principal characters will be given in the following pages; also comparisons with other genera will be instituted whenever individual peculiarities can be emphasized thereby.

The length of the skeleton of the American Museum specimen, measured in a straight line, is 1107 cm. (36′ 4″). It was taken from a very old male (No. 20), 1250 cm. (41′ ½″) long, on January 19, 1912, at Ulsan, Korea.

The vertebral epiphyses are all firmly ankylosed, in most cases the lines of union being lost, and there are other evidences of extreme age.

Skull.

Plates XXV–XXVII.

In general form the skull of *Rhachianectes* is directly intermediate between the skulls of *Eubalæna* and *Balænoptera*, and somewhat resembles *Neobalæna*. The dorsal outline is much curved and especially high from the nares posteriorly, thereby giving to the occipital plane a comparatively slight obliquity, scarcely greater than in *Eubalæna*. The skull, as seen in profile, is thus quite unlike that of a Fin Whale, not only the whole dorsal outline being more convex but the rostral portion more arched. The interorbital region is thus deep and quite constricted.

The rostrum is narrow and elongate and the lateral outline tapers regularly toward the tip. The premaxillæ in the distal portion are very deep and have almost vertical sides, as in *Eubalæna*, but become somewhat flattened where they spread apart for the narial opening. Proximally they end a considerable distance from the vertex of the skull *leaving a wide area of the frontals exposed*, a primitive condition. The proximal portions of the premaxillæ enclosing the nasals appear as broad strips, superiorly placed, and articulate with the frontals by a deep interdigitating suture.

The maxillæ instead of being almost horizontal as in the Balænopterinæ are sharply oblique. Their inner (superior) edges slope abruptly downward in the distal half of the rostrum but in the proximal half are almost parallel with the skull axis. Each maxilla sends a narrow projection backward toward the vertex of the cranium, ending beside the premaxillæ. The lateral extentions of the maxillæ are remarkable in the fact that each one *overlaps the anterior edge of the orbital process of the frontal*, and bears posteriorly a strong tubercle which, with the anterior end of the orbit, partially encloses a large oblique foramen.

The nasals are very broad and long, joining in the median line to form a prominent crest; they occupy half the space between the nares and the summit of the occipital bone.

Compared with *Balænoptera* and *Megaptera* the orbital processes of the frontals are narrower, shorter and consequently less massive, but are much wider and less elongate than in *Eubalæna*. Viewed from below they have the trumpet-shaped form so characteristic of the fossil genus *Plesiocetus*. The posterior edges of the orbital processes of the frontals from the skull-vertex to the orbits present irregular margins; a primitive character.

The squamosal is comparatively small and has a straight outer edge quite unlike the concave squamosals of either *Balænoptera*, *Megaptera* or *Eubalæna;* in this respect the squamosal of *Rhachianectes* resembles that of fossil genera. The "temporal ridge," formed by the anterior margins of the temporal fossa, is well marked, thus showing an interesting primitive condition.

The supraoccipital presents three deep concavities, and on the superior portion two prominent and peculiar rugosities. These are undoubtedly homologous with the similar processes just under the lambdoid crest on the supraoccipital of dogs and other mammals, where the *rectus capitis posterior major* and *minor* muscles, which assist in raising the snout, are attached.

Their development, and the presence of similar rugosities below upon the basi-sphenoid and basi-occipital bones, are probably correlated with the fact that the cervical vertebræ are all free, and the neck is somewhat less abbreviated than in other large cetaceans thus allowing greater movement of the head.

The most interesting characters of the inferior surface of the skull are the comparatively short posterior extension of the vomer and pterygoid bones, the heavy pterygoids and, as mentioned above, the strongly down-turned edges of the basioccipital and basi-sphenoid which are exceedingly thick and massive.

Fig. 1. Inner view of tympanic bulla of *Rhachianectes glaucus*.

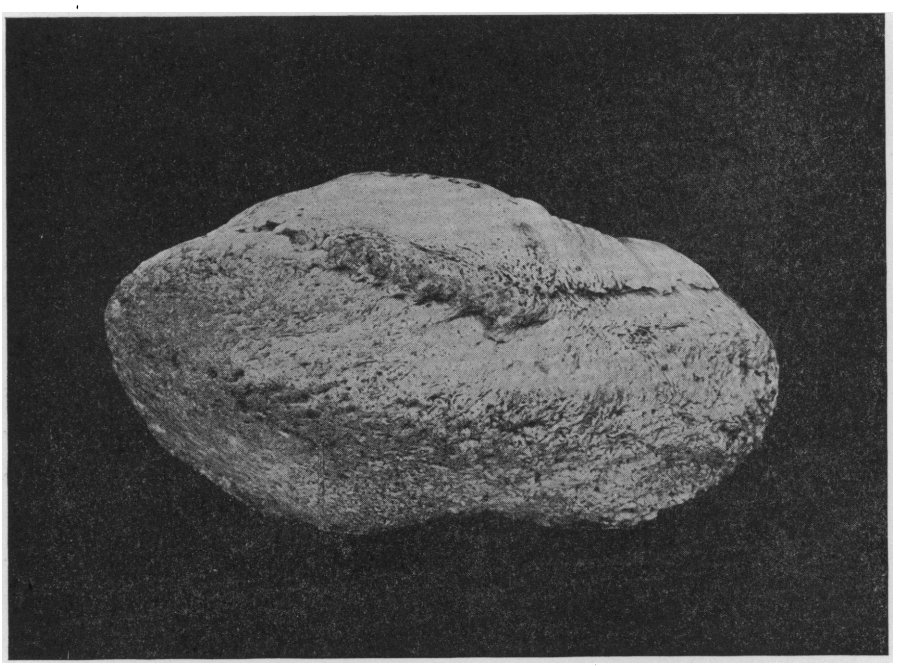

Fig. 2. Inferior view of tympanic bulla of *Rhachianectes glaucus*.

True remarks in regard to the peculiarities of the skull of *Rhachianectes:* "Most striking are the rugosities of the occipital, the large size of the nasals, the shortness of the nasal portion of the intermaxillæ, and their great depth anteriorly, the overlapping of the orbital processes of the frontal by the proximal portion of the maxilla, and the strong tubercle on the posterior margin of the former. All these characters are seen equally as well developed in the skulls figured by Malm as in the Monterey specimen.

"These and many other characters stamp it as a very distinct form, approaching closely neither *Balæna* nor *Balænoptera*" (*l. c.*, p. 291). Dall, Van Beneden, Malm and Beddard have also more or less completely described the skull of *Rhachianectes*.

The mandibular rami are without coronoid processes these being represented only by flattened tubercles. Each

PLATE XXV.

PLATE XXV.

RHACHIANECTES GLAUCUS.

Fig. 1. Dorsal view of the skull from California in the U. S. National Museum.
Fig. 2. Dorsal view of the skull from Korea in the American Museum.

1 2

RHACHIANECTES GLAUCUS.

PLATE XXVI.

PLATE XXVI.

RHACHIANECTES GLAUCUS.

Fig. 1. Ventral view of the skull from California in the U. S. National Museum.
Fig. 2. Ventral view of the skull from Korea in the American Museum.

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RHACHIANECTES GLAUCUS.

ramus is moderately bowed and the superior outline from the coronoid rudiment to the distal end is regularly convex; the inferior outline is a succession of slight convexities and concavities as shown by the figures. On the inner side of the superior edge for the distal three fourths of the ramus is a well-marked alveolar sinus which becomes very deep near the tip. Both rami show the effects of a former injury.

The mandible of *Rhachianectes* strongly resembles that of the Balæninæ, and shows little concavity on the inner side proximally; it is surprising to find a specialized mandible of this type when the many other primitive characters of the skull are considered.

The tympanic bullæ of *Rhachianectes* are small and remarkable because of their strong lateral compression and slightly grooved internal border (that is, the border nearest the median line of the skull). They are totally unlike those of *Eubalæna* in size and general shape and differ from *Balænoptera* in being much less elongate, wider, and more compressed as well as in other points. In size and general outline they somewhat resemble *Megaptera* but instead of being almost globular, as in the latter genus, are greatly flattened. By their compressed form and concave internal border they strongly suggest the tympanic bones of certain fossil genera.

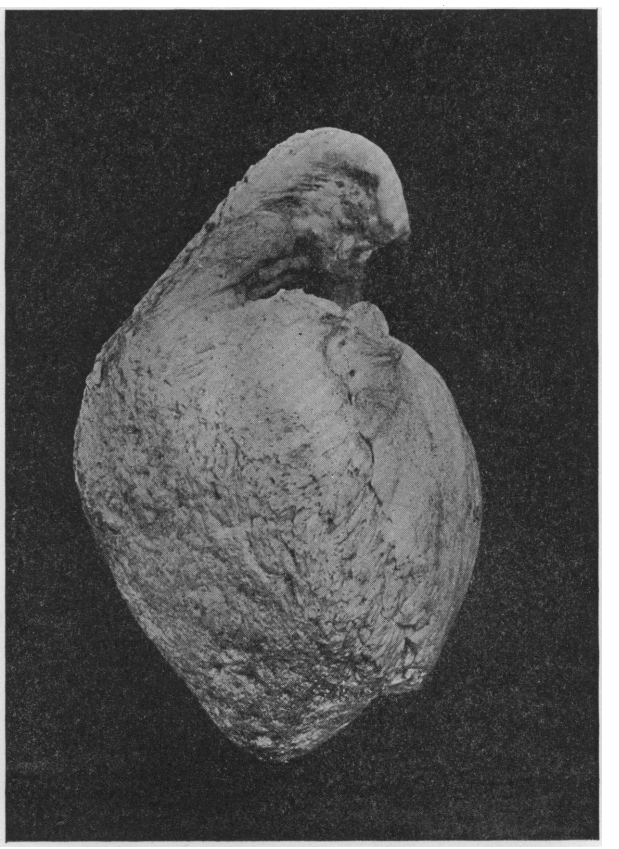

Fig. 3. Posterior view of tympanic bulla of *Rhachianectes glaucus*.

Table VI.— Measurements of skull of Rhachianectes glaucus.

	No. 34260 A. M. N. H. Andrews	No. 13803 U. S. N. M. Dall
	mm.	mm.
Total length from the tip of premx. to occipital condyle (straight)	2570	2464
Greatest breadth	1110	1041
Length of rostrum	2122	1740
Breadth " " at base	605	584
" " " " middle	429[1]	337[1]
" across pmx. at same point	202	184
Length of mx. from frontal border	1761	1651
Greatest breadth across mx. proximally	908	851
Length of premx.	2115	2007
" " nasals in median line	320	305
Breadth " " at anterior end	196	171
Distance from anterior end of nasals to anterior end of supraoccipital	383	375
Length of orbit (least)	172	165
" " palatine bones	424[2]	394[2]
Breadth across anterior ends of zygomatic processes of squamosals	1130	940
Breadth across anterior angles of orbital processes of frontals	950	889
Breadth across posterior angles of orbital processes of frontals	1035	991
Depth of skull from crest of supraoccipital to lowest point of pterygoids	731	

[1] Straight.

[2] The exposed position.

Table VI.— Continued.

	No. 34260 A. M. N. H. Andrews
	mm.
Length of mandible (straight)	2425
" " " (curved)	2500
Depth " " at middle	375
Greatest length tympanic bulla	102
" width " " posteriorly	79

Hyoid Bones.— The hyoid bones differ from those of all other baleen whales with which I am familiar.

The basihyal and two thyrohyals are ankylosed into a long, extremely massive and rugose bone. The central portion (basihyal) is dorso-ventrally compressed and has two short, anterior, conical projections (ceratohyals), but each thyrohyal rapidly thickens, becoming cylindrical

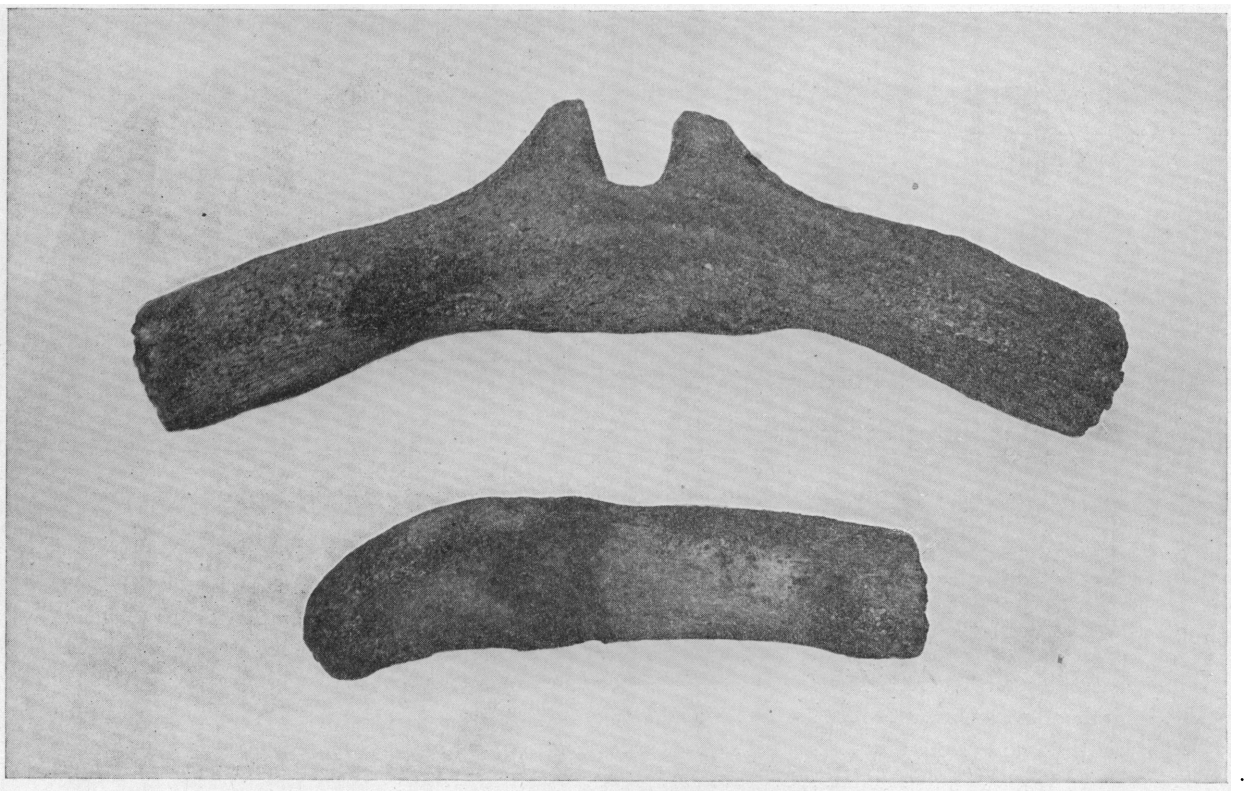

Fig. 4. Hyoid bones of *Rhachianectes glaucus*.

in the distal two-thirds and curved slightly backward. The shape of this portion of the hyoidean apparatus is distinctly individual but resembles that of *Eubalæna* much more than any *Balænoptera*.

The stylohyals, on the other hand, are decidedly more like those of the latter genus than the former. Each is a massive, rugose bone, slightly curved upward and forward. The anterior edge for its greater part is sharp and the posterior margin rounded so that a cross section of the stylohyal would be an ovoid ellipse. These bones are nearly half again as long and twice wider than are the roughly cylindrical stylohyals of an adult 54 ft. female *Eubalæna glacialis* in this Museum.

PLATE XXVII.

PLATE XXVII.

RHACHIANECTES GLAUCUS.

Fig. 1. Lateral view of the skull from California in the U. S. National Museum.
Fig. 2. Lateral view of the skull from Korea in the American Museum.
Fig. 3. External side of the left ramus of the mandible; Korea specimen in the American Museum.
Fig. 4. Internal side of the left ramus of the mandible; Korea specimen in the American Museum.

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RHACHIANECTES GLAUCUS.

Measurements of the hyoid bones.

Extreme length of base (thyrohyals and basihyal)	631 cm.
Antero-posterior width across ceratohyal	149 "
Greatest thickness of thyrohyal distal end	105 "
" length of stylohyal	392 "
" width " "	106 "

VERTEBRÆ.

The vertebræ of *Rhachianectes*, through the combination of characters, differ widely from those of the other known genera of baleen whales, the general resemblance being rather more toward *Megaptera* than *Balænoptera* or *Eubalæna*.

The extremely rugose surfaces of practically all of the bones of the skeleton is interesting. I know of no other large Cetacean, except *Physeter macrocephalus*, in which this condition is so pronounced. Fifty-six vertebræ seems to be the normal number for *Rhachianectes glaucus*, the formulæ of three skeletons being as follows:

C	D	L	Ca.	Total		
7	14	12	23	= 56	Am. Mus. Nat. Hist.	(R. C. A.)
7	14[1]	12	23	= 56	U. S. Nat. Mus.	(R. C. A.)
7	14	14	21	= 56	British Mus.	(Beddard)

The differences in these formulæ will be discussed later.

Cervical vertebræ.— The cervical vertebræ are all free and show no tendency toward ankylosis. The atlas differs strongly from that of both *Eubalæna* and *Balænoptera* but bears a considerable resemblance to *Megaptera*. Its most distinctive characters are the massive neural arch, the short transverse processes, and the small size of the condylar facets relative to the height of the vertebræ.

The neural arch is high and exceedingly thick and massive, having an irregular rugose superior surface and an indistinct spine; it is perforated by a transverse arterial foramen. The short bunch-like transverse processes are set obliquely to the vertical plane of the axis, have irregular rounded ends, and are directed slightly upward. They resemble the transverse processes of the *Megaptera* but are shorter and not so wide.

The centrum of the atlas at the bottom slopes strongly upward, and at the sides inward, so that the posterior face is considerably smaller than the anterior. The opening between the condylar facets in conjunction with the neural canal is much shallower than is usual with the atlas of other baleen whales; this character is not so pronounced in the National Museum specimen, the opening being roughly V-shaped, the point directed downward.

On the posterior surface, the internal-superior corners of the facets for articulation with the axis are produced inward appearing as two irregular tubercles when seen from the anterior face of the axis through the space between the condylar facets.

The axis resembles, in general, that of a *Balænoptera*. The neural arch is very thick and massive, has a rugose, truncated summit and an indistinct spine. Each of the posteriorly directed, wing-like transverse processes is perforated somewhat above the center by a rather small oval foramen; the processes are thick and have irregular, rugose surfaces. The articular facets for the atlas are small and between them is a rather prominent odontoid process.

[1] Although but thirteen pairs of ribs are present in the U. S. National Museum specimen, the distal ends of the transverse processes of the twenty-first vertebra show distinct articular facets and indicate that the last pair of ribs has been lost.

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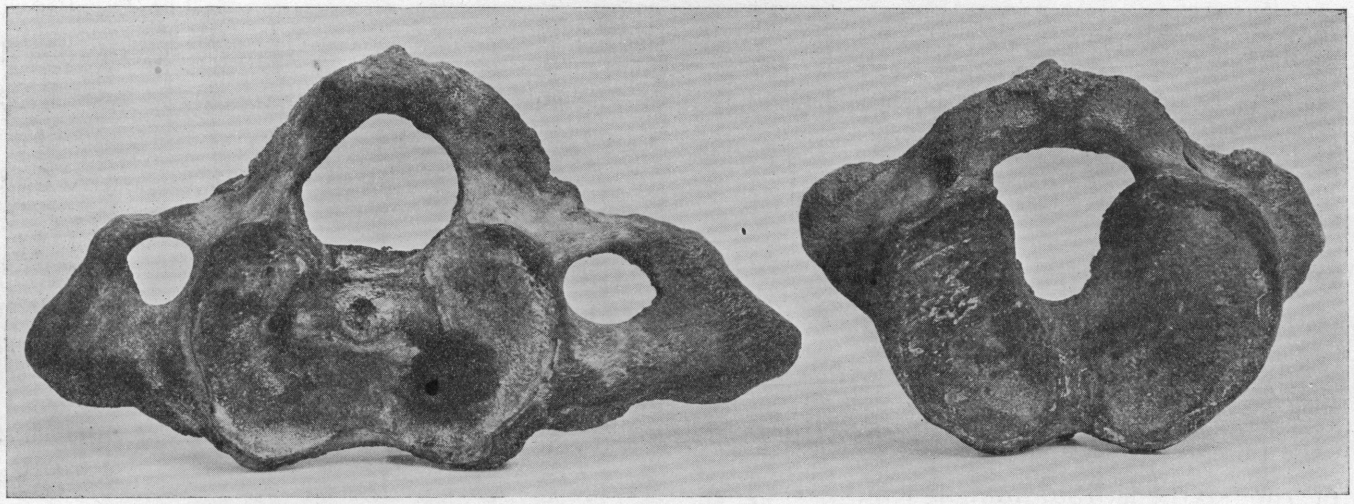

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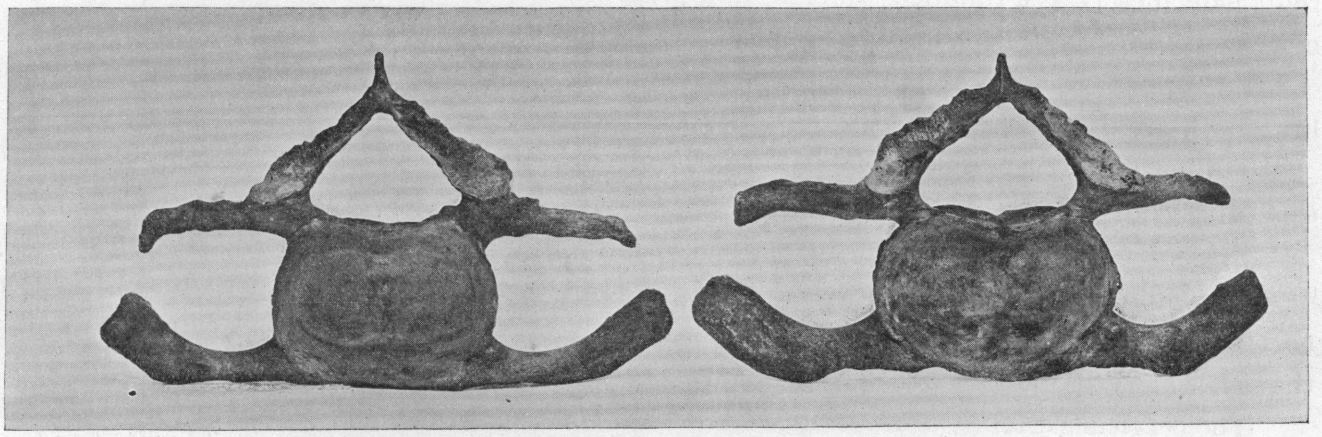

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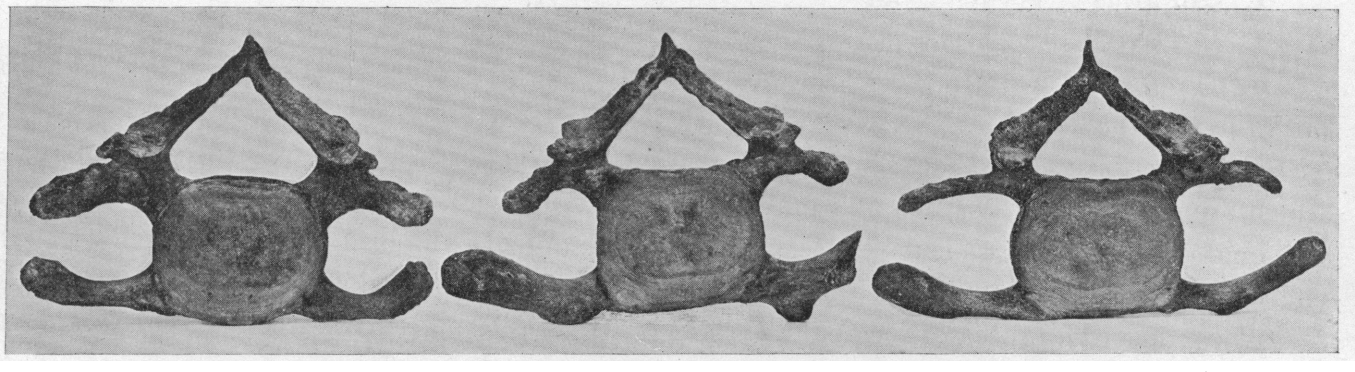

Fig. 5. Atlas and axis of *Rhachianectes glaucus*.
Fig. 6. Third and fourth cervical vertebræ of *Rhachianectes glaucus* (right to left).
Fig. 7. Fifth, sixth and seventh cervical vertebræ of *Rhachianectes glaucus* (right to left).

The third cervical vertebra has a circular body, somewhat compressed dorsally, and on either side two well developed transverse processes. The lower process is thick and roughly cylindrical for half its length, projecting somewhat downward but bends up and back in the distal half where it becomes compressed and blade-like. The upper process is straight, except at the distal end, and directed backward; the distal ends of the two processes stand widely apart (on the right side 50 mm.).

Both the upper and lower transverse processes of the fourth vertebra are similar to those of the third in length and direction, but the lower process is less massive and expanded distally.

On the fifth cervical the lower process is compressed throughout, especially so at the distal end where it is thin and expanded; instead of being directed slightly backward, as are those immediately preceding, it projects straight out and turns upward in the distal portion. The superior process is shorter than that of the fourth vertebra and curved slightly backward and downward.

The inferior transverse process of the sixth cervical is more massive than that of either the fifth or fourth, projects upward and forward and bears on the posterior side, proximally, a prominent flattened tubercle. The superior process of this vertebra is the shortest in the cervical series and projects strongly downward.

The seventh cervical has a lower transverse process which, although it is shorter than that of the sixth, is 135 mm. in length, roughly cylindrical and slightly expanded distally. The lower transverse processes of the seventh cervical of the U. S. Nat. Mus. specimen appear on the right side merely as a rounded tubercle and upon the left as a short process 64 mm. in length; neither seem to have been broken or otherwise injured.

The upper process is thick, compressed and considerably longer than that of the sixth vertebra; both are directed downward.

The anterior zygapophyses of the third vertebra are well developed, becoming larger on each succeeding cervical and appearing on the seventh as tubercles 43 mm. in length.

The spines of all the cervicals increase in height and thickness from the third to the seventh.

The laminæ of the neural arches of the third, fourth, and fifth vertebræ are wide at the bases, narrowing rapidly and uniting at the apices in erect and prominent spines. The arches of all the cervical vertebræ are high and triangular, considerably resembling those of *Megaptera*.

The cervical vertebræ of *Rhachianectes*, considered as a whole, are unique in the *combination* of the following characters:

1. An atlas of peculiar shape.
2. An axis having wing-like transverse processes.
3. Triangular neural arches and long inferior transverse processes in all cervical vertebræ posterior to the axis.[1]

Dorsal vertebræ.—The most distinctive character of the dorsal vertebræ is the zygapophyses, which are extraordinarily thick and massive with heavily rugose surfaces. They appear on the proximal ends of the transverse processes of the fifth dorsal as well developed tubercles rapidly enlarging on the succeeding vertebræ into prominent projections having massive globular ends.

The transverse processes are heavy throughout the series and have expanded, concave distal ends except in the case of the first and last dorsals; the ends of the transverse processes of the tenth thoracic vertebra are the widest of the series.

The neural spines of the first six dorsals are directed forward, those of the seventh, eighth, and ninth are vertical, and the remainder directed backward.[2] The spines increase steadily in antero-posterior width from the first to the twelfth dorsal, which bears the widest spine in the entire vertebral column.

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[1] As noted above, this was not entirely true of the U. S. Nat. Mus. specimen in which the lower transverse processes of the seventh cervical were small.

[2] The spines of the first four dorsal vertebræ of the U. S. Nat. Mus. specimen are directed backward, the fifth, sixth and seventh upward and the remainder backward.

The centrum of the first thoracic is circular except for a slight dorsal flattening; the dorsal compression of the centra becomes more pronounced in the posterior members of the series.

Lumbar vertebræ.— The lumbar vertebræ present certain individual peculiarities in the spines and zygapophyses, by means of which they may be distinguished from those of other whales. The spines of the entire lumbar series are directed strongly backward, that of the ninth being the most oblique of the vertebral column; the backward direction of the spines in the posterior vertebræ of the series is much greater than in *Megaptera* and somewhat more than in *Balænoptera*. All of the spines are regularly convex distally and that of the seventh lumbar is the longest.

The zygapophyses are prominent and show, in a modified form, the expanded distal ends so characteristic of the dorsal vertebræ. Those of the anterior half of the lumbar series are directed outward so that they overhang the anterior faces of the centra more strongly than is usual. The spines and zygapophyses differ in numerous minor ways from those of other genera.

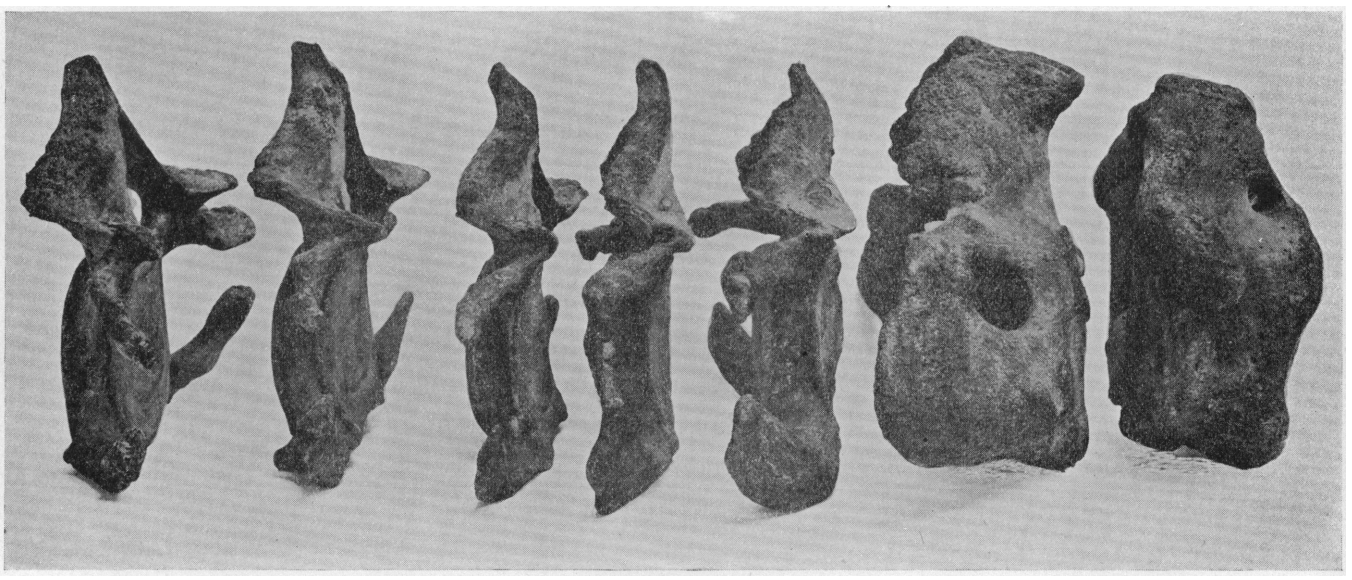


Fig. 8. Cervical vertebræ of *Rhachianectes glaucus*.

The transverse processes of the first four units of the lumbar series are curved somewhat upward, the fifth, sixth and seventh are horizontal, and those of the remaining vertebræ directed more or less downward. The transverse processes of the sixth lumbar are the longest.

Caudal vertebræ.— The caudal vertebræ do not agree closely with those of other baleen whales. In the size, shape, and direction of the transverse processes, spines and zygapophyses, and in the appearance and disappearance of the foramina and processes, many differences are apparent.

The spines decrease gradually in height from the first to the eleventh caudal where they become lost. The zygapophyses of the anterior caudal vertebræ in their expanded, globular distal ends resemble those of the dorsal series, and disappear with the neural spines upon the eleventh vertebra. The spines and zygapophyses show a decidedly greater resemblance to *Megaptera* than to *Balænoptera*.

The transverse process of the first caudal is the widest in the entire vertebral column and is directed strongly downward. The transverse process of the fourth, fifth and sixth caudals arise from the posterior part of the centra and project outward and forward, their inner edges almost meeting the expanded outer margins of the anterior faces of the centra; in this way a partially

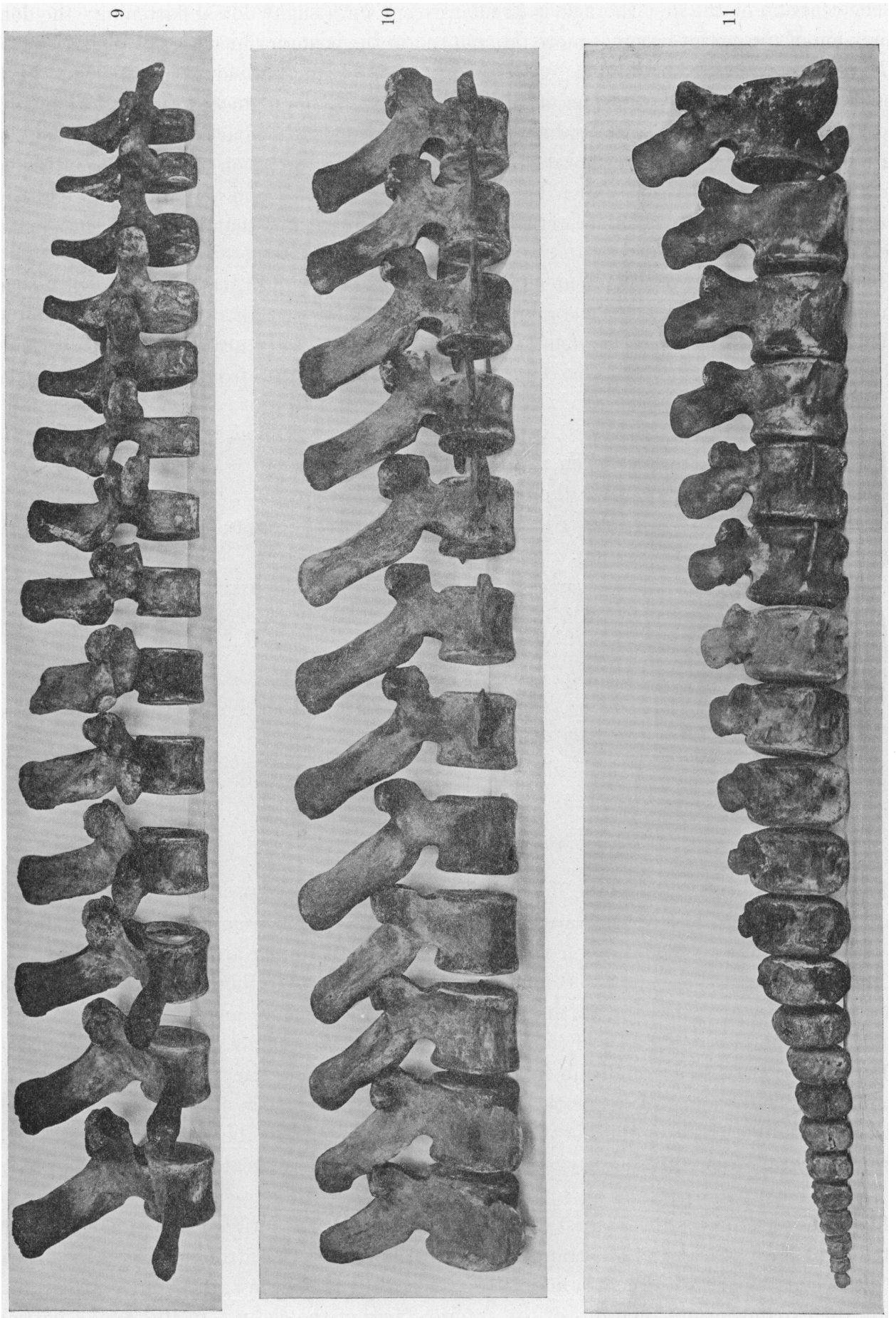


Fig. 9. Dorsal vertebræ of *Rhachianectes glaucus*.
Fig. 10. Lumbar " " " "
Fig. 11. Caudal " " " "

enclosed foramen is formed. On the right side of the sixth caudal this foramen is completely encircled [1] and the transverse process near the center is also perforated by a second vertical canal.

The antero-posterior diameter of the centrum of the first caudal is the greatest of the entire vertebral column and the anterior face is almost a perfect circle. Although the inferior median carina of the thirty-third vertebra is distinctly bifurcated posteriorly, the thirty-fourth is definitely indicated as the first caudal by the presence of the first pair of chevrons which have become firmly ankylosed to its centrum.

Beddard states that he counted in the British Museum specimen 14 lumbar vertebræ and 21 caudals, whereas both the American Museum and U. S. Nat. Mus. skeletons have 12 lumbars and 23 caudals. Since the total number of vertebræ, and also those of the dorsal series, are alike in the three specimens, I believe they will be found to possess a similar number of lumbar and caudal units. Unless the skeletons have been examined with the chevrons *in situ*, or there happens to be an ankylosis as in the case of our specimen, it is difficult to make an absolutely correct determination of the lumbar and caudal units. Although the inferior median carina is usually first distinctly bifurcated upon the first caudal, the division may sometimes occur upon the last lumbar and cannot, therefore, be taken as an infallible guide.

In the following table data as to the appearance and disappearance of the several processes and foramina in *Rhachianectes glaucus* is given. For convenience of reference similar data of other genera are placed in apposition.

	Rhachianectes glaucus		*Eubalæna glacialis*	*Megaptera nodosa*	*Balænoptera physalus*
	Am. Mus. Nat. Hist.	U. S. Nat. Mus.			
Last vertebra to bear a transverse process is No.	41	41	42	39	48
Last vertebra to bear a neural spine is No.	44	44	45	41	50
First vertebra with perforated transverse process is No.	39	38	39	—	43

Table VII.— Measurements of Vertebræ of Rhachianectes glaucus.

	mm.
Atlas, greatest breadth across transverse procesess	417
" " depth	312
" " breadth across condylar facets	317
" " depth of condylar facet	224
" breadth of condylar facet	124
" greatest depth of neural arch	69
" breadth of distal end of tr. proc.	109
Axis, greatest breadth across tr. proc.	662
" " depth	327
" " " of centrum	162
" " breadth " "	289
" " length of right tr. proc.	243
" length of foramen in tr. proc.	89

[1] This foramen does not become enclosed in the U. S. Nat. Mus. specimen.

Table VII.—Continued.

	mm.
5th cervical, breadth across upper tr. proc.	446
" " " " lower " "	528
" " greatest depth (vertical)	318
" " depth of centrum "	157
" " breadth of centrum	195
" " length of upper tr. proc.	130
" " " " lower " "	176
7th cervical, breadth across upper tr. proc.	434
" " " " lower " "	445
" " greatest depth (vertical)	329
" " " " of centrum	164
" " " breadth " "	189
" " " length of upper tr. proc.	135
" " " " " lower " "	135
1st dorsal, breadth across tr. proc.	460
" " greatest depth (vertical)	371
" " " " of centrum	166
" " " breadth of centrum	214
" " length of tr. proc.	155
" " " " spine	94
5th " breadth across tr. proc.	—
" " greatest depth (vertical)	445
" " " " of centrum	175
" " " breadth " "	210
" " " length of tr. proc.	173
" " " height of spine	184
10th " " breadth across tr. proc.	636
" " " depth (vertical)	496
" " " " of centrum	174
" " " breadth " "	227
" " " length of tr. proc.	243
" " " greatest height of spine	259
1st lumbar, breadth across tr. proc.	831
" " greatest depth (vertical)	542
" " " " of centrum	186
" " " breadth " "	229
" " " length of tr. proc.	340
" " " height of spine	323
5th " breadth across tr. proc.	886
" " greatest depth (vertical)	600
" " " " of centrum	206
" " " breadth " "	240
" " " length of tr. proc.	340
" " " height of spine	363
10th " " breadth across tr. proc.	780
" " " depth (vertical	580
" " " " of centrum	225
" " " breadth " "	265
" " " length of tr. proc.	285
" " " height of spine	363
1st caudal, " breadth across tr. proc.	665
" " " depth (vertical)	535
" " " " of centrum	243
" " " breadth " "	274
" " " length tr. proc.	230
" " height of spine	265

Table VII.— Concluded.

			mm.
5th caudal,		breadth across tr. proc.	468
"	"	greatest depth (vertical)	465
"	"	" " of centrum	270
"	"	breadth " "	281
"	"	length tr. proc.	115
"	"	height of spine	210
10th	"	breadth across tr. proc.	275
"	"	depth (vertical)	330
"	"	" of centrum	258
"	"	breadth " "	275
"	"	length of tr. proc.	—
"	"	height of spine	83

Chevrons.

The American Museum skeleton has twelve chevrons and the National Museum ten; apparently two have been lost in the latter case and twelve would seem to be the normal number.

The first chevron in the American Museum series is firmly ankylosed to the centrum of the first caudal vertebra. It is 75 mm. in length, 118 mm. wide and free distally. The second chevron is 180 mm. long and 91 mm. wide, the laminæ uniting distally to form a long hæmal spine. The third chevron is the longest of the series, having a maximum length of 240 mm. and a width of 120 mm.

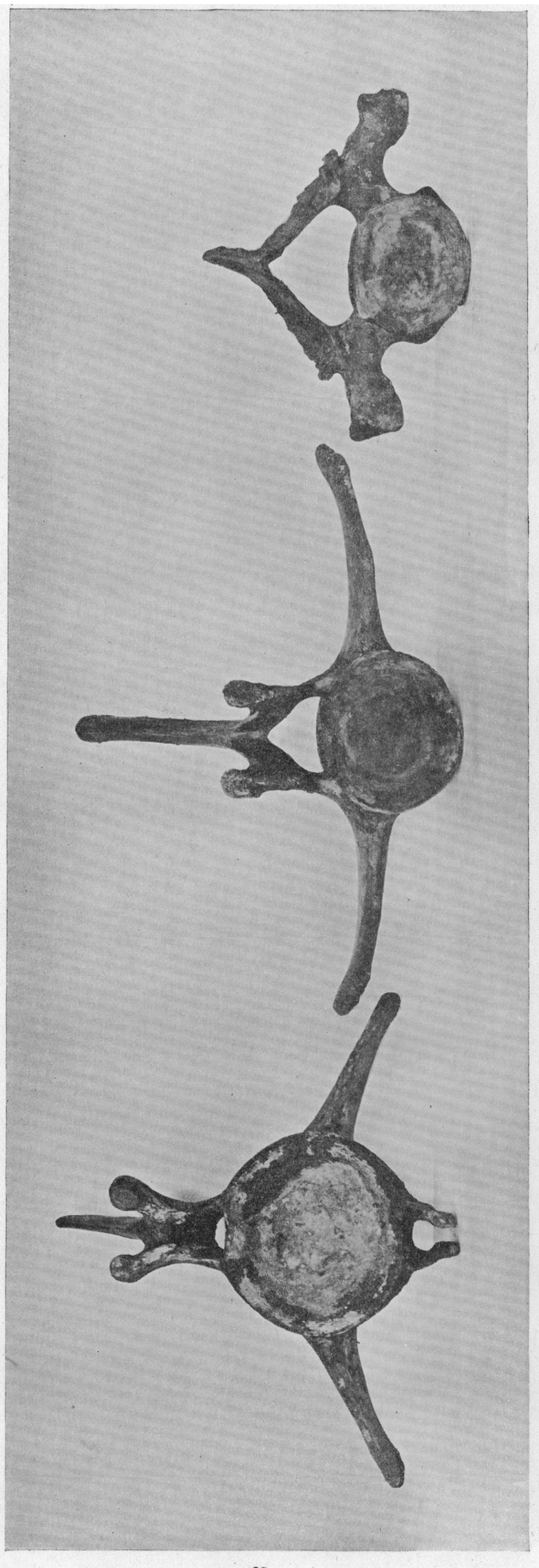
From the third backward, the chevrons increase rapidly in width and gradually decrease in length, the fifth being the widest of the series; its maximum width is 212 mm. The last two members of the series have their distal ends free.

Ribs.

The ribs of *Rhachianectes* are exceedingly interesting. The most important feature of their morphology is to be seen in the proximal ends of the third, fourth, fifth, sixth, and seventh, *on each of which a large tubercle, neck and head are developed.* The prominent tubercle, and the deep concavity between it and the head in all of these ribs gives them a shape very similar to those of the toothed whales and quite unlike any Mystacoceti.

In *Balænoptera* the second and third ribs usually have prominent tubercles and long necks while in the remainder of the series the necks and heads become atrophied, or lost. In *Rhachianectes* the necks and heads do not disappear until the *eighth rib* and up to this point are well developed and prominent. Thus the anterior half of the rib series is articulated to the vertebral column much more firmly than in other baleen whales, and presumably the thorax is capable of less lateral movement.

The proximal end of the first rib is thin and rounded but has a small, outwarding projecting tubercle (the head) near the lower edge. On the second rib this tubercle (the head) is more thoroughly developed, and on the third has become extended into a long neck and an expanded head which project outward at a right angle to the remainder of the rib. The tubercle is very prominent and has a large flattened articular fossa. On the fourth rib the neck is slightly shorter than that of the third and the angle it forms with the shaft is a little wider; its tubercle, however, is considerably larger than that of the third.



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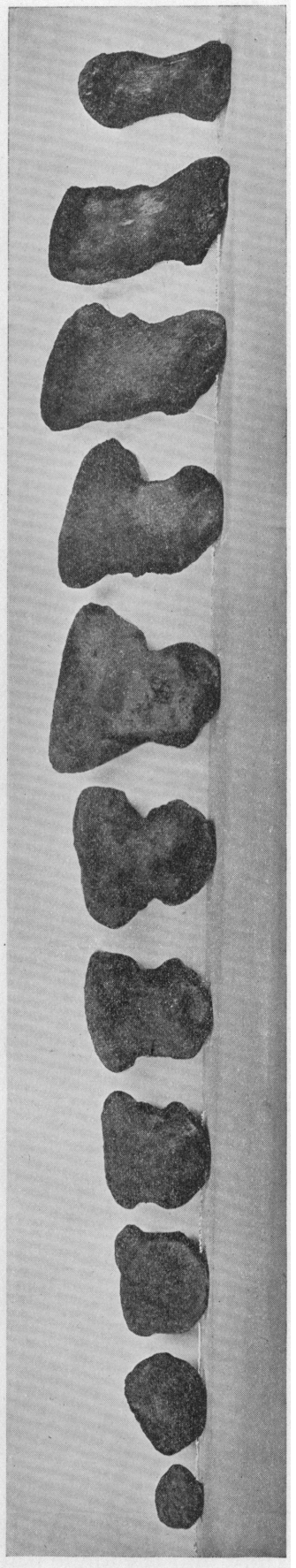

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Fig. 12. First dorsal, first lumbar and first caudal vertebræ of *Rhachianectes glaucus* (right to left).
Fig. 13. Chevrons of *Rhachianectes glaucus*.

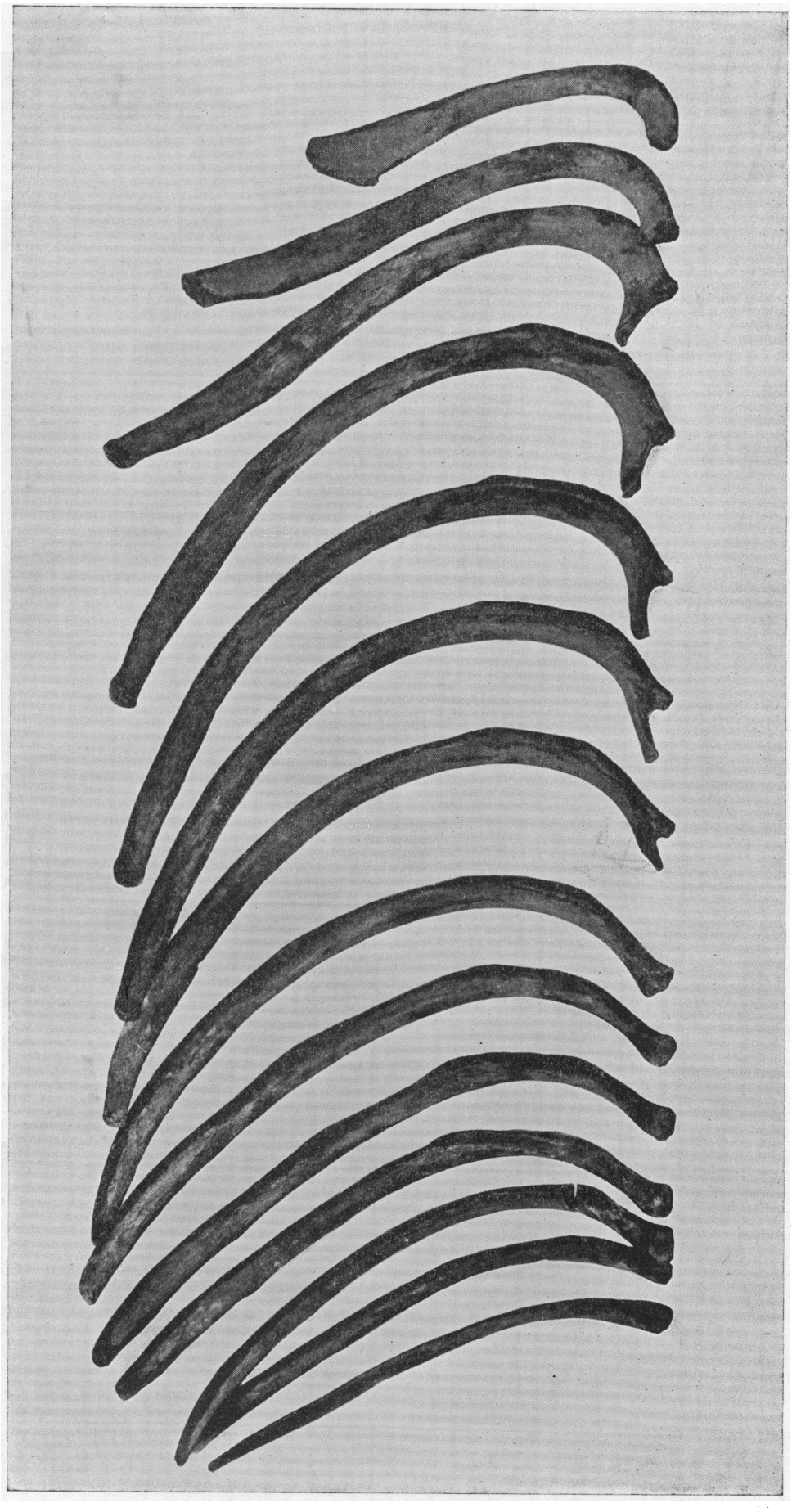

Fig. 14. Ribs of *Rhachianectes glaucus*.

The neck of the fifth rib is shorter and forms a wider angle with the shaft than does the fourth, but its tubercle is larger and more prominent and the concavity of the neck between it and the capitulum is deeper.

The neck of the sixth rib is similar to the fifth in length, size of tubercle and the angle with the shaft. That of the seventh is a little shorter than the sixth, the angle is somewhat wider and the tubercle a little larger.

Upon the eighth rib the neck and head disappear and are represented only by a small projection; the tubercle of the rib is greatly enlarged, however, and is separated from the process representing the neck by a well-marked concavity, which is present to a less extent upon all the succeeding ribs except the last two pairs.

The ribs are all long and massive, considerably exceeding in measurements those of the 40-foot *Megaptera* and the 50-foot *Balænoptera physalus* recorded by Struthers.[1]

The first is of uniform width in its proximal half but rapidly expands in the distal portion where it becomes the widest of the series; the fifth is the longest.

The ribs of the U. S. National Museum specimen differ in the important particulars that upon the first the portion representing the neck and head is considerably more produced than in the American Museum skeleton and that *the second rib bears a fully developed neck and head;* the distance from the tubercle to the end of the head of this rib is 225 mm.

Measurements of the ribs and of the capitular processes of the first eight pairs are given in the appended table:

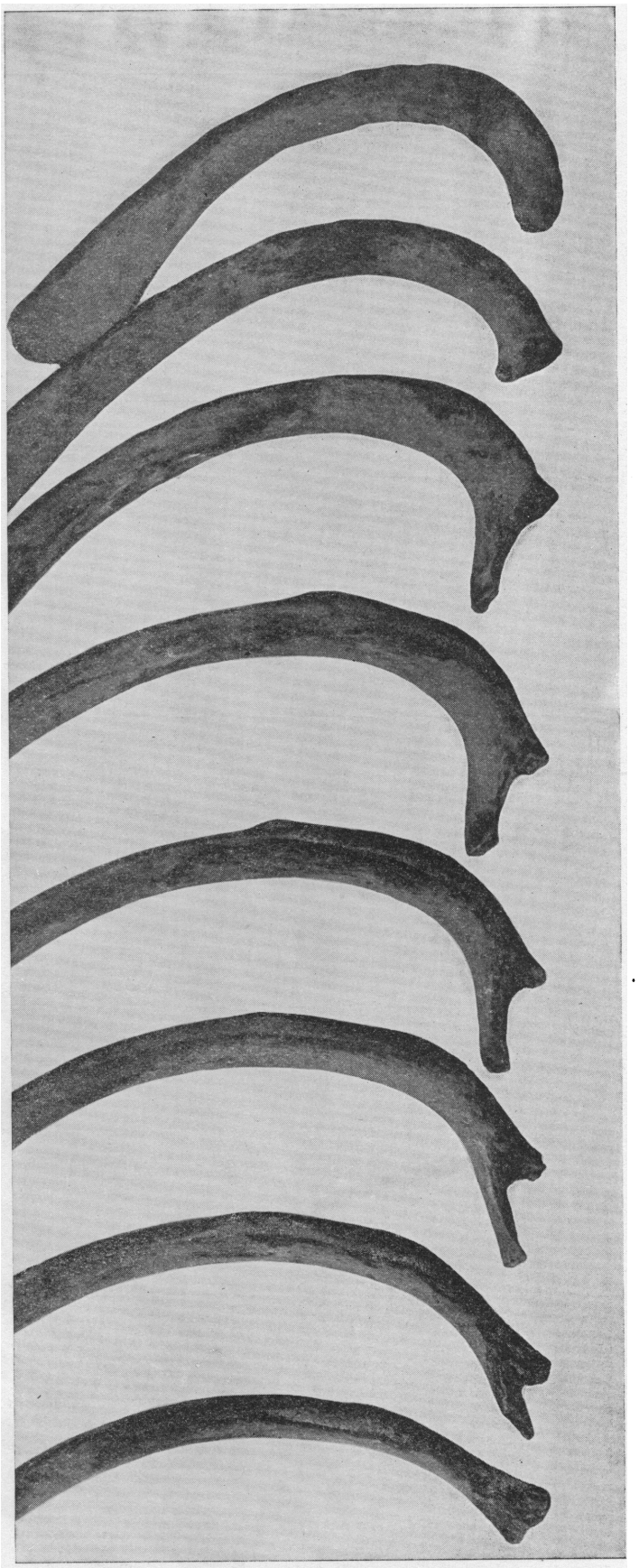

Fig. 15. Proximal portions of first eight ribs of *Rhachianectes glaucus*.

[1] Journal of Anatomy and Physiology, Vol. XXIII (new ser. Vol. III), 1889, p. 143.

Table VIII.—Measurements of the ribs of Rhachianectes glaucus.

	1st	2nd	3rd	4th	5th	6th	7th	8th	14th
Length on outside curve from tip of head to distal end	mm. 1400	mm. 1855	mm. 2255	mm. 2455	mm. 2515	mm. 2490	mm. —[1]	mm. 2335	mm. 1430
Length, straight, from tubercle to distal end	1020	1335	1590	1700	1785	1750	1765	1725	1370
Distance from back of tubercle to end of head	—	125	251	233	213	213	—[1]	110	—

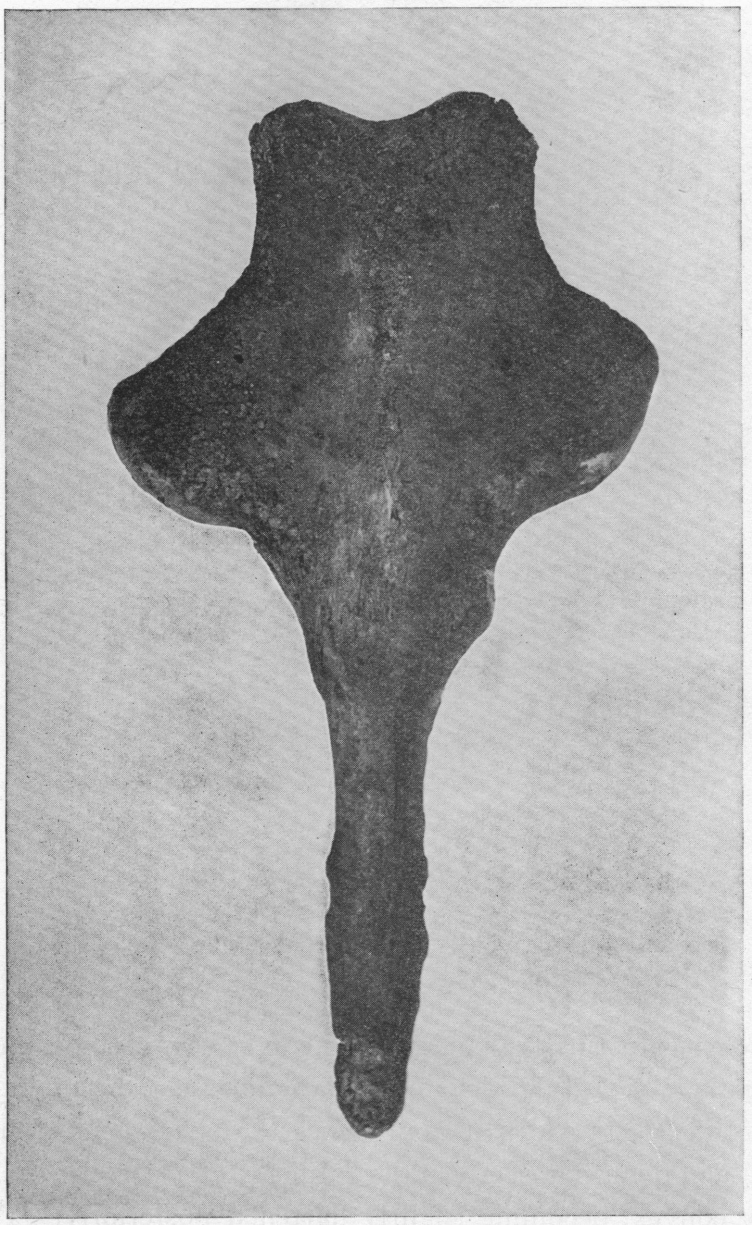

Fig. 16. Sternum of *Rhachianectes glaucus;* Am. Mus. skeleton.

Sternum.

The sternum belonging to the skeleton of *Rhachianectes* in the American Museum has the form of a Latin cross and closely resembles the corresponding bone of *Balænoptera acuto-rostrata*. The lateral arms of the cross are short and irregularly rounded and the summit of the superior portion is abruptly truncated and has a shallow concavity. The inferior prolongation of the sternum is irregularly cylindrical terminating in a blunt point, and is remarkable for its length. The entire sternum, but especially the anterior surface, is rugose and covered with small osseous tubercles which apparently are not due to exostosis but have been developed for tendon attachments.

The sternum of the United States National Museum specimen shows an extraordinary difference in shape from that described above and demonstrates the enormous individual variation to which such almost rudimentary bones are subject. The sternum is concave on the superior surface, has two rounded, wing-like lateral processes and terminates inferiorly in a short irregular spine.

[1] End of neck injured.

Measurements of sternum.

	American Museum	U. S. Nat. Museum
	mm.	mm.
Greatest height (vertical)	460	223
" breadth (across arms)	260	242
Length of lower process	276	165

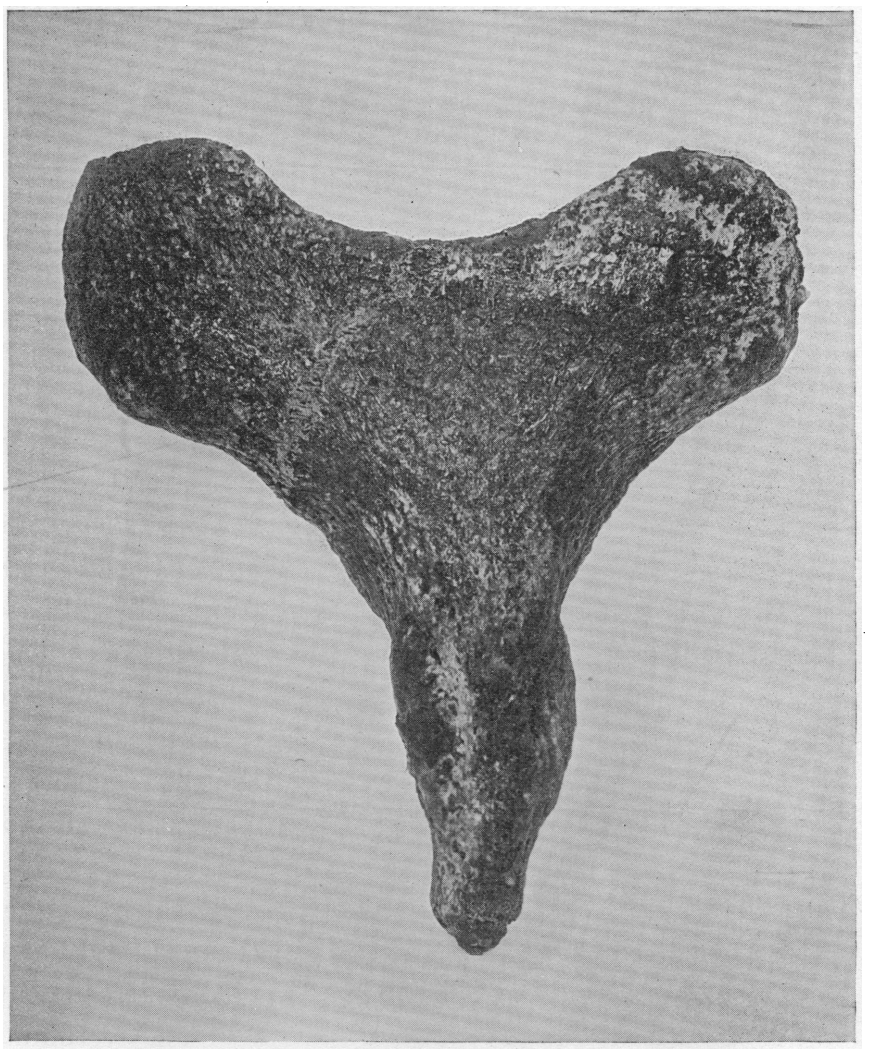

Fig. 17. Sternum of *Rhachianectes glaucus;* U. S. Nat. Mus. skeleton.

Pectoral Limb.

Scapula.— The scapula of *Rhachianectes* is distinctive being intermediate between the wide, low blade of *Balænoptera* and the high, narrower and more symmetrically fan-shaped scapula of *Eubalæna.* In the great height proportional to its width it approaches the latter genus while in the well developed coracoid and large acromion it resembles the former.

The superior margin is quite evenly convex, becoming slightly flattened posteriorly. The glenoid border is almost straight except for a short concavity where it rises from the glenoid fossa and neither it nor the coracoid border overhangs as strongly as in the scapulæ of *Balænoptera.*

The acromion is exceedingly wide throughout, expanded and irregularly rounded distally, and slightly curved.

The coracoid is thick and massive, turned sharply inward and directed somewhat upward from the margin of the glenoid fossa.

The external face of the scapula is quite strongly concave as in *Eubalæna*. It is much thicker and more massive than in *Balænoptera* but not as thick as that of a Right Whale.

Measurements of the scapula are given in Table IX.

Humerus. — The humerus is nearly straight, the superior edge is but slightly concave and the external tuberosity is prominent. In all of these characters the humerus differs from that of *Balæna*, *Eubalæna* and *Megaptera* and strongly resembles the fossil genus *Plesiocetus*; while in *Balænoptera* the head is almost directly upon the summit of the bone, the concavity of the sides gives the humerus quite a different appearance from that of *Rhachianectes*.

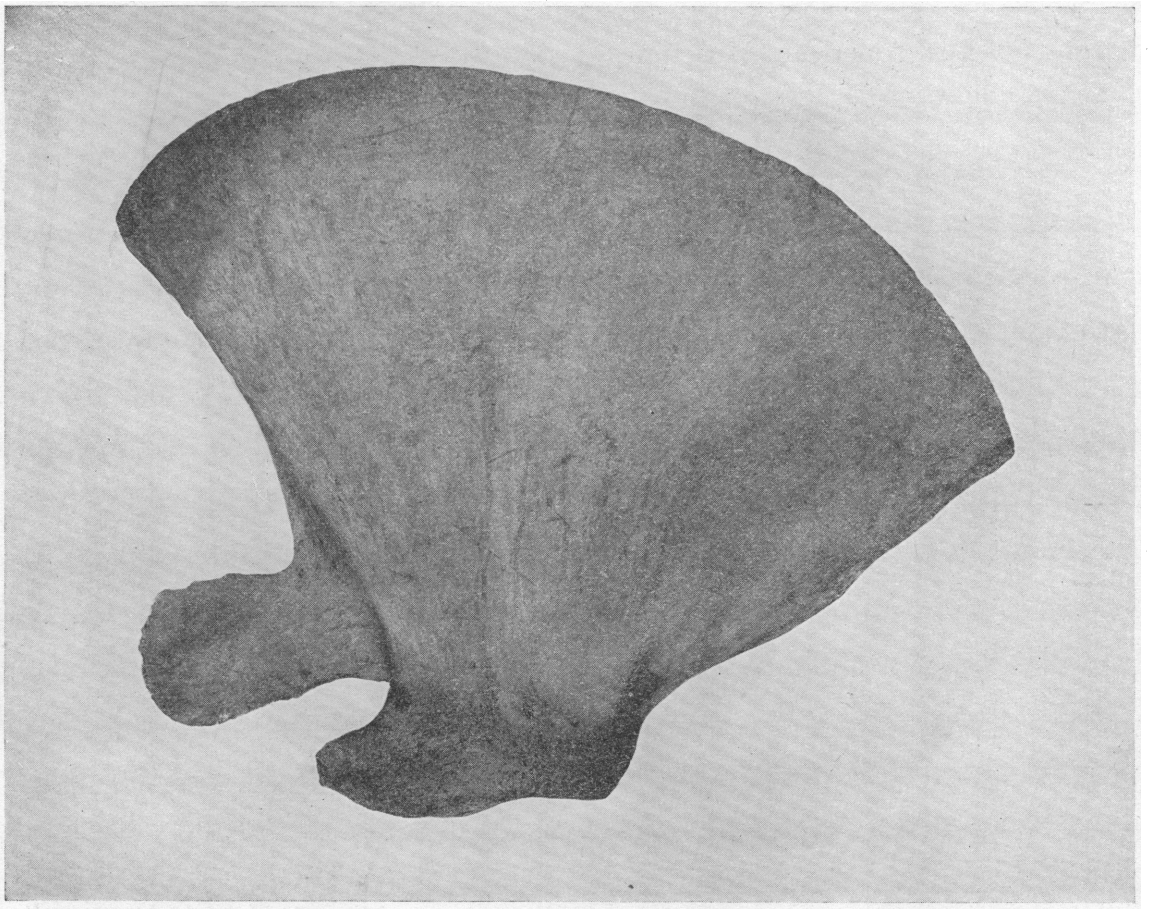

Fig. 18. Inner view of right scapula of *Rhachianectes glaucus;* Am. Mus. skeleton.

Radius.— The radius is remarkable for its width. The exterior edge for its proximal half is slightly convex and in the distal portion a little concave. The interior edge presents a shallow concavity due to the broadening of the bone at the carpal end. For the proximal half the radius is of almost uniform width but in the distal half rapidly expands.

Ulna.— The ulna has a nearly straight inner edge but a strongly concave outer margin due to the rapid broadening of the bone in the distal half. The olecranon process is prominent and projects upward.

The radius and ulna differ markedly from those of *Balæna*, *Eubalæna* and *Megaptera* but in general resemble *Balænoptera*. The broad radius is somewhat similar to that of *B. musculus* but the straight ulna is quite unlike the bone in that species. The radius and ulna of *B. physalus* and *B. borealis* are more slender, more curved and less expanded distally than in *Rhachianectes glaucus*.

Manus.— *Rhachianectes* has four digits in the manus. The phalangeal formulæ of the flippers of the U. S. National Museum specimen (which are more nearly perfect than are those of the American Museum skeleton) are as follows:

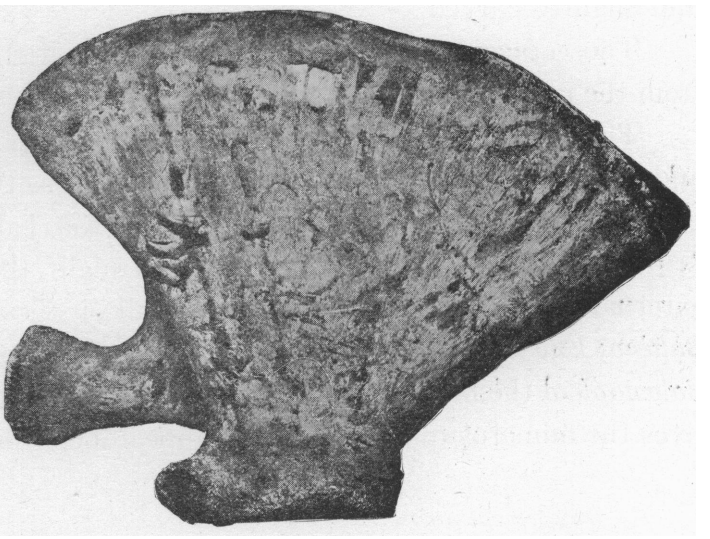

Fig. 19. Inner view of right scapula of *Rhachianectes glaucus*, photographed at Ulsan, Korea.

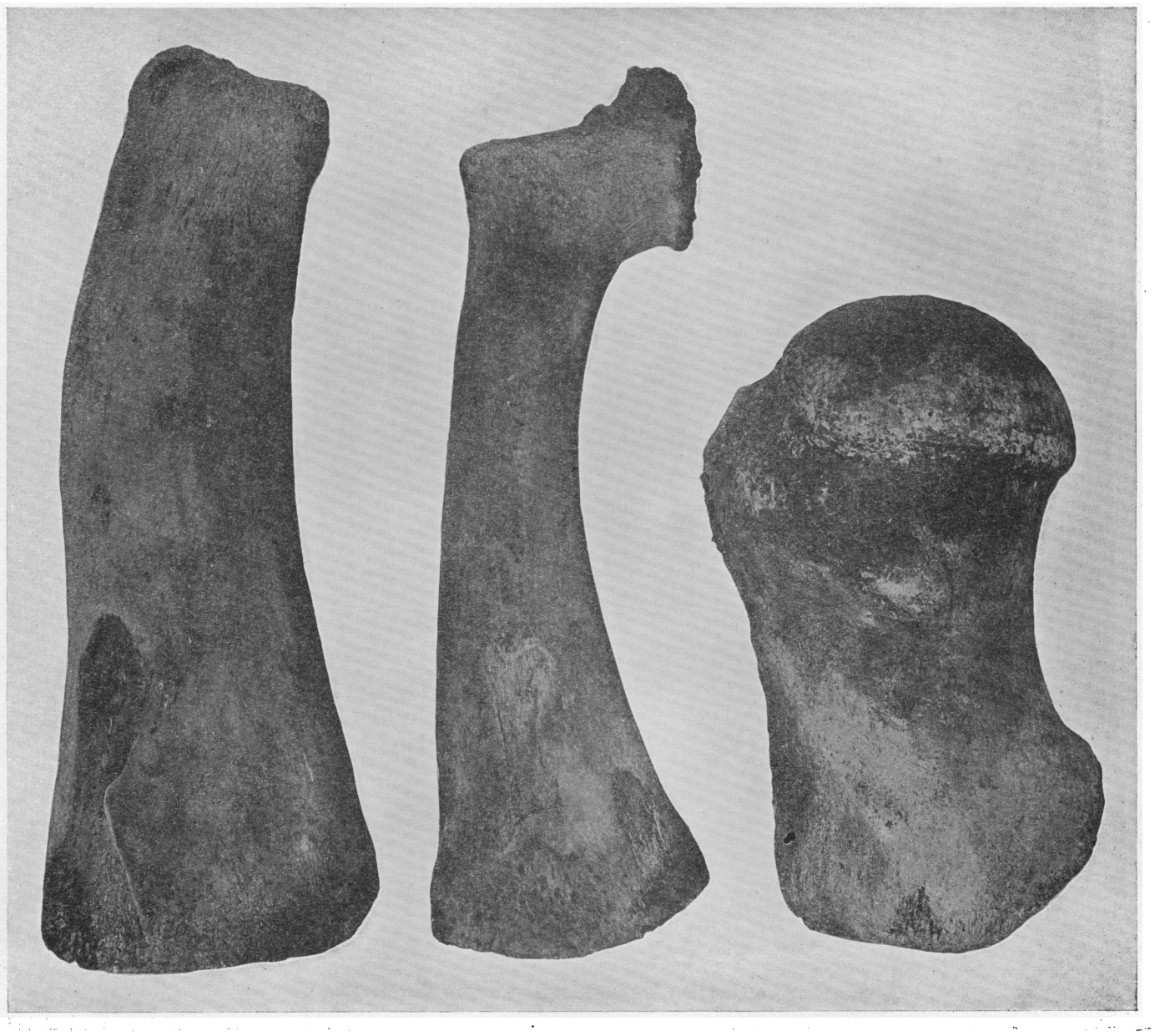

Fig. 20. Humerus, radius and ulna of *Rhachianectes glaucus;* Am. Mus. skeleton.

	II	III	IV	V
Right:	3	3	4	1
Left:	3	4	4	1

The terminal phalanx of the third digit of the left pectoral is a shell of bone and seems to be a normal phalanx which has been injured. This has all the appearance of bony tissue and not of hardened cartilage but it is not present in the right manus. Presumably the tips of both flippers were injured and the correct formulæ for the phalanges is that of the left. The terminal phalanx of the fourth digit of the right manus is also a bony shell but in the corresponding finger of the left hand it has a normal shape and size.

Table IX.—Measurements of Pectoral Limb of Rhachianectes glaucus.

	Am. Mus., No. 34260 mm.
Scapula, greatest height (vertical)	856
" " breadth	1125
" length acromion (inferior edge)	335
" breadth " distally	180
" length coracoid (inferior edge)	146
" breadth glenoid fossa	268
Radius, greatest length	750
" " breadth proximally	183
" " " distally	265
Ulna, greatest length	758
" " breadth proximally	222
" " " distally	226
Humerus, greatest length	520
" " breadth proximally	316
" " " distally	282

Pelvic Rudiments.

The pelvic elements of *Rhachianectes* are exceedingly interesting, the most remarkable features in comparison with other whales being their great size, the less reduction of the pubis and ischium, and the presence of a large foramen.

Those of the American Museum skeleton are two long, slightly curved bones of exactly the same length. The ilium is exceedingly massive, laterally compressed, and has a long dorsal and ventral ridge; a cross-section would be a wide ellipse. The ischium has the same length as the ilium but it is not as massive, is more compressed, and is deeply excavated at the distal end.

The pubis appears as a prominent, roughly cone-shaped tubercle, turned sharply downward and standing at right angles to the remainder of the bone instead of projecting directly outward as in other baleen whales.

Along the inner base of the pubis is a deep longitudinal concavity in the bottom of which, and slightly posterior to the pubis, is a large curved foramen which perforates the bone transversely, emerging on the dorsal surface almost opposite the point of entrance.

Although both the American and U. S. National Museum specimens from which the pelvic elements were secured were males, there is considerable variation in the size and shape of the bones in the two individuals. Those of the U. S. National Museum skeleton are shorter, due to a reduction of the iliac portion, wider through the pubis, slenderer throughout and more

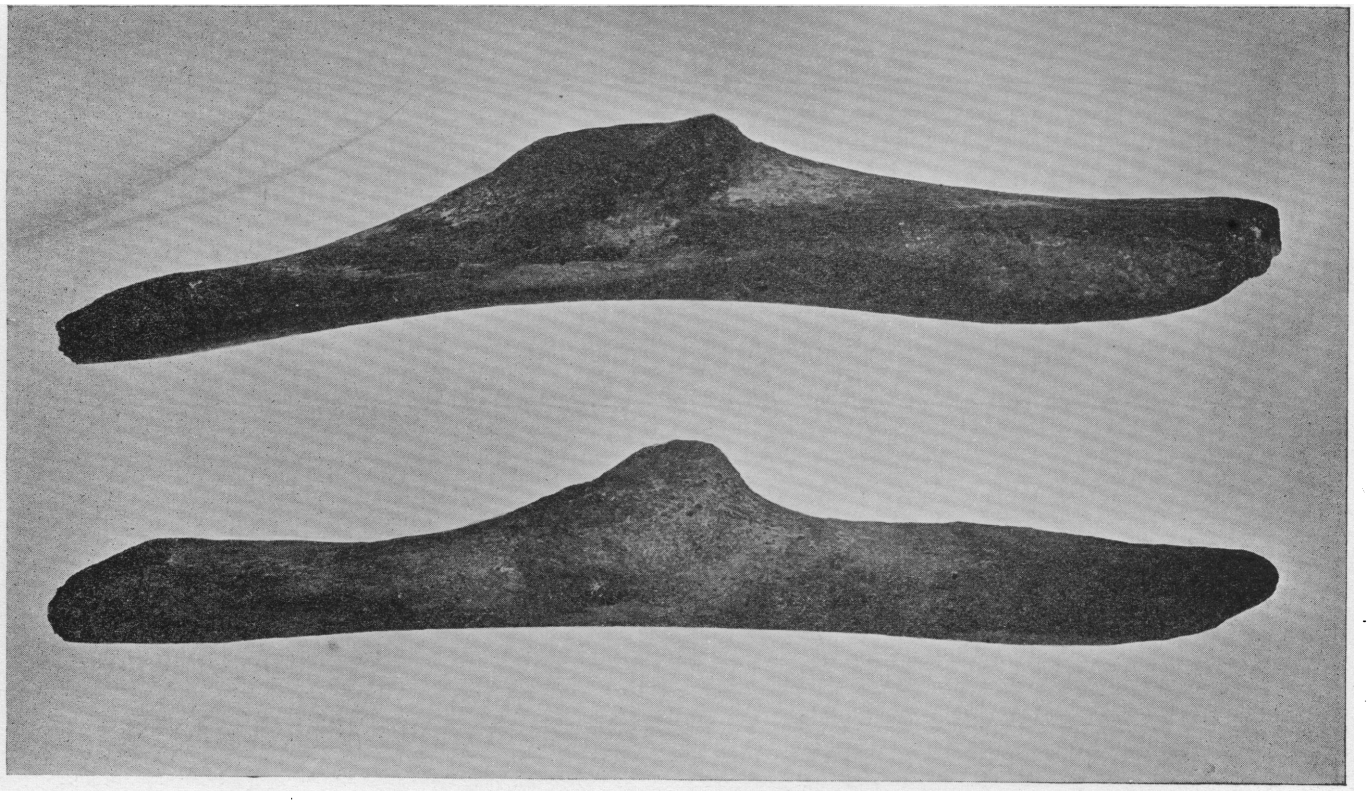

Fig. 21. Pelvic elements of *Rhachianectes glaucus;* Am. Mus. skeleton.

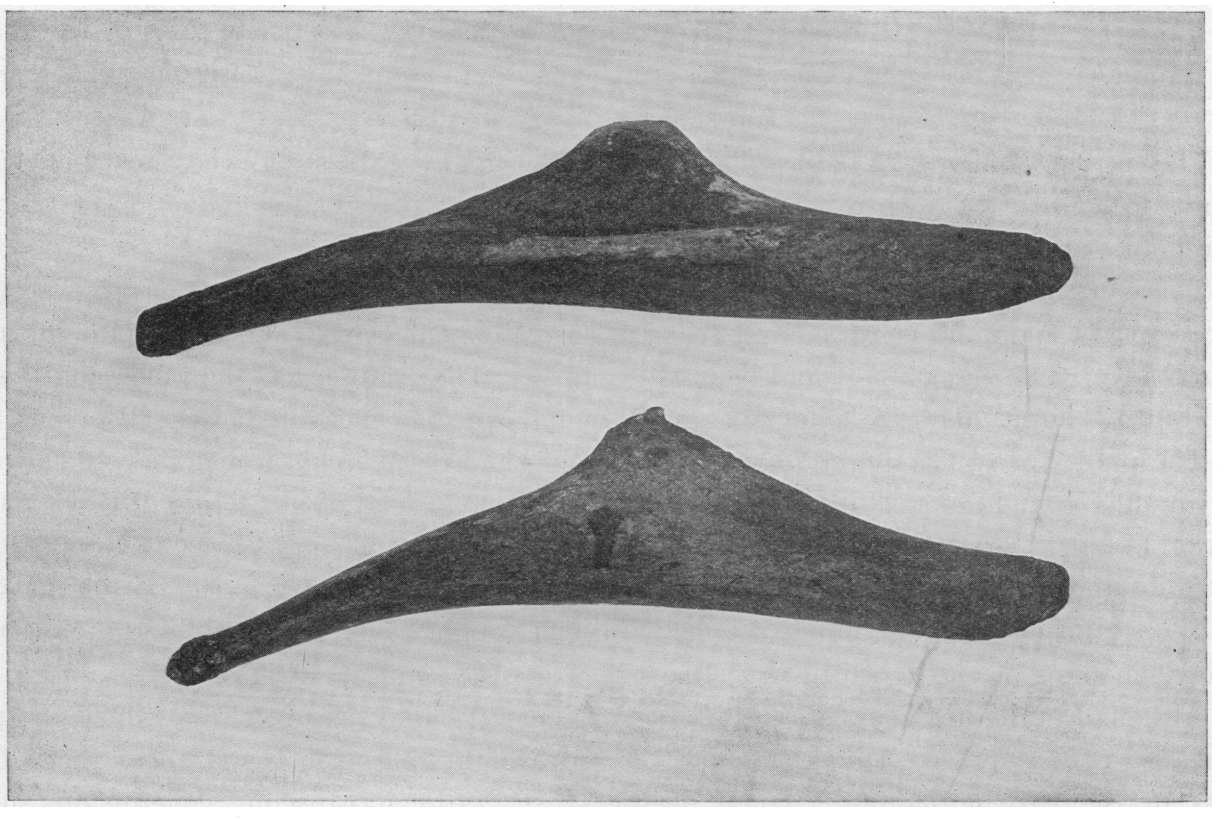

Fig. 22. Pelvic elements of *Rhachianectes glaucus;* U. S. Nat. Mus. skeleton.

curved. In both the ilium is considerably shorter than the ischium, the pubis is not turned as sharply downward as in the American Museum specimen, and the transverse foramen is larger; also there is no excavation of the distal end of the ischium.

The presence of a foramen perforating the pelvic rudiment has been recorded by Struthers in the case of *Balæna mysticetus* but it is rare in other Cetaceans.

It is to be regretted that it was not possible to make a careful examination of the flesh containing the pelvic elements to determine the condition of the femoral rudiments. I believe that *Rhachianectes* will be found to possess a femur larger than that of any other baleen whale when this subject has been more carefully investigated.

Measurements of the pelvic elements.

	American Museum mm.	U. S. Nat. Museum mm.
Length of entire pelvis	501	439
" " ilium	258	210
" " ischium	258	259
Breadth of ilium	74	62
" " ischium	53	49
" across pubis	75	100

CONCLUSIONS.

Specific relationship of California and Korea specimens of Rhachianectes.

Descriptions and measurements of the external anatomy and post-cranial skeleton of California examples of *Rhachianectes* are so general and inaccurate that they furnish few reliable data for use in deciding the specific relationship of the specimens from opposite sides of the Pacific. A discussion of this question, therefore, must rest almost entirely upon the basis of skull characters.

A careful comparison with our Korea specimen of the figures, descriptions and measurements of the American skulls presented by True and Malm shows a remarkably close agreement in all essential points. Examination of the table of measurements shows the only difference worthy of note to be in the proportionately shorter rostrum of the California skull and its less squamosal breadth. Judging from the figures the former difference seems to be due to the fact that the slender prolongations which the maxillæ send backward toward the vertex of the skull are somewhat broken, thus reducing the rostral length. The proportional squamosal breadth of the California skull is somewhat less than in the one from Korea, but since the orbital widths are almost exactly the same, this cannot be considered as of great importance.

There is, so far as I can discover, not the slightest ground for believing the Gray Whales of the east and west Pacific to represent other than a single species. Whether or not the animals mingle in the north during their summer migration has been discussed in the section of this paper relating to habits and need not be again taken up here.

Systematic Position.

Review of former classifications.

1871.— J. E. Gray places *Rhachianectes* in the family Agaphelidæ.

1874.— Gill makes Agaphelidæ of Gray a subfamily under Balænopteridæ and divides that family into the three subfamilies Agaphelinæ, Balænopterinæ and Megapterinæ.

1891.— Flower and Lydekker combine all genera under the family Balænidæ without subfamily divisions.

1897–1904.— Trouessart gives two subfamilies, Balænopterinæ and Balæninæ, under the family Balænidæ and includes *Rhachianectes* in the former.

1900–1902.— Beddard considers *Rhachianectes* as an aberrant genus of the family Balænopteridæ.

1901–04–05.— Elliot recognizes two subfamilies of the Balænidæ and in the Balæninæ includes *Balæna*, *Rhachianectes* and *Megaptera*.

1904.— Max Weber recognizes three families, Rhachianectidæ, Balænidæ and Balænopteridæ.

1910.— Osborn, under the family Balænidæ, recognizes the three subfamilies Rhachianectinæ, Balæninæ and Balænopterinæ.

It will be seen from this brief review of the various classifications of the genus *Rhachianectes* that there has been little agreement as to its systematic position. This is partly due to the fact that up to the present time only the skull has been studied, the post-cranial skeleton never having been described. The results of my work upon this remarkable animal, presented in the preceding pages, lead me to believe that it cannot be included in either of the subfamilies of the Balænidæ and must take rank as a separate family. For this designation Weber's Rhachianectidæ is available and a definition of the family and genus may be formulated as follows:

Family *Rhachianectidæ*.— Skull with a broad strip of the frontals exposed upon the vertex. Maxillæ overlapping the anterior edges of the orbital processes of the frontals. Nasals very long and broad. Mandible without a coronoid process. Cervical vertebræ free. Manus consisting of four digits. Ribs of the anterior half of the series provided with tubercles, necks and heads. Furrows few and short.

Genus *Rhachianectes*.— Head less than one-fourth the length of the body. Baleen laminæ few, short, and thick. No dorsal fin. Pectoral limbs of medium width. Furrows only upon the throat. Rostrum of skull narrow and moderately arched. Premaxillæ sending broad, overlapping projections toward vertex of skull. Prominent rugosities upon the supraoccipital and basioccipital bones of the skull. Tympanic bullæ compressed and somewhat concave on internal border. Scapula having both acromion and coracoid processes.

Primitive Characters of Rhachianectes.

The external and internal anatomy of *Rhachianectes glaucus* presents certain characters which seem to demonstrate that this animal is more primitive than any other existing baleen whale. These may be summarized as follows:

1. Long hairs scattered over the entire head and mandible and not confined to certain regions as in other whales.

2. Baleen plates very short, thick, fewer in number and more widely spaced than in other whales.

3. Skull:

a. Exposure of a wide strip of the frontals upon the vertex of the skull.

b. Long nasal bones.

c. Comparatively small squamosals having straight outer edges. This is noticeably different from the concave squamosals of existing baleen whales and is a character of fossil genera.

d. Proximal ends of the premaxillæ very broad, superiorly placed, and articulate with the frontals by a deep, interdigitating suture.

e. Orbital processes of the frontals anteriorly overlapped by the edges of the maxillæ, posteriorly with irregular margins, and trumpet-shaped; all well marked characters of certain fossil baleen whales.

f. A well emphasized temporal ridge.

g. Prominent rugosities upon the supraoccipital, pterygoids, and basioccipital bones of the skull.

h. Compressed tympanic bullæ having concave internal borders.

4. Cervical vertebræ entirely free and showing no evidences of ankylosis between any members of the series.

5. Atlas and axis possessing massive, rugose neural arches; axis with comparatively small foramina through the wing-like transverse processes.

6. Ribs possessing tubercles, necks and heads as far back as the eighth, and in these portions resembling an Odontocete.

7. A long and straight humerus of the *Plesiocetus* type.

8. Very large pelvic elements, the presence of a large foramen in them and the comparatively slight reduction of the pubis and ischium.

Relationship of Rhachianectes.

Rhachianectes glaucus is apparently not closely related to any of the existing baleen whales but in some respects it stands intermediate between the Balæninæ and Balænopterinæ being nearer the latter. In many skull characters it approaches closely the Pliocene whales of the genus *Plesiocetus* which is allied to the existing Balænopterinæ; in fact, were it not for its specialized mandible it must certainly be considered as nearly related to them. The fossil whales of the *Pleisiocetus* group possessed mandibles having the proximal portion of each ramus, internally, widely concave and leading into a large dental canal; in short, much as in the mandibles of the existing toothed whales. *Rhachianectes*, however, although resembling *Plesiocetus* in many important skull characters, possesses a specialized mandible similar to that of the Right Whales; that is the proximal portion, internally, is not concave and the dental canal is small. This type of mandible prevents the phylogenist from taking *Rhachianectes* off from the *Plesiocetus* group, unless he wishes to consider that while persisting until the present day with comparatively little modification of its primitive skull characters, it has undergone considerable specialization of the mandible alone. This is a perfectly possible supposition, which I am inclined to believe is true, since *Rhachianectes* shows such marked affinities to *Plesiocetus* and is so strongly separated from the other known genera of fossil and recent whales. It is, upon the whole, one of the most remarkable of existing Cetaceans and might be called a "living fossil."

ILLUSTRATIONS.

PLATES.

Plate XIX.

Fig. 1. Lateral view of peduncle showing white markings, mostly cirriped scars.
Fig. 2. Lateral view of peduncle showing normal gray and white markings and total absence of cirriped scars.
Fig. 3. Head, pectoral fin and section of back blubber.
Fig. 4. Direct lateral view of peduncle showing dorsal crenulations.
Fig. 5. Dorsal view of peduncle showing normal gray markings and flukes.
Fig. 6. Peduncle lying upon the wharf.
Fig. 7. Posterior portion of body showing inferior outline.

Plate XX.

Fig. 1. Direct lateral view of head showing few parasite scars.
Fig. 2. Three-quarters posterior view of head showing many parasite scars.
Fig. 3. Dorsal view of head and blowholes; note the barnacles *Cryptolepas rhachianecti* embedded in the skin, and the masses of *Cyamus scammoni*.
Fig. 4. Front view of head.
Fig. 5. Direct lateral view of head and mandible of fœtus No. 1*a*.
Fig. 6. Section of peduncle showing normal gray and white markings.

Plate XXI.

Fig. 1. Eye and ear.
Fig. 2. Inner view of baleen.
Fig. 3. Blowholes and *Cyamus scammoni*.
Fig. 4. Three-quarters view of tongue.
Fig. 5. Lateral view of anterior portion of snout showing cornified areas due to the action of parasites.
Fig. 6. Inferior view of anterior portion of snout.
Fig. 7. Fœtus No. 1*a*.

Plate XXII.

Fig. 1. Throat showing two grooves.
Fig. 2. " " " "
Fig. 3. " " three "
Fig. 4. " " " "
Fig. 5. " " " "
Fig. 6. Tongue in position.

Plate XXIII.

Fig. 1. Superior surface of uninjured pectoral fin.
Fig. 2. Pectoral fin injured and infested with parasitic *Cyamus scammoni*.
Fig. 3. Superior surface of slightly injured pectoral fin.
Fig. 4. Inferior surface of pectoral fin showing usual type of coloration (slightly injured).
Fig. 5. Inferior surface of pectoral fin.
Fig. 6. " " " " "
Fig. 7. " " " " " (injured).
Fig. 8. " " " " " "

Plate XXIV.

Fig. 1. Flukes showing barnacle scars; posterior edges slightly injured.
Fig. 2. Flukes; posterior edges very slightly injured.
Fig. 3. Posterior edge of flukes.
Fig. 4. Peduncle of fœtus No. 1*a*.
Fig. 5. Section of blubber at end of peduncle crenulations ("hump").
Fig. 6. Gray Whale spouting blood.
Fig. 7. Normal spout of a Gray Whale.

Plate XXV.

Fig. 1. Dorsal view of the skull from California in the U. S. National Museum.
Fig. 2. Dorsal view of the skull from Korea in the American Museum.

Plate XXVI.

Fig. 1. Ventral view of the skull from California in the U. S. National Museum.
Fig. 2. Ventral view of the skull from Korea in the American Museum.

Plate XXVII.

Fig. 1. Lateral view of the skull from California in the U. S. National Museum.
Fig. 2. Lateral view of the skull from Korea in the American Museum.
Fig. 3. External side of left ramus of mandible; Korea specimen in the American Museum.
Fig. 4. Internal side of left ramus of mandible; Korea specimen in the American Museum.

TEXT FIGURES.

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