Phoca wymani and Other Tertiary Seals (Mammalia: Phocidae) Described from the Eastern Seaboard of North America

CLAYTON E. RAY

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ABSTRACT

Ray, Clayton E. *Phoca wymani* and Other Tertiary Seals (Mammalia: Phocidae) Described from the Eastern Seaboard of North America. *Smithsonian Contributions to Paleobiology,* number 28, 36 pages, 3 figures, 11 plates, 1976.—Fossil seal remains from Richmond, Virginia, first reported by Wyman in 1850, and named *Phoca wymani* by Leidy in 1853, have been neglected and unjustifiably regarded as cetacean by most subsequent authors. Recently recognized parts of the holotype and other material, in part recently collected in Richmond, show that the species is a monachine seal, here called *Monotherium? wymani* (Leidy, 1853a). It is derived from Miocene beds that are definitely older than the Yorktown Formation and probably correlative with the Calvert Formation of Maryland. Thus *Monotherium? wymani* is probably the oldest known monachine. Other evidence of fossil phocids in eastern North America is reviewed.

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Contents

Phoca wymani and Other Tertiary Seals (Mammalia: Phocidae) Described from the Eastern Seaboard of North America

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Introduction

The evidence and literature of pre-Pleistocene fossil seals, family Phocidae, in North America have been extremely skimpy and unsatisfactory. Barnes and Mitchell (in press) have now reviewed and clarified the meager evidence for the Pacific coast. With the exception of *Leptophoca lenis* True, 1906, the published record for the Atlantic seaboard may for the most part be characterized as at best obscure, confused, and without focus. Presented here is a brief historical review of that record, followed by a detailed account of *Phoca wymani* and other remains of fossil seals from Richmond, Virginia, with notes on, and illustrations of, some other relevant specimens. Specimens deposited are in the Museum of Comparative Zoology (MCZ) and in the National Museum of Natural History, Smithsonian Institution, the latter under the catalog numbers of the United States National Museum (USNM).

ACKNOWLEDGMENTS.—I wish to thank Farish A. Jenkins, Jr., for the loan of the temporal bones of *Monotherium? wymani,* MCZ 8741, and for permission to prepare them and extract the auditory ossicles of the left side. Elaine Anderson and Ralph Lutz provided the essential information from Jeffries Wyman's catalog that demonstrated conclusively the identity of the specimens. Barbara Lawrence, Antony J. Sutcliffe, Jane Knapp, Alta Copeland, and Robert W. Purdy supplied useful historical data, as did Robert Mayo, Elizabeth Childs, and Mrs. Stuart Gibson, all of the Valentine Museum, Richmond. Peter A. McCrery and associates of the Richmond Gem and Mineral Society salvaged fossil vertebrates from the Ballard Street locality in 1968 and donated them to the Smithsonian Institution. Calvin F. Allison was the first to notice and bring to my attention seal remains among specimens from Ballard Street. Franklin L. Pearce and Gladwyn B. Sullivan prepared all of the phocid fossils from Richmond. James G. Mead granted free access to the modern pinniped collections and permission to extract auditory ossicles. Paul Sartenaer granted access to the collections of the Institut Royal des Sciences Naturelles de Belgique, and permitted my borrowing pertinent specimens. Q. Brett Hendey provided excellent casts of many elements of *Prionodelphis capensis.* Derek Siddons loaned and permitted casting a partial mandible of *Leptophoca lenis.* Charles A. Repenning reawakened my interest in the problem, made available auditory ossicles of several species of phocids, and read a draft of the manuscript critically. Thomas G. Gibson, Lauck W. Ward, and Blake W. Blackwelder have been very generous in sharing their knowledge of the

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stratigraphy and correlation of the Chesapeake series. In the Museum and in several rewarding field excursions, L. W. Ward has imparted in a short time an otherwise unobtainable understanding of Virginia coastal plain stratigraphy develloped by him through years of work, and not yet published. George W. Andrews processed several matrix samples from Richmond and reported upon the diatoms. Frank C. Whitmore, Jr., provided previously unpublished data on cetaceans from Richmond and elsewhere, and reviewed the manuscript. Victor A. Krantz, assisted by Franklin L. Pearce, made the photographs from which Lawrence B. Isham and Jeffrey Lund prepared the plates and the figures. The work on which this paper is based was supported by the Smithsonian Institution, in part through the Remington Kellogg Memorial Fund, the Walcott Fund, and the Smithsonian Research Foundation.

Historical Review of Tertiary Phocidae in Eastern North America

FIGURE 1; PLATE 5: FIGURES 1–6; PLATES 8–11

The first notice of a fossil phocid in the western hemisphere seems to be that by Richard Harlan (in Conrad, 1838:xi, footnote, Dall reprint, 1893: [13]; Harlan, 1842:143), who mentioned "seal" among fossils identified from excavations for marl on the plantation of Lucas Benners, near the north bank of the Neuse River 15–16 miles downstream from New Bern, North Carolina. Although recent search has failed to identify with certainty any material on which this record was based, new collections from nearby localities and modern biostratigraphic interpretations suggest that Harlan's "seal" might well have been derived from beds of late Tertiary age, possibly equivalent to the Yorktown Formation (Ray, in press).

The second report of a fossil phocid of possible Tertiary age in eastern North America is that of Lyell, apparently first recorded in Murchison (1843:551), and subsequently in a series of publications, mostly of similar content by Lyell (1843: 32, 1845:257). The specimen was identified by Owen as a canine tooth, with the crown fractured, of a seal thought to be allied to the modern hooded seal, *Cystophora cristata*. It was collected by Lyell, apparently from the greensand, at Gay Head, Martha's Vineyard, Massachusetts (Lyell, 1845:257, fig. 6). These beds have been regarded as Miocene and/or Pliocene, possibly correlative with the Yorktown Formation (Dall, 1894:299; Gibson, 1965:980), but are now regarded as older on the basis of the invertebrates (Gibson, personal communication, 1975) and the vertebrates, principally *Squalodon,* which is not known to occur in deposits younger than the Calvert Formation in the Atlantic Coastal Plain (Whitmore, personal communication, 1975). Intrusion of the seal tooth from the Pleistocene cannot be discounted. The specimen has been lost sight of and may have been destroyed. The only other pinniped fossil obtained by Lyell on Martha's Vineyard, a rolled rostrum of a probably Pleistocene walrus skull (Lyell, 1845:258, pl. 5: fig. 1), was compared, also by Owen, to modern walrus specimens in the Museum of the Royal College of Surgeons, and was deposited there (Flower and Garson, 1884:203), where virtually the entire collection, excepting specimens out on loan, was destroyed during World War II (Sutcliffe, personal communication, 1972). The seal canine may not have been in the Museum of the Royal College of Surgeons as neither Owen (1845) nor Flower and Garson (1884) listed it, but neither was it listed by Lydekker (1885) in the collections of the British Museum (Natural History), nor did I find it there in reviewing the collections of fossil pinnipeds in 1972. Although its affinities can scarcely be determined unless the specimen is found, it seems safe to say that a special relationship to hooded seal would be difficult to support solely on the basis of a broken canine, particularly if the tooth were as old as Miocene, and not Pleistocene. However, there is no particular reason to doubt that the specimen was indeed the canine of some seal of late Tertiary age, especially in view of the reliability of Owen and Lyell. Confidence in the record is bolstered further by the recent discovery, in the greensand at Gay Head, by Clifford Kaye, U. S. Geological Survey, of a fragmentary, incomplete right humerus, now USNM 214625 (National Museum of Natural History), tentatively assigned to *Monotherium aberratum,* and suggestive of an age greater than that of the Yorktown Formation (Plates 8–11: figures 1, 2). *Monotherium* was described from the Diestian deposits of the Antwerp Basin, Belgium. The major part of a large right humerus, USNM 25874,

and a few other elements, from the St. Marys Formation of Maryland, are assigned tentatively to *Monotherium affine*. *Monotherium* has not been recognized among the abundant remains of phocids from the Yorktown Formation.

Third, from the Miocene of Richmond, Virginia, Wyman (1850a, b, c) reported fossil seal material that included the basis for *Phoca wymani* named by Leidy in June 1853. This, with recently collected material from Richmond, is the principal subject of the present report, and is discussed at length below.

Fourth, at a meeting of the Academy of Natural Sciences of Philadelphia on 2 August 1853 (the proceedings of which, volume six, numbers 9–10, were published prior to 5 September 1853, the date on which the Smithsonian Institution acknowledged receipt of this issue, according to Nolan, 1913:xi), Leidy (1853b) reported upon a new species of fossil seal, the complete text of which follows:

> Mr. Conrad has presented me with an outline drawing (of which the accompanying wood engraving is a copy,) of a tooth, discovered by Mr. Samuel A. Wetherill in the green sand, of the cretaceous series, near Burlington, New Jersey. The specimen was given to Mr. Conrad, who made the drawing indicated, and afterwards loaned it to an acquaintance, from whom he has not been able to obtain it again. The figure represents a double-fanged tooth, with a crown divided into five prominent lobes. It is, without doubt, the tooth of a mammal, and resembles very much one of the posterior molars of *Stenorhynchus serridens*, Owen [=*Lobodon carcinophagus*], an animal of the seal tribe. It may have belonged to a cetacean allied to *Basilosaurus*, but until further evidence is obtained, I propose to call the species indicated by the tooth *Stenorhynchus vetus*.

Although the incredible Cretaceous age (undoubtedly antedating the origin of pinnipeds) has been carried into the later literature by some authors as a troublesome anomaly (Kellogg, 1922:68, 115; King, 1964:129), Leidy (1865:1–2, ftn; 1869: 416) had long ago expressed the opinion that the tooth was of Miocene age, and had pointed out as well (1865:1) that Pleistocene mammals were known from the same deposits. The geologic age of many fossils from the New Jersey coastal plain is subject to gross misinterpretation (Ray, 1975: 296–298). However, a crabeater seal in the North Atlantic of any geologic age is inexplicable. The drawing (Figure 1*a*) does indeed suggest a tooth essentially identical to a lower post-canine of the

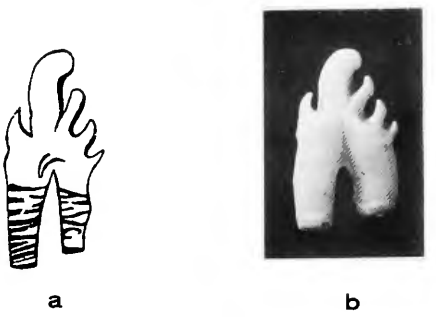

FIGURE 1.—*Lobodon* species: *a*, the holotype of *Lobodon vetus*, after Leidy (1853b) (× 1), as confirmed by Leidy (1869: 416), though not indicated by Leidy (1853b); *b*, lower right fourth postcanine of modern *Lobodon carcinophagus*, USNM 270385, in lingual aspect (× 1).

living crabeater, *Lobodon carcinophagus* (Figure 1*b*), and dissimilar to any tooth of any other seal. The postcanines of some individuals of *Phoca vitulina* and of *Pusa* are rather comblike, but are much smaller, lower-crowned, fewer-cusped, and lack the posteriorly directed apical hook of the principal cusp seen in some teeth of modern *Lobodon* and apparently in the fossil. Efforts to explain this tooth away, for example as an abraded shark tooth by Murray (1866:124), have not been successful (Allen, 1880:475–476). As the name has been validly proposed for a seemingly distinctive species, it would seem best, following the lead of Leidy (1869:415), to retain it as a species inquirenda in the form of *Lobodon vetus* (Leidy, 1853), of Miocene or later age, pending recovery of the holotype or discovery of new material.

One does not work long with fossil marine mammals before becoming aware of the chronic confusion between remains of cetaceans and seals, from the earliest times at least through the nineteenth century, if not to the present (see for example the synonymies of various squalodonts in Kellogg, 1923), particularly pernicious being the penchant of authors until recently to name taxa on the basis of isolated teeth. In some instances it has been possible to resolve the resultant problems, but there remain in limbo too many troublesome taxa, based originally upon nondescript teeth, and subsequently shuttled inconclusively about among various cetacean and pinniped assignments. Among these are *Phoca debilis* Leidy, 1857 (usually cited as 1856, but the publication not received at the Boston Society of Natural History earlier than 25

April 1857, according to Nolan, 1913:xi), and *Phoca modesta* Leidy, 1869, both named from small isolated teeth of unknown age in the collections of the Academy of Natural Sciences of Philadelphia, from the Ashley River deposits of South Carolina. Kellogg (1923) listed them as *Delphinodon? debilis* (p. 13) and *Phoca? modesta* (p. 26) respectively, and he (1922:127, 128; 1923) and Hay (1902:589) cited the earlier literature. In my opinion both taxa represent small porpoises, neither *Delphinodon* nor *Squalodon,* whose affinities may or may not be determinable by thorough comparison with other taxa, including modern representatives, but which in any event are not pinnipeds and thus are outside the scope of this paper.

The fifth record is that of *Leptophoca lenis* True, 1906, from the Calvert Formation of Maryland (and referred material from Virginia), thus far the only eastern North American Tertiary phocid adequately understood in the literature and based upon reasonably satisfactory material, though certainly not "the first authentic remains of American fossil seals" as claimed by True (1905). Considerably more material has accumulated since True's description, reinforcing the phocine character of the species. This will be reported elsewhere, with the exception of two specimens from Richmond reported herein, one of which, a partial humerus, is illustrated alongside the holotype (Plates 8–11: figures 3, 4) and a mandibular ramus illustrated for comparison with monachine mandibular fragments from Richmond and North Carolina (Plate 5: figures 1–6).

From 1906 onward has been a period of quiescence for eastern North American Tertiary pinnipeds, completely so in terms of new, published information, and predominantly so in terms of additions to collections, until the past decade, during which collections have grown at an accelerating rate. New material is known from the Calvert, Choptank, and St. Marys Formations, and elsewhere, and most abundantly from the Yorktown Formation (Ray, in press). Now, on the threshold of significant advancement of knowledge of the subject after more than half a century without progress, it seems particularly fortunate to be able to reinstate among the pinnipeds a species that was among the earliest named and most securely founded Tertiary phocids, but which has languished, not forgotten, but misused, among the Cetacea virtually from its conception. *Phoca wymani* Leidy, 1853, had aroused my curiosity years ago, but so long as its holotype was unrecognized and presumed missing, and additional material was unknown, there seemed little prospect of clarifying its position. These handicaps have now been in part overcome by recovery of at least part of the original material and by discovery of a few additional specimens.

Phoca wymani Leidy

FIGURES 2, 3; PLATES 1–7

TAXONOMIC HISTORY.—Jeffries Wyman was a native and lifelong resident of Massachusetts, excepting for travel and frequent wintering in the southern United States for reasons of health (see Gray, 1875, for this and most of the biographical information about Wyman). His specific association with Richmond, Virginia, stemmed largely from his occupying "the chair of anatomy and physiology in the medical department of Hampden-Sidney College, established at Richmond, Virginia," from 1843–1847, where he spent the winter and spring of each year in teaching. This was terminated in 1847 by his appointment to a position at Harvard, where his affiliation continued until his death on 4 September 1874. It was undoubtedly through acquaintances made while at Hampden-Sidney College (its medical department, since 1853, the Medical College of Virginia, Rucker, 1950:292) that he received the fossils collected by Dr. Martin Burton in Richmond, which in part form the primary subject of the present report.

In the *Proceedings of the Boston Society of Natural History* for 6 February 1850 (Wyman, 1850a:241), it is recorded that "Prof. Wyman exhibited some fossil bones of Seals found in the Miocene deposit beneath the city of Richmond, Va., where they occur in company with the teeth of Sharks and Zeuglodonts [squalodonts?]." Again, in the meeting of 7 August 1850 (Wyman, 1850b: 323), "Prof. Wyman announced that he had received other fossil remains of seals from the Miocene deposit of Virginia, near Richmond . . . . He had a large portion of a cranium, of a well known genus, but of a species not yet ascertained. As these bones were found at some distance from each

other, farther discoveries would probably be made." In November of the same year he reported upon vertebrate remains from Richmond, mostly collected by Dr. Martin Burton of Richmond; the complete text on the seal remains (Wyman, 1850c: 229–230) is as follows:

Among the most interesting of the relics discovered by Dr. Burton were parts of the cranium of an animal belonging to the natural family of Phocidae, a family of which but few remains had been previously detected, and in so far as I have been able to find any record. only in one other locality in the United States. The bones were fragile, and had evidently been crushed previous to exhumation. The pieces in my possession consist of two temporal bones nearly entire, a fragment including a portion of the parietal and occipital bones; and in addition a part of the base of the skull. The reëntering angle of the occiput, the well marked depressions corresponding with the cerebral convolutions on the parietal bones, the form of the cranial cavity, the deep fossa above the internal auditory foramen, the vascular canals opening on the occiput, and the inflated tympanic bones, all indicated an affinity to the Phocidae. The size varied but little from that of the common Harp seal, (P. Groenlandica.) The presence of an interparietal crest indicating a large development of the temporal muscles, offers a diagnostic sign by which it may be distinguished from P. barbata, P. Groenlandica, P. hispida, P. mitrata, and P. vitulina. From those species of seals which are provided with a crest the fossil presents a well marked difference in having the mastoid process much larger, more rounded, and prominent, nearly equalling the tympanic bone in size. The entrance to the carotid canal is in full view when the base of the skull is turned upwards. The imperfectly divided canal which lodges the Eustachian tube and the tensor tympani muscle is of remarkable dimensions, especially when compared with that of P. Groenlandica. The interparietal crest extending from the occiput to the anterior edge of the frontals, is most narrow posteriorly where it is but slightly elevated above the surrounding bones.

The fragments of cranium above described were found in the Shockoe creek ravine near the base of Church Hill. In the ravine at the eastern extremity of the city and in the neighborhood of [end p. 229, begin p. 230] the penitentiary, Dr. Burton obtained several other portions of the skeleton of another seal. These consisted of an imperfect cervical vertebra, a lumbar vertebra nearly entire, a fragment of the sacrum, coccygeal vertebra, fragments of ribs and the lower extremity of a fibula. Their generic characters have been satisfactorily made out by comparisons with recent bones.

In figure 1, page 232, I have represented the coccygeal vertebra which corresponds in its general characters very accurately with recent bones of P. Groenlandica from the same region of the vertebral column. The small size of the vertebral canal and the imperfect transverse process, the wide spread articulating processes and the blunted spinous process indicate its affinity to the seals.

The fragment of a left fibula (figs. 2 and 3) presents at its lower extremity (fig. 3), an oblique regularly concave articulating surface, on its inner face, and on its outer (figs. 2 and 3,) an elevated ridge or crest on either side of which is a groove for the passage of a tendon.

Leidy (1853a:8) lists among the Miocene mammals of North America:

Phoca Wymani, Leidy. Wyman: Am. Journ. Sc. 1850, X. 229.

In my opinion this constitutes valid publication of the species under the *International Code of Zoological Nomenclature* (1961), in that it satisfies Articles 11, 12, and 16, the last of these by "indication" of "a bibliographic reference to a previously published description, definition, or figure." The month and year of publication of Leidy's "The Ancient Fauna of Nebraska . . ." are June 1853 (see Rhees, 1882:8), the latter not 1854 as commonly cited; the whole volume six of *Smithsonian Contributions to Knowledge,* of which Leidy (1853a) is part seven, was completed in 1854, as indicated on its title page.

In 1857 Leidy (p. 265) published "Notice of remains of two species of Seals" (not two new species!), of which the part relevant here is as follows:

1. Phoca Wymani.
   Remains of a Seal. Wyman, Am. Jour. Sci. X. 229.
   Phoca Wymani, Leidy. Anc. Fauna of Nebraska, 8.

A tooth, apparently an inferior canine, from the miocene deposite [sic!] of Virginia, recently presented to the Academy by Prof. Tuomey, I suspect to belong to the same species as the remains of a seal from the same deposite, described by Prof. Wyman.

It is abundantly clear that Leidy did not regard this as the type description, but as the referral (retracted in 1869) of a specimen to a previously established species. Certainly Prof. Tuomey's tooth from Virginia did not contribute to Leidy's concept of *Phoca wymani* when he named it in 1853, as the tooth was not donated to the Academy of Natural Sciences of Philadephia until 2 September 1856 (anonymous, 1857:xviii).

The proceedings of a meeting of the Academy of Natural Sciences of Philadelphia on 5 November 1867, record (Cope, 1868a:132; see Nolan, 1913: xiii, for year of publication) that *"Squalodon mento* Cope was characterized from four molar teeth, which were between two and three time[s] as large as those belonging to the Squalodon wy-

manii (*Phoca* of Leidy) with similar incurved crowns, but much more rugose." Again, more formally, in a paper ordered to be published at a meeting of 31 December 1867, Cope (1868b:152) stated as follows:

> Squalodon wymanii m[ihi]. *Phoca wymanii* Leidy. Proceedings Academy N. Sci. 1856, 265.
>
> Of this, the smallest species of the genus, three premolar teeth are in the collection, and the type specimen is in the Academy's Museum. . . .

These two publications by Cope in 1868 mark the first use of the name *Squalodon wymanii* (also listed by Cope, 1868b:144), the first as a nomen nudum, but the second apparently validly proposed. In my opinion Cope did not intend to appropriate the species *Phoca wymani* to the Cetacea, as he did not refer to Leidy's (1853a) type description, but only to the paper in which he (Leidy, 1857) referred the tooth from Virginia, which Cope designated the holotype of *Squalodon wymanii,* indicating himself as the author of the species.

In 1869, Leidy explicitly separated the concepts of the original *Phoca wymani* and the interloping cetacean. He listed (p. 415) the former as follows:

> Phoca Wymani.
>
> *Animal belonging to the Phocidae,* Wyman: Am. Jour. Sc. 1850, X, 229, Figs. 1–3.
>
> *Phoca Wymani,* Leidy: Anc. Faun. Neb. 1853, 8.
>
> Remains found in a miocene formation at Richmond, Virginia.

His account of the latter (pp. 425–426) is in part as follows:

> Delphinodon Wymani.
>
> *Phoca Wymani,* Leidy: Proc. Ac. Nat. Sc. 1856, 265.
>
> *Squalodon Wymani,* Cope: Proc. Ac. Nat. Sc. 1867, 132, 151, 152.
>
> Three teeth, from the miocene formation of Charles County, Maryland, ascribed by Prof. Cope to a species of *Squalodon,* appear to me, at least in part, to belong to a smaller species of *Delphinodon.*
>
> One of the teeth . . bears a resemblance to that first described of the larger species . . . .
>
> A tooth [ANSP 11225, the "type specimen" of Cope, 1868b, above] . . from the miocene formation of Virginia, originally ascribed by me to the same species as the remains of a Seal described by Prof. Wyman, is very like the one above indicated . . .
>
> The remaining two teeth from Charles County, ascribed by Prof. Cope to *Squalodon Wymani,* are different from the preceding, and it is uncertain whether they belong to the same animal . . . .

Thus Leidy and Cope scrupulously maintained the separate identity of the pinniped and the cetacean. Van Beneden (1877:28) merely mentioned *Phoca wymani* as a form described early but not well characterized.

Allen (1880:470–473, 480) discussed *Phoca wymani* at length in a speculative manner, which, by weight of his authority, served largely to condemn *Phoca wymani* to nearly a century of neglect and misinterpretation. He stated first (p. 470) that:

> some supposed Phocine remains were described by the late Professor Wyman from the Tertiary deposits underlying the city of Richmond, Virginia. They came from two localities, and consisted of quite different materials. The specimens are at present unknown, so that their reëxamination is impossible. A part of these remains were in all probability Squalodont, while others may have been Phocine.

Further (p. 470), under the heading *"Squalodont Remains described as Phocine,"* he indicated:

> No less than three species referred originally to *"Phoca"* are in all probability referable, in part or wholly, to *Squalodon,* as is more or less explicitly admitted by their original describer. These are *Phoca wymani, P. debilis,* and *P. modesta,* of Leidy.

On page 471 he quoted Wyman's (1850c:229) description of the skull of *Phoca wymani,* followed by the assertion:

> In the description above given there is nothing to prevent the supposition that these cranial fragments are referable to a small species of Squalodont. If, however, they are really Phocine, they represent a type very unlike anything at present known, either existing or extinct. But other remains are described by Professor Wyman, from the same locality, and in the same paper, which do not seem to admit of such an interpretation.

He then quoted Wyman's description of the postcranial remains, followed (pp. 472–473) by the commentary that:

> the specimens here described do not appear to have been preserved, or to have been seen by subsequent writers, but Professor Wyman was an osteologist of too well-known proficiency to admit of the supposition that these remains did not present well-marked Phocine affinities. Indeed, his description and rude figures of the fibula above mentioned show clearly that its affinities were rightly interpreted. The vertebra is not so evidently Phocine. Three years later the description of these remains became the basis of Dr. Leidy's *"Phoca wymanii,"* who, in proposing the name, merely cited Wyman's description. In 1856 [1857] he referred to it a tooth. . . . In 1867 [1868] Professor Cope referred *Phoca wymani,* Leidy, to *Squalodon.* . . . The *Squalodon wymani*

of Cope thus, inferentially at least, includes the remains described by Wyman, though direct reference seems to be made only to the tooth referred by Leidy to his *Phoca wymani* in 1856, and which is that of a squalodont. The *Phoca wymani,* if not originally a composite species, as was in all probability the case, certainly became so in 1856. In 1869 Dr. Leidy retained, under the name *Phoca wymani,* the specimens above mentioned as described by Wyman in 1850, separating the tooth referred by him to this species in 1856 under the name *Delphinodon wymani.*

In concluding his account of fossil pinnipeds, Allen (p. 480) stated that:

in North America few remains of Pinnipeds have been found, and these, with two exceptions, are all from the Quaternary, and are referable to existing species. The exceptions are the so-called *Phoca wymani,* based in part at least upon veritable Phocine remains from the Miocene of Richmond, Virginia, and the enigmatical *Lobodon vetus* . . . .

Judging from the foregoing statements, Allen vacillated radically in his thinking about *Phoca wymani;* much of what he said is contradictory or wrong. For example: Leidy never "admitted" that *Phoca wymani* was referable to *Squalodon;* Allen trusted Wyman's interpretation of the postcranial elements, but cast doubt on that of the skull; the *Squalodon wymani* of Cope did not, inferentially or otherwise, include the remains described by Wyman; erroneous subsequent (1857) referral of a specimen to a species in no way makes the species composite.

Roger listed "Ph. [Phoca] Wymanni," misspelled, in 1887 (p. 145), and "Ph. Wymani," correctly in 1896 (p. 74). Toula (1897:49, 53, 55) reviewed the history of *Phoca wymani,* noting Cope's and Allen's (1880) conclusions in large part correctly, while retaining the species among the fossil seals. Trouessart (1897:388, footnote) indicated under Pinnipedia, *"Phoca Wymani, Ph. debilis, Ph. modesta,* Leidy (1853–1869) sunt dentes *Squalodontium* (Cetacea); vide infrà: *Squalodon Wymani,"* but when the Cetacea were published (1898:1023) listed it as *Delphinodon Wymanii* Leidy, 1856.

Hay (1902:591) indicated that "the name *Delphinodon leidyi* is intended to replace *D. wymani* Leidy . . . . The type of *D. leidyi* is Leidy, J.1869 A, pl. XXX, fig. 12 [ANSP 11225]." The new name must have been proposed under the erroneous belief that *Phoca wymani* and *Delphinodon wymanii* were specific homonyms, which they were not and are not. In my opinion *Delphinodon leidyi* was an unnecessary replacement name and should be relegated to the junior synonymy of *Delphinodon wymanii* (Cope, 1868b). Hay's bibliographic citations under *D. leidyi* (p. 591) and *Phoca wymani* (p. 785) do not reflect the distinction between the two—for example, none of the references to teeth (Cope, 1868a, b; Leidy, 1857) has anything to do with *Phoca wymani,* and no reference to Wyman's 1850 material has anything to do with *Delphinodon wymanii.* Hay did apparently understand the real separation of the two taxa, as evidenced by his listing them separately and in part distinguishing their respective literature, and by listing *Phoca wymani* again in 1930 (p. 564). Trouessart (1905:762) followed Hay, and made no mention of the species under Phocidae (1904:282–288).

True (1912:185–186; confirmed by his unpublished notes) obviously accepted Allen's (1880) interpretations, implying that Leidy (1856 [= 1857]) was a validation of Leidy (1854 [= 1853a]), not the mere referral of a specimen as in fact it was. He also accepted Hay's replacement name, *Delphinodon leidyi,* for the cetacean, but he did recognize that the seal material of Wyman (1850) was a separate entity.

Kellogg (1922:74, 75, 120, 130) perpetuated the unfounded notion that Wyman's original material described as seal was at best composite, and in part cetacean (squalodont).

Wilson (1935:126), without reference to *Phoca wymani* as such, accepted Wyman's (1850c) report as a valid record of fossil phocid remains, although erroneously supposing it to be the first for the United States.

The taxonomic history of *Phoca wymani* cannot be concluded without reference to the work of William Palmer, a taxidermist and naturalist in the United States National Museum, and an active collector of Miocene vertebrates along Chesapeake Bay approximately from 1907 until his death in 1921 (Gilmore, 1941:337). His prowess as collector has been adequately noted in published acknowledgments (as in True, 1912:166) and in one case by specific epithet (*Parietobalaena palmeri* Kellogg, 1924), but his taxonomic insights have gone unremarked. In one of those rare occurrences that occasionally rewards antiquarian research, I found, long after reaching my own conclusions on the literature of *Phoca wymani,* in perusing notebooks

found among the late Remington Kellogg's papers, that William Palmer had covered essentially the same ground more than 50 years earlier, from the viewpoint of his interest in *Delphinodon,* and had written up his results in a formal manner under the title "Fauna Calvertensis, no. 2. The Fossil Cetacean Genus, *Delphinodon.*" This projected series of publications never materialized, not even the first, which was to have been the description, under almost the same generic name, of the material ultimately described as *Parietobalaena palmeri* Kellogg, 1924. In a note written in May 1920 and placed with the holotype tooth of *Delphinodon wymani* in the collections of the Academy of Natural Sciences of Philadelphia, Palmer recorded the synonymy of that species. The remarkable congruence of our conclusions would make it a pleasure to enter his name as coauthor of the present notes were he not so many years removed from the option of declining. However, it seems no disservice to quote the following excerpt from his notes, which will reveal how perceptively he analyzed the main problems and how succinctly he stated them:

Delphinodon wymanii

Owing largely to careless citations the naming of this species has been remarkably confused. It was described [in the morphological, not taxonomic, sense] but not named by Leidy in 1856 in conjunction with a reference to remains of a seal described though not named by Prof. Wyman in 1850, but named and not described by Prof. Leidy in 1853 as *Phoca wymani.* It is clear that the porpoise tooth collected by Prof. Tuomey was without a name in 1856. We next find it named by Prof. Cope in 1867 as *Squalodon wymanii.*

On page 132 occurs, "Squalodon wymanii (Phoca of Leidy)." This is a nomen nudum here.

On page 144 occurs, "Squalodon wymanii. Cope, miocene." Again a nomen nudum.

On page 152 he writes, "Squalodon wymanii m[ihi]. Phoca wymanii Leidy." He mentions the type, compares it with other specimens, and states that it is the smallest of the genus and distinctly uses a new valid name, the first for this type. Leidy had never used *wymanii* but had incidently discussed this porpoise tooth under the name of *Phoca Wymani* which of course rightfully belonged to the "seal remains" described by Wyman and named by Leidy in 1853, the first fossil seal named in North America. It is clear that Cope correctly identified this specimen as a cetacean tooth and his language clearly shows that he had written a new name.

THE HOLOTYPE.—Leidy (1853a:8) seems clearly to have had in mind the cranial material as the basis for his name *Phoca wymani,* as he cited the page reference as 229, on which only the cranium is described, not 230, on which the postcranial remains are described, nor the figures, on page 232, in which the latter are in part illustrated. Further, Toula (1897:53) wrote that *"Phoca Wymani* Leidy ist auf zwei Paukenbeine begründet; eines der Stücke weist auch noch ein Stück des Parietale und Occipitale auf. (Wyman: Amer. Journ. 1850, 229.)." If Leidy's intent were not regarded as sufficiently definite, then Toula's statement should qualify as subsequent designation of a lectotype, or, if not, then certainly True's (1912:186) statement that "in 1902, Dr. O. P. Hay pointed out the fact that the name *Phoca wymani* really belonged to the seal skull originally described by Wyman in 1850, and could not properly be applied to the teeth from Virginia and Maryland" would so qualify, even if he drew more than was warranted from Hay's bibliographic annotations. In any case, the prerogative of lectotype selection was not available to Kellogg (1922:74) when he asserted, "The form *Phoca wymani* is here restricted to the fibula and vertebra from the ravine outside of the city limits of Richmond, Virginia." Thus, I feel that a conclusive case exists for the cranial remains as holotype by original indication (Leidy) or as lectotype by subsequent designation (Toula, Hay, or True), and that Kellogg's later attempt is without force.

FATE OF THE SPECIMENS.—Apparently no one has knowingly restudied Wyman's phocid specimens since his original reports of 1850. Although Leidy borrowed other specimens from Wyman, including some of cetaceans from Richmond (see, for example, Leidy, 1869:426, 432, 439; much or all of this material, in part still bearing Wyman's catalog numbers, is now in the collections of the Academy of Natural Sciences of Philadelphia, under the numbers, ANSP 11227, 11257, 11263, and 11268), there is no indication that he ever saw the material on which he based the name *Phoca wymani,* nor apparently did any other author who wrote about it until more than 100 years later, when I (1958:441) unwittingly reported upon the two temporal bones, cataloged in the collections of the mammal department of the Museum of Comparative Zoology under the number MCZ 8741, labeled *"Monachus?,* S.C.?, R. W. Gibbes coll. ?." At that time I tentatively accepted

the questioned data, and suggested that it provided a northerly (Pleistocene?) record for the monk seal.

There the matter rested until 1971, when, in connection with comprehensive studies of Tertiary pinnipeds of the Atlantic Coastal Plain, and at the urging of Charles A. Repenning, my interest in *Phoca wymani* was reactivated. Restudy of the literature suggested that MCZ 8741 might conceivably be part of the material. Borrowing and reexamining these temporal bones showed that they did in fact differ somewhat from those of modern *Monachus,* and showed as well the presence of the faint but legible old numbers 825 on both specimens. At my request, Elaine Anderson, with the aid of Ralph Lutz, then of the Boston Museum of Science (successor to the Boston Society of Natural History) found in the library of that institution the Catalog of Jeffries Wyman's Collection of Comparative Anatomy in Boylston Hall (at Harvard University). The entries for fossil seal remains in the catalog are as follows:

824. A mass of clay presenting a cast of the interior of the cranium of a seal, from the Tertiary at Richmond, Va. [illegible word].
825. Right and left temporal bones, with a portion of the parietal bones fitting the preceding specimen. From Dr. Martin Burton of Richmond.
826. Lumbar vertebrae of a fossil seal found at Richmond. From Dr. Martin Burton.
827. Fragment of the sacrum of a seal. Fossil. From Dr. Martin Burton.
828. Cervical vertebra of a seal. Fossil. From Dr. Martin Burton.
829. Dorsal vertebra of a seal. Dr. Burton.
830. Caudal vertebra of a seal. Dr. Burton.
831. Lumbar vertebra of a seal. Dr. Burton.
833. Ribs of a seal from Dr. Burton.
834. Metatarsal bone of a seal from Dr. Burton.
844. Extremity of the fibula of a seal, from Richmond. Presented by Dr. Burton.
[This last entry lined out and replaced by an unrelated specimen.]

During recent curation of the collections of fossil marine mammals in the National Museum of Natural History there were found two casts of the distal part of a single left fibula of a seal, one with the number 929 and the other 930, from the old catalog of vertebrates, now in the Division of Mammals, NMNH, entered in 1852 as follows: Fossil seal cast; Richmond, Va.; bone of hand; Dr. J. Wyman. These are noted as item 36 in the "List of Additions to the Museum of the Smithsonian Institution during the year 1851" (Baird, 1852:62). They are now cataloged in the collections of the Department of Paleobiology under the single number USNM 214650. Possibly representing the same bone may be the cast "of the inferior extremity of the radius of a fossil mammal obtained near Richmond, Va. From Dr. J. Wyman." listed among "Donations to Museum" at the stated meeting of 5 January 1847 of the Academy of Natural Sciences of Philadelphia (Anonymous, 1847:141). The cast has not been found in recent examinations of the collections of the Academy.

Thus far then, of the seal remains in Wyman's catalog, only the temporal bones, no. 825, now MCZ 8741, and the casts of the distal part of the fibula, no. 844 (stricken), now USNM 214650, have been relocated. We know by Wyman's own assertion (Gray, 1875:105) that, during the summer of 1874, "he had gone through his own museum of comparative anatomy, which had somewhat suffered in consequence of the alterations in Boylston Hall, and had put the whole into perfect order," just prior to his death on 4 September 1874, and that "The collections . . . forming a part of the late Prof. Wyman's Anatomical Museum in Boylston Hall, have been deposited in the Museum [of Comparative Zoology] by the corporation of the College [Harvard]" in 1875 (Agassiz, 1876:8). The entry for the temporal bones in the catalog of the mammal department of the MCZ is in the handwriting of G. M. Allen (Barbara Lawrence, prrsonal communication, 1975), and was made probably in 1907–1909, during his first, part-time employment at MCZ, when his chief activity was curation of the mammalian osteological collections, including fossils, which he completed by mid-1909 (Henshaw, 1908:7; 1909:8), obviously after the deterioration of the "perfect order" of Wyman's collection of comparative anatomy, else he would undoubtedly have salvaged *Phoca wymani.* G. M. Allen was Wyman's younger cousin and said to resemble him in personal manner, including meticulous scholarship (Barbour, et al., 1943:299, 303, 304). Not so readily understood is the role of J. A. Allen, who surely was in a better position to have saved *Phoca wymani* for posterity than anyone could ever be again. On arriving at the MCZ in 1862 he was "to attend the course by Jeffries Wyman on comparative anatomy"

(Allen, 1916:8), and he mentions Wyman as "a frequent caller" in Agassiz's laboratory where he worked (p. 9). Wyman and Allen overlapped at Harvard from 1862 until Wyman's death in 1874. Both were active and held various responsible positions in the Boston Society of Natural History during the period (Gray, 1875:106; Allen, 1916: 44). Allen was curator of birds and mammals including fossils) both in the MCZ and the Boston Society at Wyman's death and at the time of transfer of his collections to the MCZ. Allen had published major papers on pinnipeds prior to 1874 and began work for his "History of North American Pinnipeds" no more than three years thereafter. All of these factors notwithstanding, he stated in 1880 that "the specimens are at present unknown, so that their reëxamination is impossible" (p. 470) and "the [postcranial] specimens here described do not appear to have been preserved, or to have been seen by subsequent writers" (p. 472). It is difficult to imagine how he could have failed to see and preserve the specimens.

Additional Material.—On 18 January 1968, vertebrate remains were salvaged from excavations in downtown Richmond (Figure 2, locality 5) by Peter A. McCrery and other members of the Richmond Gem and Mineral Society, including Richard May, William Packard, and Donald Woolford, and were donated to the Smithsonian Institution by the Society. Some months later in the vertebrate paleontological laboratory of the Smithsonian Institution, Peter McCrery, working as a volunteer, prepared out the most promising specimen that turned out to be the major part of the skull of the small porpoise, *Kentriodon pernix,* now USNM 171077. Nothing further was done with the collection until the fall of 1973 when Calvin Allison, another volunteer in the Smithsonian laboratory, discovered the distal part of a phocine humerus, now USNM 187409, loose in a box of miscellaneous material from the site. This led to close examination of all remaining material, which yielded a large cetacean lumbar vertebra, a few fragments of fishes, and most importantly, from a single block of matrix, several parts, poorly preserved, probably from a single individual of a monachine seal, all now USNM 187410, including a very incomplete right mandibular ramus, a left ulna lacking the distal epiphysis, a left tibia and most of the shaft of a left fibula, each lacking the distal epiphysis, a left ectocuneiform, and several fragments of ribs, all carefully salvaged and skillfully restored by F. L. Pearce. A right lower canine tooth from the same block seems not to belong with this material.

Localities.—Various sources for *Phoca wymani* have been cited in error, for example, "Carolina merid." by Trouessart (1898:1023) and "Maryland" by Trouessart (1905:591) and by Hay (1930:564). In 1958 (p. 441) I erroneously recorded the source of the temporal bones as "South Carolina?" on the basis of queried entries in the MCZ catalog—to be ignored now that the true identify of the specimens has been recognized.

Wyman (1850c:229) recorded the locality for the partial cranium as "Shockoe creek ravine near the base of Church Hill." A plan of Richmond made by Charles S. Morgan in 1848, showing the principal topography of the area by hachures, places the base of Church Hill on the Shockoe Creek (northwest) side approximately at Twenty-first Street, and the southwest side, paralleling the James River, near Franklin Street, essentially similar to the present situation. Broad Street, paralleling Franklin Street, and trending approximately S 53.5° E, traverses the center of Church Hill as labeled on the map of 1848. The intersection of Broad Street and Twenty-first Street is central to the Shockoe Creek side of the base of Church Hill. Thus the type locality of *Phoca wymani* may be fixed as "Shockoe Creek ravine near the base of Church Hill," at or near the intersection of Broad Street and Twenty-first Street (Figure 2, locality 1).

According to Wyman (1850c:229–230), "In the ravine at the eastern extremity of the city and in the neighborhood of the penitentiary, Dr. Burton obtained several other portions of the skeleton of another seal." These included all the postcranial remains listed in Wyman's catalog (above), of which only the casts of the fibula in the USNM have been relocated at this time. His reference to "portions of the skeleton of another seal" suggests a single individual, but reference to "the ravine at the eastern extremity of the city" and "the neighborhood of the penitentiary" entails two widely separated localities. The ravine in question can only be that of Bloody Run, bordering Chimborazo Hill on the west (Figure 2, locality 2), as the

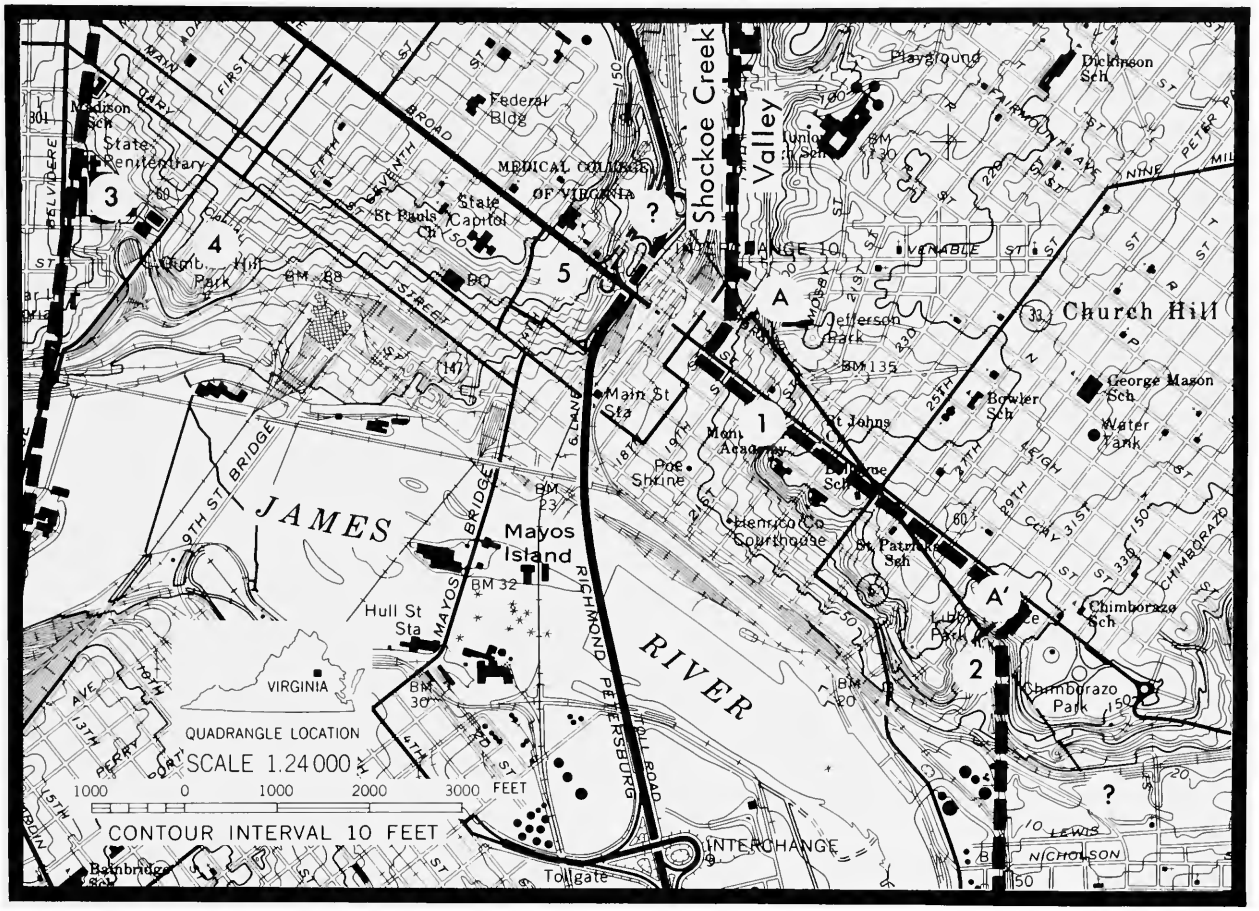

FIGURE 2.—Map of a part of the city of Richmond, Virginia, based on the Richmond Quadrangle, 7.5 minute series (topographic) map, 1968, of the U. S. Geological Survey. (Segments of the city limits as of 1848 according to Morgan are indicated by a heavy broken line. The line A-A' indicates the line of section along the Church Hill Tunnel, shown in Figure 3. The line of section beyond the ends of the tunnel (broken) is imprecisely known. Localities for fossil pinnipeds and other vertebrates are as follow: 1, the type locality of *Phoca wymani;* 2, the ravine (of Bloody Run) at the (1848) eastern extremity of the city; 3, the neighborhood of the penitentiary; 4, downtown expressway excavations, Byrd Street between Third and Fourth streets; 5, Ballard Street, now Fourteenth Street, between Grace and Broad streets.)

easternmost boundary of the city at that time followed the middle of Bloody Run ravine (Morgan, 1848). The penitentiary in question could not have been the Libby Prison of Civil War infamy, which stood on the south corner of Twenty-first and Cary Streets, but which was in 1850 a ship chandlery and tobacco warehouse, having been commandeered as a prison only after the first battle of Bull Run (21 July 1861), and dismantled and moved to Chicago shortly after the War. Instead the "penitentiary" in question undoubtedly was the state penitentiary which then (Morgan, 1848) as now occupied an irregular area bounded approximately by Belvidere, Byrd (now the downtown expressway), Second, and Spring Streets, (Figure 2, locality 3), and at that time directly on the western boundary of the city, approximately 1.5 miles slightly north of west of the type locality. In February 1975, vertebrate remains, representing *Squalodon,* were again encountered in this area, less than 0.25 mile east of the penitentiary, at 113 feet above sea level in excavations for the down-

town expressway (Whitmore, personal communication), immediately north of Byrd Street between Third and Fourth Streets (Figure 2, locality 4). Thus, Wyman's "several other portions of the skeleton of another seal" probably came in part from Bloody Run ravine (locality 2) and in part from near the penitentiary (Locality 3), at the then eastern and western limits of the city.

The material salvaged in 1968 by the Richmond Gem and Mineral Society was obtained from a road cut made in widening the former Ballard Street, now Fourteenth Street, from two to four lanes, in the block between Broad and Grace streets, on the west side of Shockoe Creek ravine, directly opposite, and approximately 0.5 mile northwest of, the type locality, on the east side of Shockoe Creek ravine (Figure 2, locality 5). A portion of this roadcut remains exposed along the west side of Fourteenth Street.

GEOLOGY.—Hay (1930:564) listed *Phoca wymani* as "upper Miocene (Calvert); Maryland," and Clark and Miller (1912:167) listed *Phoca wymani* from the Calvert Formation of Richmond, but the presence of other Neogene beds in Richmond was not understood at that time. The exact horizon from which any of the fossil pinnipeds of Richmond was derived is unknown, but only Paleocene, Miocene, and Quaternary deposits are present. However, as no phocid is known otherwise before the Miocene, that may be taken as the lower limit stratigraphically in Richmond, and the Paleocene beds of Richmond, including those known in and near the valley of Shockoe Creek (Aquia Formation of Darton, 1911:16–17, pl. 1; Nanjemoy Formation of Daniels and Onuschak, 1974:21, pl. 3; definitely Aquia Formation, and largely if not entirely Paleocene, Hazel, 1969:C64, and Ward and Blackwelder, personal communication, 1975), may be eliminated from serious consideration. There is no evidence of Oligocene deposits in Richmond.

The latest Tertiary or Quaternary sands and gravels capping Church Hill and other uplands and the Quaternary alluvium flooring the lower end of Shockoe Creek Valley, the James River Valley, and other lowlands, are virtually nonfossiliferous and largely nonmarine (Daniels and Onuschak, 1974:28–36, pl. 3; Lafayette Formation and Columbia Group of Darton, 1911:27–31, pl. 1), and are thus exceedingly improbable sources for the fossil phocid material.

Here and there in the older literature the indication "Yorktown" age or epoch occurs in connection with the Miocene of Virginia (Cope, 1868a:131; 1868b:138, 150) and in a few instances explicitly with *Phoca wymani* (for example, Dana, 1863:521; Guiscardi, 1871:8). The "Yorktown Epoch" was a regional time-term proposed and used by Dana but not widely adopted, essentially coextensive with the Miocene as then understood, and applied to the time of deposition of rocks of the Chesapeake group (Calvert, Choptank, St. Marys, and Yorktown formations). Most of the evolution of the stratigraphic nomenclature of the Chesapeake group in Virginia was noted by Mansfield (1948:3–4); the Yorktown Formation of modern usage was named formally by Clark and Miller only in 1906 (p. 19) and is now regarded in whole or in large part as Pliocene in age. The westernmost known occurrence of the Yorktown Formation in the Richmond area is at Quinton, New Kent County, approximately 18 miles due east of Richmond (Ward and Blackwelder, personal communication, 1975). Thus the Yorktown Formation is not a possible source of *Phoca wymani*.

The probable source beds for fossil pinnipeds in Richmond are limited to the strata of Miocene age, younger than the time of deposition of the Aquia Formation and older than that of the Yorktown Formation. They have been assigned traditionally to the Calvert Formation (Darton, 1911: 18) or Calvert and questioned St. Marys Formations (Daniels and Onuschak, 1974:21). These Miocene beds overlying the largely diatomaceous layers correlated with the Calvert Formation of Maryland are well represented in sections in and near Richmond, are under regional biostratigraphic study at present, and are assignable neither to the Calvert nor to the St. Marys Formation (Ward and Blackwelder, personal communication, 1975).

The beds in Richmond universally assigned to the Calvert Formation include a conspicuous diatomaceous layer, visible at distance on both flanks of Shockoe Creek ravine because of its light color on weathered outcrops and its sparse vegetation. This bed was made known by W. B. Rogers in 1841, and has been written about extensively since (see Roberts, 1942, for citations to the many publications and reprintings). It has been correlated

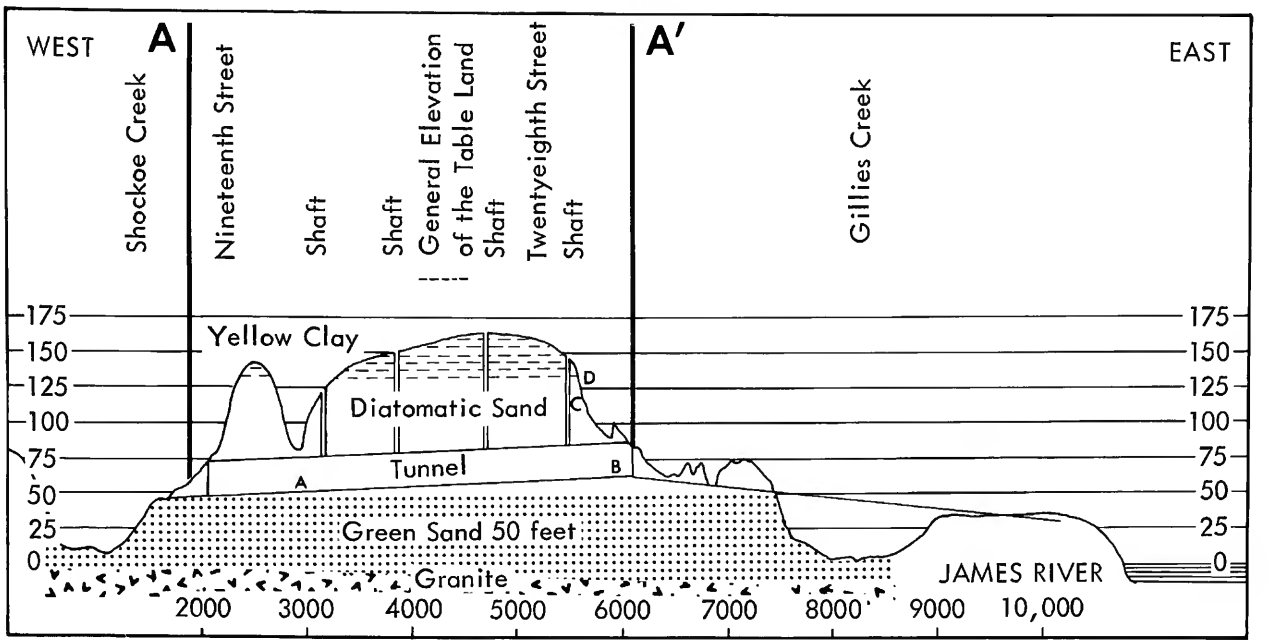

FIGURE 3.—Vertical section from northwest to southeast along the line A-A', extended, of Figure 2 along the course of the Church Hill Tunnel of the Chesapeake and Ohio Railway. (Modified from Coryell, 1876, pl. 5, and Darton, 1911, fig. 1. The letters A-D indicate the sources of Coryell's samples analyzed for diatoms, of which only C was rich in diatoms. The stratum labeled "Yellow Clay" corresponds to Darton's Lafayette Formation; the "Diatomatic Sand" to the Calvert Formation, and possibly in part younger Miocene beds; the "Green Sand" to the Aquia and (below) the Patuxent Formations.)

with the Fairhaven member of the Calvert Formation in Maryland, on the basis of the abundant diatoms.

Among the areas noted especially for the diatomaceous bed are the slopes of Church Hill. Rogers (1841; reprinted 1881:59; 1884:452) refers especially to the area "at the foot of the abrupt bare bank which has been cut into north of Main street, on Church hill, and thence south nearly to the next street—Indeed, along the slope of Church hill, as on the other side of the valley, this stratum may be found in all the ravines and cuttings, at the proper level." He refers also to the overlying sands and clays with plant remains and molds of scallops and other Miocene shells. His most extensive account of the diatomaceous deposits of Shockoe Creek Valley is that of 1859.

Along with Rogers' publications, perhaps the most useful in connection with *Phoca wymani* is that of Coryell (1876; reprinted 1881), particularly his geologic profile (his pl. 5; here modified in Figure 3) through Church Hill from northwest to southeast along the course of the Church Hill Tunnel of the Chesapeake and Ohio Railway. This tunnel, which was begun in February 1872, opened in 1874, and largely disused from 1901 to 1925, collapsed in part during repairs on 2 October 1925, burying a work train and several workmen, after which it was mostly filled with sand and the ends sealed with concrete in 1926 (cf. Teal and Armitage, 1950:775, and Blackford, 1973, Bower, 1975, and Heite, 1964). Its portals are still preserved, located immediately north of the intersection of Nineteenth and Marshall streets on the northwest (visible at surface), and near the head of Bloody Run ravine on the southeast (roofed, by a concrete extension of the tunnel some 241 feet in length), and indicated on the map (Figure 2) by the points A and A'. Coryell's section was reproduced with modifications by Darton (1911: fig. 1), who assigned all beds between his Aquia and Lafayette Formations to the Calvert Formation.

Coryell (1876:231–232) described the section in Church Hill very well, in part as follows:

Upon this granite bed is a sandy clay some fifty feet thick, of various colors and composition, then a ferruginous sand [Aquia Formation of Darton], so compact in places as to resist the pick and crowbar, and which, when struck, produces sparks of fire, and is classed with the rocks. Upon this stratum is the blue deposit [Calvert Formation] through which the tunnel was made. The thickness of the stratum in the tunnel was found to be eighty feet; and the color; when first exposed, a dark blue, but on long exposure becoming nearly white. Upon this is a yellow clay [Lafayette Formation of Darton], very distinct in color, and filled with water-worn silicious boulders, nearly the size of hens' eggs. This stratum is thirty feet in thickness, and upon it are various strata of clays which make the soil of the upland country, and under present cultivation do not indicate much fertility. In excavating the tunnel, large quantities of bones and teeth were found, not interspersed through the material, but generally in pockets. . . .

Mr. Peticolas, recognizing the importance and value of the true position and thickness of the strata from a known base-line, very kindly devoted his time to establish these facts for this paper, and, with the knowledge and assistance of Major Channing M. Bolton, he was furnished with material from well-established points in the tunnel and the railroad excavations, marked on the profile A, B, C, D.

To the eye, there is a uniform stratum eighty-five feet in thickness, blue in color when first exposed, and becoming nearly white after long exposure; this was generally denominated the diatomaceous stratum. Material from the bottom of the tunnel and lower portion of the blue stratum (A and B), was nearly barren, and the remains of an inferior type; at the point C diatoms were found in great abundance, and at D, near the top, the clay was quite barren.

Most important is the probable 80–85 feet of Calvert Formation, extending on the east side of Shockoe Creek ravine (Figure 2, locality 1), from an altitude of approximately 50 feet to 135 feet, which is to say from below the base of Church Hill well up its slopes. The cranium of *Phoca wymani* inevitably came from the lower part of this stratum (through which the tunnel was later excavated, yielding numerous vertebrate remains) if it was collected in place, as seems probable in view of the improbability of such a delicate object surviving a tumble from high up the slope. Matrix recovered from the auditory bullae was insufficient for analysis, but rediscovery and study of the associated endocranial cast would almost certainly yield significant results.

Darton (1911:24) described the extensive development of the diatomaceous Calvert Formation on the southeast side of Church Hill, on the nose of the slope bordering Libby Hill Terrace (Figure 2, locality 2) and extending along the west side of Bloody Run ravine to the old tunnel entrance. These beds constitute a likely source for the seal remains found by Dr. Burton "in the ravine at the eastern extremity of the city" (Wyman, 1850c: 229).

Darton (1911:25), in discussing the western margin of the Calvert Formation in Richmond, noted several exposures "in the neighborhood of the penitentiary" (Figure 2, locality 3). These include the "east side of Hollywood Cemetery," "railroad cuts on the north bank of the river at the foot of Pine and Laurel streets," "Bank near the foot of First Street," "formerly exposed in the steep slopes of the park just opposite [Gambles or Gimbles Hill Park]," and "penetrated by the railroad tunnel under Byrd Street between Third and Fourth streets." This last locality (Figure 2, locality 4) is exactly that of the present roadcut for the downtown expressway, from which *Squalodon* remains were recovered recently.

The cut bank exposed still at the Ballard (Fourteenth) Street locality (Figure 1, locality 5) consists of up to 12 feet of diatomaceous, Calvert?, clay, overlain by a six-inch bed of bone and other rubble, grading upward into a bed of sandy clay up to 10 feet in thickness. Matrix associated with the phocid remains (described below) from this locality indicates that the partial humerus of *Leptophoca* came from the lower clay, with abundant well preserved diatoms; and the monachine remains, from the upper, sandy clay with sparse, generally fragmentary diatoms. The diatoms in the upper bed may be reworked and not stratigraphically significant, those in the lower are suggestive of zone 15 or 16 of the uppermost Calvert or lowermost Choptank Formation (Andrews, pers. comm., 1975). The upper bed is probably equivalent to the horizon from which the *Squalodon* material was recovered at locality 4 to the west (Ward, pers. comm., 1975), and therefore is probably assignable to the Calvert Formation.

Thus, all specimens of fossil seals from Richmond probably came from the Calvert Formation, rather than from the overlying Miocene beds under study by Ward and Blackwelder.

DESCRIPTION.—Wyman's identification and description (1850c, quoted in full above) of his fossil seal remains have been taken unjustifiably lightly, especially by his associate, J. A. Allen. Besides being a professional comparative anatomist, Wy-

man had long and special acquaintance with phocids, as revealed by a superficial review of the record. For example, his first recorded communication to the Boston Society of Natural History, on 20 January 1841, was on a skull of the crabeater seal (Wyman, 1844; Gray, 1875:107), and in a letter to Spencer Fullerton Baird of 28 March 1851, in the archives of the Smithsonian Institution, he stated, "I have a plenty of crania of the Harp Seal which I brought from Labrador [in 1849], but obtained but two crania of the Hooded Seal and one of the Ph. vitulina." Further, his description of the Richmond material was highly pertinent in terms of phocid cranial anatomy, particularly in view of his limited comparative material, including no fossil phocids and no *Monachus*. There could be little or no justification for the suggestion that he had misidentified cetacean cranial material (Allen, 1880:471; Kellogg, 1922:75) particularly as he recorded a cetacean petrosal at the same time (1850c:231).

Of cranial features noted by Wyman and no longer available on the remnants of the holotype, most are characteristic of phocids generally, or are not susceptible to evaluation without the material, as "the reëntering angle of the occiput [lambdoidal crest], the well marked depressions corresponding with the cerebral convolutions on the parietal bones [presumably in internal aspect, as the convolutions are not clearly reflected externally in phocids, as they are in many mustelids], the form of the cranial cavity, . . .the vascular canals opening on the occiput. . . ." However, "the interparietal crest extending from the occiput to the anterior edge of the frontals . . . most narrow [lowest?] posteriorly where it is but slightly elevated above the surrounding bones" is a feature that clearly separates the fossil from all modern phocines except adult *Halichoerus* and some old individuals (males only?) of *Phoca vitulina,* and aligns it with the fossil monachines in which the skull roof is known (*Monotherium gaudini, Pliophoca etrusca,* and *Prionodelphis capensis*) and with the living monachines, *Monachus, Hydrurga,* and *Leptonychotes*. My observations on modern phocids do not coincide completely with those of King (1972:98) who states, "In phocids other than . . . [*Pusa, Histriophoca* and *Pagophilus*] the temporal ridges meet to form a sagittal crest . . . ." It seems safe to assert that, in addition to *Pusa, Histriophoca,* and *Pagophilus,* among living phocines, *Erignathus* and probably *Cystophora* never form a sagittal crest. In the USNM collections there are two skulls of very old male *Cystophora* (USNM 38233 and 188846) in which high parasagittal lips, separated by a narrow trough, are developed on the frontals; it is not inconceivable that exceptional individuals of *Cystophora* could be found in which these lips unite to form a sagittal crest, but I have seen none. Among modern monachines, some individuals of *Mirounga* develop a very short, low sagittal crest on the parietals only; I have seen no approach to formation of a sagittal crest in *Lobodon,* but the small USNM collection includes no very old individuals; *Ommatophoca* characteristically not only does not develop a sagittal crest but has only a weak, unfused sagittal contact between left and right frontal and (anteriorly) parietal bones, with a strong tendency to retain in adulthood a fontanelle, especially between the unfused frontals (cf. King, 1969:27–28).

Other cranial features of *Phoca wymani* remaining available are limited to the temporal bones (and auditory ossicles, discussed below), of which examples are at hand for all the living species of phocids. It is immediately apparent through comparison with these that *Phoca wymani* is a monachine seal. Temporal bones are known for very few fossil monachines, including an incomplete left temporal from the Scaldisian of the Antwerp Basin, referred to *Callophoca obscura;* some half dozen well preserved temporals and many fragments from the Yorktown Formation of North Carolina, referred to *Callophoca* (Ray, in press); the incomplete left temporal in the type skull of *Pliophoca etrusca* from the late Pliocene of Italy, inadequately described and illustrated for present purposes, but apparently essentially as in modern *Monachus* (Tavani, 1941:100, fig. 1; pl. 14 (1): figs. 2a, 2d, 3); and one well-preserved right temporal, and some fragments, of *Prionodelphis capensis* from the Pliocene of South Africa (Hendey and Repenning, 1972:80–81, pl. 6: fig. B).

Naturally, as is intuitively clear to anyone who has looked critically at pinniped skulls, and as well demonstrated for the oceanic species of *Phoca* by Burns and Fay (1970:389), any conclusions based on small numbers of skulls, to say nothing of isolated temporal bones, must be regarded as highly tentative in view of the great variation. Compari-

son of limited numbers of temporal bones, especially limited for ones with the intracranial surface exposed to view, among the living monachine seals shows that they are highly diagnostic at the generic level, indicating that their characteristics do have some taxonomic, and possibly phylogenetic, utility. The temporal bones of the southern monachine genera, including *Mirounga,* are highly diverse, with each exhibiting unique modifications. For example, in *Mirounga* the petrosal apex is greatly swollen much as in all phocines (except *Erignathus*), and the auditory process (ectotympanic) forms a crescentic ossification ventral to the external acoustic meatus and posterior to and conforming to the retroarticular process of the glenoid fossa. In *Ommatophoca* the auditory process of the bulla is greatly thickened, long, and prominent, there is a massive mastoid-like swelling of the squamosal region dorsal to the external acoustic meatus and the mastoid region, and the petrosal is much reduced, especially the apex (absolutely smaller than in any other phocid). In *Lobodon* the bulla is globose, and the auditory process short and inconspicuous in relation to the large bulla. In *Leptonychotes* the petrosal is remarkably broad, including the apex, which is widely rounded and flat. In *Hydrurga* the petrosal apex is somewhat swollen, the bulla is triangular in outline in ventral aspect, and its walls are enormously thickened (as in *Ommatophoca,* King, 1969:11). No claim to originality is implied in these observations of what are in any case only some of the most obvious characters in the temporals of southern monachines, as most, if not all, have been noted before, for example, by Turner (1887:65) and King (1969:29) for *Ommatophoca,* and by Hendey and Repenning (1972:81, pl. 7: fig. C) for *Leptonychotes.* However, it seems not to have been emphasized that this observed diversity is in harmony with the strongly divergent adaptive radiation reflected in the overall biology and morphology of southern monachines. The petrosal apices illustrate the point forcefully, including as they do the most reduced (*Ommatophoca*), the broadest and flattest (*Leptonychotes*), and one of the most swollen (*Mirounga*), among the phocids.

In most features, including overall proportions, the temporals of *Phoca wymani* are generally most similar to those of *Monachus* among living seals, but bear an equally or even more striking resemblance in virtually every feature to that of *Prionodelphis capensis* and in many respects to referred temporals of *Callophoca.* In my opinion these similarities reflect an expectable community of features and lack of extreme modification indicative of real relationship among the fossils, *Phoca wymani* and *Prionodelphis capensis,* and the living *Monachus,* which I regard as persistently primitive. Because of the complexity of the temporal bone, many features are subtle and difficult to describe, but many of the similarities and differences are obvious on inspection (Plates 1 and 2). Salient features of the temporal bones of *Phoca wymani* are noted below, and compared and contrasted with those of other seals.

As revealed in ventral aspect (Plate 1), the bulla is rather small, little inflated, triangular in outline, and bulking little more than the large mastoid (as noted by Wyman, 1850c:229), which is shaped as in monachines generally, rather than in phocines, but is unusually swollen, perhaps exceeding somewhat those of *Prionodelphis capensis* and *Callophoca obscura* (referred), with which it compares best. King (1966:387, fig. 1) indicated that in northern phocids (including *Monachus*) the posterior extremity of the petrosal is visible externally behind the bulla when the skull is viewed in ventral aspect, whereas in southern phocids the bulla essentially conceals the petrosal. Hendey and Repenning (1972:81) stated, "The latter condition is very evident in *P. capensis,* strongly suggesting an affinity with the Antarctic seals [as opposed to *Monachus*]." *Phoca wymani* is very similar to *Prionodelphis capensis* in this character, and neither is very different from *Callophoca* (referred) or *Monachus.* It seems to me that the features of this complex region do not lend themselves readily to reduction to "key" characters, and that weighing the spatial relations among its components indicates that the distinctions among *Monachus, Prionodelphis capensis, Callophoca obscura* (referred), and *Phoca wymani* are meager, and that those between *Monachus* on the one hand, and *Prionodelphis capensis* and the living southern monachines on the other, are neither so clearcut nor significant as might be supposed. The southern monachines do tend to have little or none of the petrosal exposed adjacent to the posterior lacerate foramen behind the bulla, and instead generally have the exoccipital and the

bulla in close approximation lateral to the foramen. However, lateral to that approximation the condition is variable and uncertain, depending in part on the generally unclear boundary between petrosal and mastoid. Additionally, in at least some individuals of *Ommatophoca* and *Leptonychotes* (with which *Prionodelphis capensis* has been especially compared) the petrosal is exposed immediately adjacent to the posterior lacerate foramen. In any event, based on the totality of its characters, the temporal bone of *Prionodelphis capensis* appears to be aligned best with the northern (especially fossil) monachines, not the southern.

Also in ventral aspect, the posterior carotid foramen opens in full view (as noted by Wyman, 1850c:229) in contrast to most phocines, in which it lies partially concealed on the medial wall of an inflated bulla (cf. King, 1972:98–99), except in *Erignathus* in which it is clearly exposed and posteriorly situated. The foramen in *Phoca wymani* also opens far anterior to the posterior extremity of the bulla, in contrast to *Monachus* and *Prionodelphis capensis, Callophoca* (referred), and most other monachines, in which it is situated more posteriorly, in *Monachus* approximating the posteromedial corner of the triangular bulla.

Not visible in strictly ventral aspect, but opening anteriorly near the anterior apex of the bulla, is the auditory canal, exceptionally large as noted by Wyman (1850c:229) in contrast to that of *Phoca groenlandica.* This canal is quite large in *Phoca wymani,* as it is in *Monachus* and in most monachines, and is generally quite small in most phocines. Its variable and irregular shape makes quantification of the differences unfeasible.

King (1966:387) has indicated that in northern phocids, including *Monachus,* the mastoid region is visible when the skull is viewed in dorsal aspect, whereas it is not visible dorsally in southern phocids. As with the ventral exposure of the petrosal, the situation with the mastoid region seems less clearcut than one might wish and not entirely susceptible to treatment as a key character, at least as defined. For example, although the mastoid is visible dorsally in *Monachus,* the entire configuration of the region is much more like that of *Phoca wymani, Prionodelphis capensis,* and *Callophoca obscura* (referred), and other monachines, than of any phocine. In exception to King's generalization also, the mastoid region of *Ommatophoca* is broadly visible dorsally.

Also in dorsal or intracranial aspect, the floccular or cerebellar fossa is extremely large in *Phoca wymani* (noted by Wyman, 1850c:229) as it is in *Prionodelphis capensis* and in phocids generally, although considerably constricted in *Monachus, Ommatophoca,* and *Hydrurga.* The anterior part of the petrosal in *Phoca wymani* is flat (not swollen dorsally) and the apex is broadly rounded, much as in *Prionodelphis capensis* (Plate 2), although perhaps not quite as broad. In all phocines except *Erignathus,* the petrosal is greatly swollen anteriorly into a more (*Cystophora cristata* and *Phoca groenlandica* for example) or less (*Phoca vitulina* and *Phoca hispida* for example) globular mass. Among monachines, the petrosal is swollen anteriorly, greatly in *Mirounga,* and less so, but considerably, in *Hydrurga.* In *Erignathus* the petrosal is rounded anteriorly and only slightly swollen dorsoventrally, less so than in any other phocine or in *Mirounga* or *Hydrurga.* Among those monachines having more or less flat petrosals, *Leptonychotes* represents the extreme in broad and rounded apex, *Monachus* the extreme in narrow and pointed apex, and *Ommatophoca* the extreme (among all phocids) in reduced apex.

Clearly the various features of the temporal bone by which phocines and monachines and northern and southern monachines have been asserted or implied to be separable are far from absolute. However, it is equally clear that the temporal bones of *Phoca wymani, Prionodelphis capensis, Callophoca* (referred), and *Monachus* are more similar to one another than are any of them to those of any other phocid, and that of these, *Phoca wymani* and *Prionodelphis capensis* seemingly are closest to one another.

With the permission of Dr. Farish A. Jenkins, Jr., the left auditory bulla of MCZ 8741 was opened along previously existing fractures for removal of matrix and search for auditory ossicles. The incus and malleus were recovered in good condition, except for the absence of the distal end of the manubrium of the malleus. Each element is similar to its counterpart in modern *Monachus* and in referred specimens of *Callophoca* from North Carolina. Studies in progress of phocid auditory ossicles are not yet sufficiently advanced to warrant secure generalizations, but preliminary observations on small numbers of sets of

ossicles of most genera and subgenera of modern phocids suggest that the ossicles will offer reliable features for distinguishing phocines from monachines (see also King, 1966:387, for example), and some genera from one another. In phocine seals examined thus far the maximum linear dimension of the incus is less than 80 percent of that of the malleus, whereas it is more than 90 percent in the monachines. The neck of the malleus is relatively long in phocines, short in monachines. The head of the malleus is relatively large in comparison to the body of the incus in phocines, whereas in monachines the body of the incus seems to be expanded, and dwarfs the bulk of the head of the malleus. In all of these features the incus and malleus of *Phoca wymani* correspond to those of monachines, and in addition show further special similarities to *Monachus* and *Callophoca* (referred) in all details of morphology (Plates 3 and 4) and most notably in the two simple incudomalleolar articulations, contrasting strongly with the multifaceted or complexly curved articular surfaces in most phocines and some monachines, and with the single confluent saddle-shaped articulation in *Ommatophoca* (King, 1969:12; confirmed on additional specimens).

The distal end of the left fibula from Wyman's original collection, represented by casts, USNM 214650 (Plate 6: figure 2; Plate 7: figure 1), affords no obviously diagnostic features. It represents a stoutly developed fibula with two strongly marked tendinal grooves on its lateral face, defining a crest or process between them. It is curious that these topographic features, widespread in both phocines and monachines, are conspicuously little developed in *Monachus, Mirounga,* and specimens from North Carolina referred to *Callophoca,* in all of which the lateral face of the distal end of the fibula is one of low relief.

The fibula does afford the one small point of morphological overlap between Wyman's original material and the Ballard Street sample of 1968. The fibula is represented in the latter collection by most of the left diaphysis, lacking the proximal part (Plate 6: figure 1; Plate 7: figure 2), of an individual (USNM 187410) in which the distal epiphysis had yet to fuse, and was not recovered. About all that can be determined is that the two pieces are compatible in size and morphology as far as revealed by the meager comparisons possible, and are far too large for *Leptophoca lenis,* as are all the elements, presumably of a single individual, cataloged under USNM 187410, excepting the right lower canine, which may represent *Leptophoca lenis.*

The left tibia of USNM 187410 (Plate 6: figure 1; Plate 7: figure 2) is essentially complete except for the unfused and missing distal epiphysis. The proximal epiphysis is present and tightly fused to the diaphysis. The proximal end of the fibula is present and tightly fused to the tibia, as it is in all known phocids except *Monachus schauinslandi* and possibly a tibial fragment from the Scaldisian of Belgium referred to *Gryphoca similis* (Van Beneden, 1877, pl. 13: figs. 19 and 20; Ray, in press).

The tibia is short and heavily built, with the shaft relatively straight, as in most monachines (except *Leptonychotes*), and in contrast to phocines in which the tibia is long and slender, and generally curved or spiraled in appearance. The length of the tibia, minus the distal epiphysis, is approximately 3.5 times or less the breadth of the proximal end in monachines (except *Leptonychotes*) and 4 times or more the breadth in phocines. The pretibial and posttibial fossae are shallow in USNM 187410, with a thick body of bone between as in monachines generally (including *Leptonychotes*), and in contrast to phocines in which these fossae are deeply excavated, developing in some instances overhanging lips on their medial borders, and in some instances reducing the bony wall between the fossae to an extremely thin lamina. In sharp contrast to most monachines including the Richmond specimen, the tibia of *Prionodelphis capensis* resembles that of phocines in development of fossae and extreme thinning of the intervening bone. The proximal articular facets in the fossil are of low relief, as in monachines, and in contrast to phocines in which the condyles are curved and their lips elevated adjacent to the intercondyloid area. The tibia from Richmond is very similar in character to those of *Monachus, Mirounga,* and *Callophoca* (referred), and in size to those of *Monachus.*

The left ulna of USNM 187410 (Plate 5: figures 8, 10) is essentially complete except for the absence of the distal epiphysis. The bone is relatively short and broad (craniocaudally) as in most monachines and in contrast to phocines (and

Leptonychotes). An unusual feature of uncertain significance is seen in the medially sloping, cranial part of the proximal surface of the olecranon process (Plate 5: figure 10). In all other phocid skeletons examined, this surface is transversely oriented (if approximately planar), or rounded or irregular, except in a single fragment from Belgium referred to *Monotherium affine* (Van Beneden, 1877, pl. 16: fig. 10), in which the surface resembles that of the specimen from Richmond, although not clearly reflected in Van Beneden's illustration. Considerable intraspecific variation may be expected in this surface of strong muscular insertion.

The left ectocuneiform of USNM 187410 is severely eroded and has not been compared in detail.

The incomplete right mandibular ramus is heavily constructed and preserves the alveoli of two large double-rooted postcanine teeth (Plate 5: figures 1, 4). Its robust character, evidence of large double-rooted cheek teeth, and details of configuration set it apart from known phocines, and suggest alliance with monachines, among which it can be matched almost exactly by specimens from North Carolina referred to *Callophoca obscura*. This similarity is taken to imply general, not precise, relationship, as the mandibles of *Monachus, Callophoca, Pristiphoca, Prionodelphis capensis,* and other fossil monachines are rather similar, and this fragment does not include the anterior and posterior parts in which characters thought to be diagnostic are found.

DIAGNOSIS.—A fully satisfactory specific diagnosis of *Phoca wymani* is not yet feasible, owing to the meager material of it and other fossil seals. Still, the holotype is better, and the additional material more confidently referred, than is the case with most fossil phocids. Thus, as so often in the systematics of vertebrate fossils, science may be better served not by adhering to the strictest taxonomic procedures, but by conserving the taxon with confidence that further discoveries will vindicate its retention.

In the meantime, *Phoca wymani* may be diagnosed as a middle Miocene monachine, generally *Monachus*-like in size and morphology of the skull, mandible, ulna, tibia, and fibula; with long, well-developed sagittal crest; temporal bone similar to that of *Monachus* but with unreduced floccular fossa, rounded petrosal apex, carotid canal opening more anteriorly, and petrosal less exposed posteriorly in ventral aspect; temporal bone similar to that of *Prionodelphis capensis* in almost all features, except more anterior opening of carotid canal; ulna with proximal surface of olecranon sloping medially, as in *Monotherium;* fibula with pronounced lateral crest at distal end.

GENERIC ALLOCATION.—Clearly Wyman's seal cannot remain in the genus *Phoca,* which should not be made to include, even in its broadest paleontological usage, a species that is definitively monachine. Even the tacitly accepted practice of using the genus to accommodate a variety of mostly poorly understood fossil phocines (as *Phoca vindobonensis, P. couffoni, P. moori,* and others) has fostered incorrect conclusions, for example, that modernized *Phoca* extends well back into Miocene time (Davies, 1958:486; King, 1972:96).

With regard to Wyman's generic assignment to *Phoca,* it should be noted that the genus was very broadly construed at the time, explicitly so by Wyman (1850c); he mentioned, as species of *Phoca,* the bearded, harp, ringed, hooded, and common seals, each accorded its own genus in most subsequent literature, and even by the most inclusive concepts of the present, arrayed among three tribes and three genera, one of which includes four subgenera (Burns and Fay, 1970:390). Also, it should be noted that there was almost certainly not a single specimen of *Monachus* in North America at the time (Allen, 1887).

There is no entirely satisfactory option available, in view of the limited material of *Phoca wymani* and the poor knowledge of other Tertiary phocids, for most of which the temporal bone is unknown.

The possibility must be considered that Wyman's seal could represent *Leptophoca.* This would be the most economical hypothesis, in that it would account for the apparent absence of monachines in the Calvert Formation of Maryland and northern Virginia, and for the presence of the leptophocine humerus (and canine) in Richmond. It is phylogenetically conceivable in that monachines and phocines must surely have diverged from a common ancestor, and surely not long before the time of deposition of the Calvert Formation. This would call for a seal combining a small, generally phocine skeleton (*Leptophoca lenis*) with a monachine temporal region (*Phoca wy-*

mani). This hypothesis is rejected here because other remains from Richmond, including Wyman's fibular fragment and the new specimens (except the partial humerus), are typically monachine, and as far as comparable parts are available, contrast in size and subfamilial character with remains assigned with some assurance to *Leptophoca lenis*. Thus it does seem that there are two very distinct seals in the Calvert Formation, indicative of well-marked divergence between phocines and monachines by that time, and there is need for a generic assignment for Wyman's seal that will serve best to reflect its relationships until it and other Miocene seals are sufficiently better known to determine whether a separate genus is warranted.

Following past practices, one might utilize the genus *Monachus* for poorly known fossil monachines as *Phoca* has been used, but this would be similarly misleading, as even the conservative *Monachus* does not extend back into the Miocene, and as there are recognizable morphological differences in the parts preserved. Of course G. M. Allen (curatorially) and I (1958:441) inadvertently assigned the remnants of the holotype to *Monachus*.

Of fossil monachines, the temporal bone is known only for *Pliophoca etrusca* (incomplete), *Callophoca obscura* (referred), *C. ambigua* (referred), and *Prionodelphis capensis*. The element has not been fully described in *Pliophoca etrusca*, but in all other respects the species is almost identical to *Monachus monachus*. The temporal bone of *Phoca wymani* is extremely close to those of *Prionodelphis capensis* and *Callophoca* (referred) in most respects. However, I refrain from assigning the species to *Prionodelphis* on the following grounds:

1. The genus *Prionodelphis* and the assignment of the South African species to it are so tenuously based at present as to offer little prospect of stability.

2. The tibias referred to *Phoca wymani* and to *Prionodelphis capensis* are very dissimilar.

3. The two species are widely separated geologically (probably early middle Miocene vs. middle or late Pliocene) and geographically (the two living species of *Mirounga* could however be cited as a modern analogy).

Phoca wymani could with reasonable justification be placed in the genus *Callophoca* for the present, but I am reluctant to do so because:

1. The temporal bones of *Callophoca* affording best comparison to *Phoca wymani* are referred specimens from North Carolina, with only a highly incomplete referred specimen from Belgium.

2. The postcranial elements referred to *Phoca wymani* are in part, notably the ulna and fibula, not closely similar to their referred counterparts in *Callophoca*, and the temporal bones differ in some respects as well.

3. *Phoca wymani* is geologically older than *Callophoca* (probably early middle Miocene vs. early Pliocene).

The striking similarity of the temporal bone to those of *Prionodelphis capensis* and *Callophoca* cannot be disregarded. The probable derivation of the two from *Monotherium* suggests that the latter ought to be considered for reception of the Richmond seal, an attractive possibility because:

1. *Monotherium* is the geologically oldest well-founded fossil monachine genus available, and is in fact the only one unquestionably of Miocene age.

2. The referred ulna from Richmond shares an apparently unique feature with one from Belgium assigned to *Monotherium*.

3. *Monotherium* is the monachine known from the most nearly contemporaneous, though younger, deposits, the Diestian of Belgium and (referred specimens from) the St. Marys Formation and Gay Head greensand of eastern United States; these occurrences are geographically reasonable in terms of fossil and modern phocid distribution around the North Atlantic.

Thus, *Phoca wymani* is here reassigned tentatively to *Monotherium*, and should now be written *Monotherium? wymani* (Leidy, 1853). As the temporal bone of *Monotherium* unfortunately is unknown, this generic assignment must be regarded as no more than a temporary device, based on scanty immediate evidence and on a weakly documented general concept of phocid evolution. Nevertheless, in light of the present alternatives, this placement affords the most plausible reflection of probable affinities, pending discovery and study of additional material.

Leptophoca lenis True

PLATES 8–11: FIGURES 3, 4

The right lower canine found in the block with

the skeletal elements under USNM 187410 seems to be too small for a monachine of the size represented by the other elements, and is on the other hand comparable in size and character to canines referred to *Leptophoca lenis,* to which species this specimen is tentatively assigned.

The right humerus, USNM 187409 (Plates 8–11; figure 3), lacking the proximal end, from the Ballard Street locality, but not directly associated with the above specimen, compares satisfactorily with the holotype of *Leptophoca lenis,* to which it is assigned. In any event, this specimen clearly represents a small primitive phocine, close to if not conspecific with *L. lenis.*

Addendum

After this paper had gone to press, an electroprint copy of the *Catalogue of Collection of Comparative Anatomy in Boylston Hall* [at Harvard University] *Belonging to Jeffries Wyman"* was received from the Boston Museum of Science and has been placed in the Remington Kellogg Library of Marine Mammalogy of the Smithsonian Institution Libraries.

Availability of the facsimile of the complete catalog revealed two additional entries for remains of fossil seals beyond those listed above under "Fate of the Specimens," as follow:

473. Cast of the lower extremity of the fibula of a seal—the original, No. [blank] was found at Richmond, Va. [Entire entry lined out and replaced by an unrelated specimen, as was number 844, above].

909. Ossicula of the ear of a Fossil Seal. Richmond. See 824–825.

The specimens listed under number 909 must have been the auditory ossicles of the right side of MCZ 8741, which Wyman, with his usual care, undoubtedly noticed and preserved in cleaning the right temporal bone, the bulla of which was incomplete, widely open, and essentially empty of matrix when it came to me (cf. Plate 1: Figure 2). Unfortunately these first-discovered fossil phocid auditory ossicles apparently were lost after Wyman's death, and have yet to be relocated.

Furthermore, review of the papers of Jeffries Wyman housed in the Francis A. Countway Library of Medicine, Harvard Medical Library, Boston, Massachusetts, revealed correspondence from Dr. Martin Burton of Richmond, Virginia, to Wyman. Relevant quotations from these letters follow.

Letter of 10 April 1850:

. . . . You will also receive a drawing, showing the upper and under view of a skull that I found not long since in the blue earth. It was about to crumble, and I got Mr. Peticolas to make a drawing of it. . . .

An opportunity has just unexpectedly offered of sending you these things, and allows me no time to be more explicit.

in haste yr very sincere friend

Richmond–Wednesday Night – April 10th Burton

I am afraid you will be able to make nothing of the drawing.

Letter of 11 May 1850 (obviously, from statements in the complete letter, in reply to a letter from Wyman, responding to his of 10 April):

. . . . I have sent you by Mr. Blake the tympanic bones of the head, the drawing of which you have, with the lump of dirt that filled the cavity of the skull. The dirt is a perfect cast of the brain, representing its size and shape, and even its convolutions.

I should be pleased to know the conclusion at which you may arrive (if any) as to the head. . . .

Your very sincere friend

M. Burton

Richmond May 11th 1850

Letter of 28 May 1850, quoted here in its entirety:

Dr. Wyman

Dear Sir

The blue earth containing fossils is (as you know) composed almost exclusively of the exuvia of infusoria, and lies at the bottom of the hills and valleys in and around Richmond. In whatever direction wells or pits have been sunk to a sufficient depth, this earth has been reached, and appears (from such observations as I have made) to have the form of the surface of the country—rising in the center of the hills, sloping on the sides, and appearing upon or near the surface in the valleys.

Where gullies have been formed on the slopes of the hills by the action of torrents, or a small stream flows through the valleys between the hills, this earth has been exposed and worn to variable depths.

Fossils have been found in this earth in so many places, as to render it probable that it contains them wherever found—many more in some places than in others.

Besides the ravine near the Penitentiary, I got many fossils from a well sunk on the western slope of the hill west of the Penitentiary—many from a well sunk on the top of the hill east of the Penitentiary—some from the foot of Church hill—and some from the gullies north of the Medical College. I have never found any except in the blue earth.

It is gratifying to me to have been the means of affording you the pleasure (I know you have experienced) in determin-

ing the nature of the different fossils I have given you, and of contributing to the advancement of your much cherished science. The seal skull was found in the blue earth at the foot of Church hill—the vertebrae of the porpoise, also of the seal, were found in the ravine near the Penitentiary—the two localities being at least a mile apart.

I thank you for your kindness in offering to give me the credit of the discoveries in the communication you are preparing for Silliman's Journal, and in return, can only promise that, I shall not be less diligent or anxious to serve you than heretofore. It gives me pleasure to collect that you may interpret.

Your very sincere friend
M. Burton

Richmond May 28th

Unfortunately, search for the drawings of the seal skull (in the Countway Library and in the Boston Museum of Science thus far) has not yet been successful, but other possible repositories are being investigated.

The last of Dr. Burton's letters quoted above confirms the conclusion that the seal skull was found in place in the Calvert Formation, i.e., "in the blue earth at the foot of Church hill."

The same letter resolves the dilemma discussed under "Localities" regarding "portions of the skeleton of another seal" coming ostensibly from two widely separated localities, one "the ravine at the eastern extremity of the city," the other "in the neighborhood of the penitentiary" (Wyman, 1850c: 229–230). Obviously "eastern" was a simple lapsus on Wyman's part for "western." Thus "locality 2" (Figure 2) is incorrectly placed in Bloody Run ravine at the (then) eastern extremity of the city and should apply to "the ravine near the penitentiary," probably the deep ravine south of the penitentiary and west of Gambles or Gimbles Hill, near localities 3 and 4, and near the (then) western extremity of the city (Figure 2).

For locating information about Jeffries Wyman, it is a pleasure to acknowledge the assistance of Charles P. Lyman and David Gunner of the Warren Anatomical Museum, Richard J. Wolfe of the Francis A. Countway Library of Medicine, and Barbara Wiseman of the Boston Museum of Science. Mr. Wolfe also granted permission to publish the quotations from Dr. Burton's letters to Jeffries Wyman.

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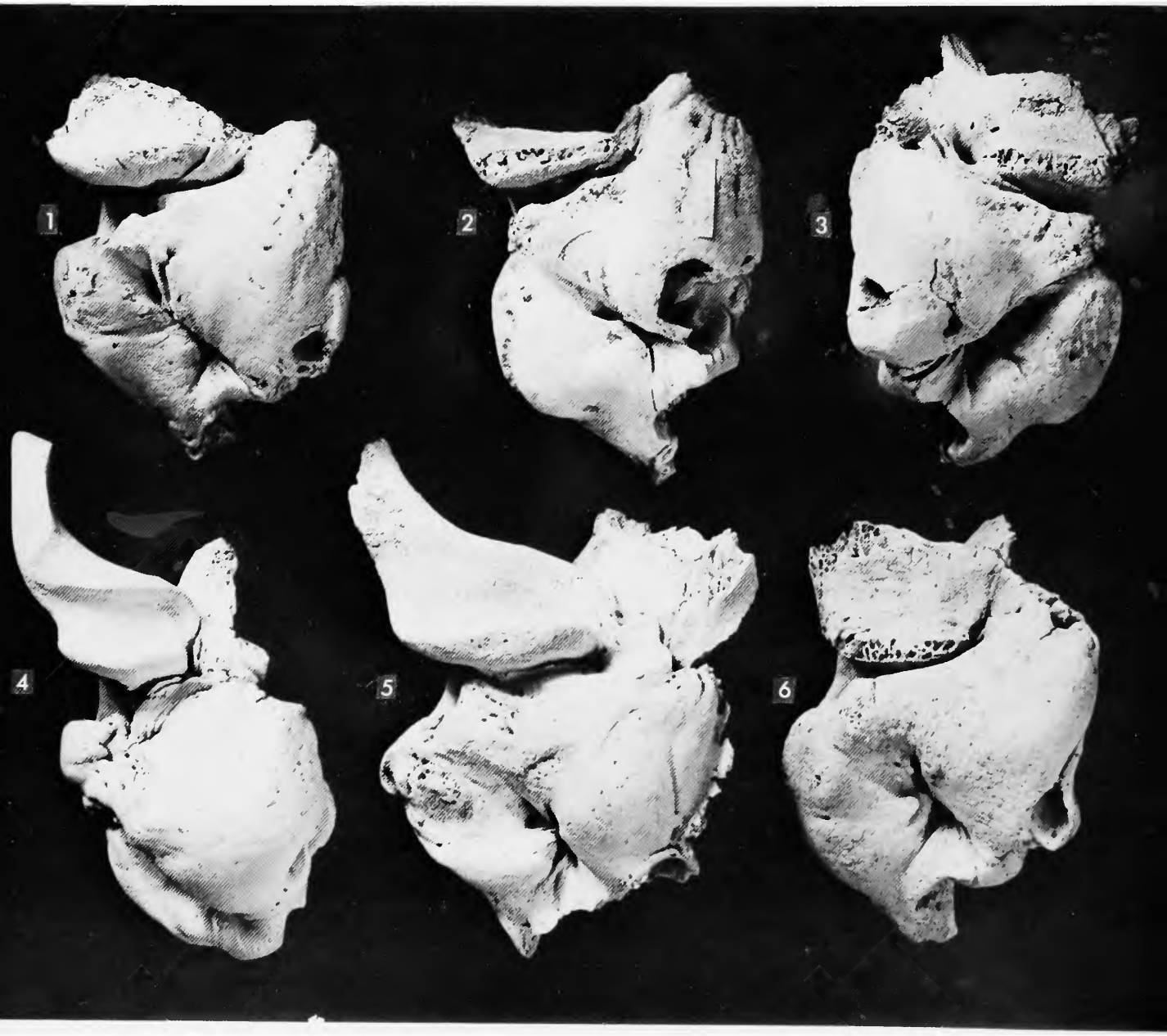

PLATE 1.—Temporal bones of some phocid seals in ventral aspect: 1, *Prionodelphis capensis,* cast of South African Museum L15652; 2, 3, *Monotherium? wymani,* holotype (part), MCZ 8741; 4, *Phoca groenlandica,* USNM 188766; 5, *Monachus schauinslandi,* USNM 243854; 6, *Callophoca obscura,* referred, Yorktown Formation of North Carolina, USNM 187581. (Right side except figure 3, all × 1.)

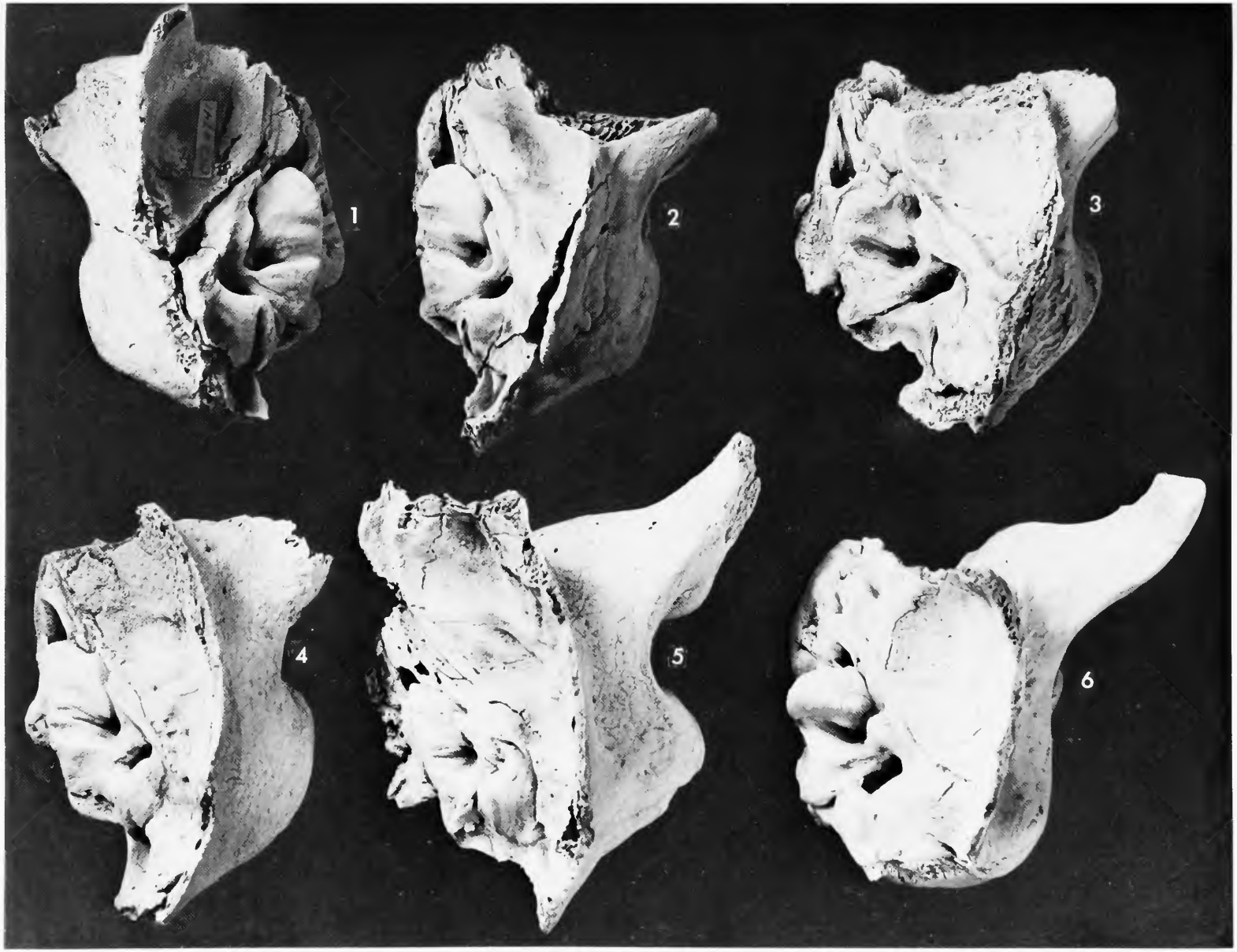

PLATE 2.—Temporal bones of some phocid seals in dorsal aspect: 1, 2, *Monotherium? wymani,* holotype (part), MCZ 8741; 3, *Prionodelphis capensis,* cast of South African Museum L15652; 4, *Callophoca obscura,* referred, Yorktown Formation of North Carolina, USNM 187581; 5, *Monachus schauinslandi,* USNM 243854; 6, *Phoca groenlandica,* USNM 188766. (Right side except figure 1, all × 1.)

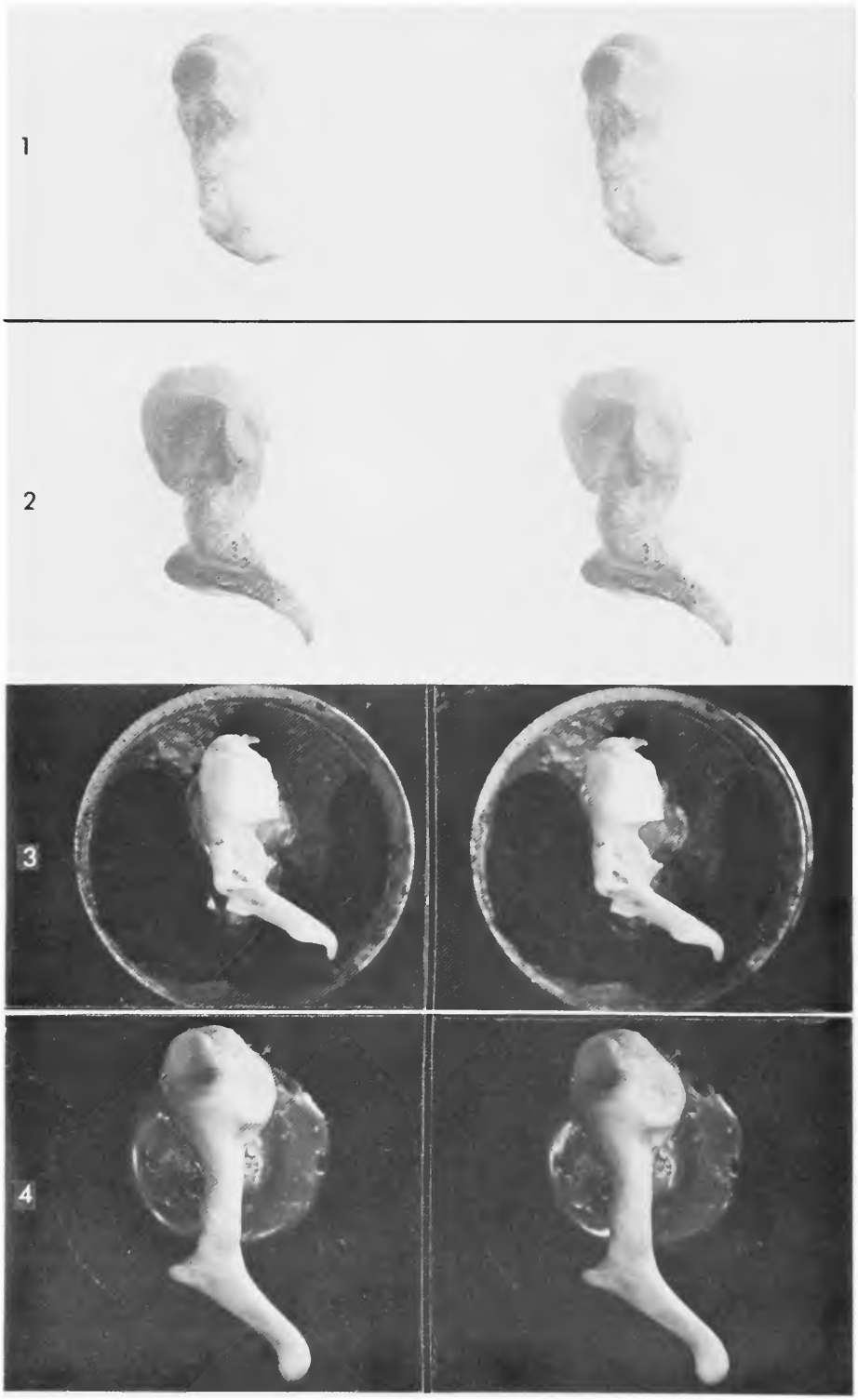

PLATE 3.—Stereophotographs of left mallei of some phocid seals, oriented with head toward top of page, articulating facets equally exposed to view, neck directed toward bottom of page, and neck and manubrium parallel to plane of page: 1, *Monotherium? wymani*, holotype (part), MCZ 8741; 2, *Callophoca obscura*, referred, Yorktown Formation of North Carolina, USNM 205516; 3, *Monachus schauinslandi*, USNM 243841; 4, *Cystophora cristata*, USNM 188963. (All approximately × 4.)

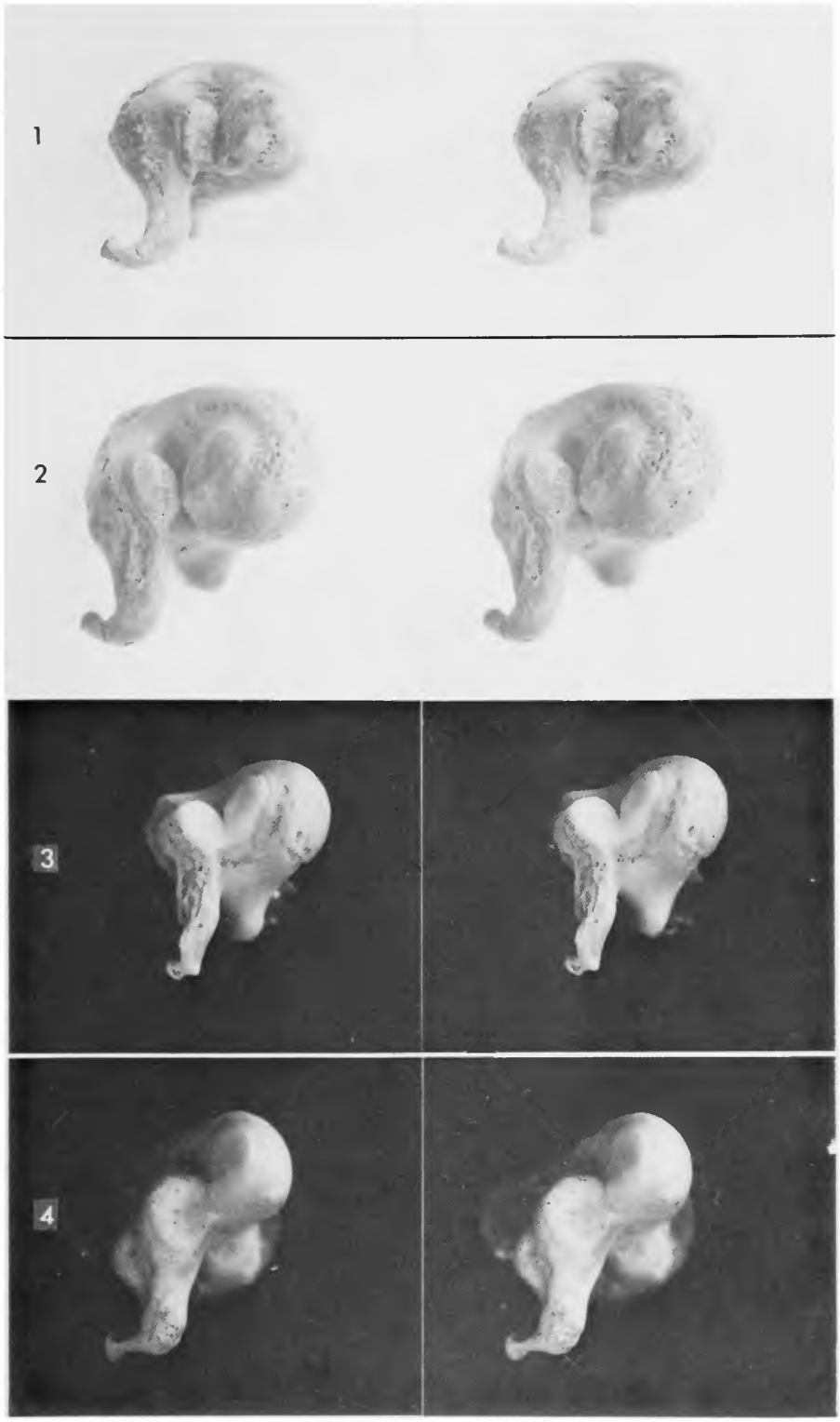

PLATE 4.—Stereophotographs of left incudes of some phocid seals, oriented with body toward top of page, articulating facets equally exposed to view, long process directed toward bottom of page, and long process parallel to plane of page: 1, *Monotherium? wymani*, holotype (part), MCZ 8741; 2, *Callophoca obscura*, referred, Yorktown Formation of North Carolina, USNM 205516; 3, *Monachus schauinslandi*, USNM 243841; 4, *Cystophora cristata*, USNM 188963. (All approximately × 4.)

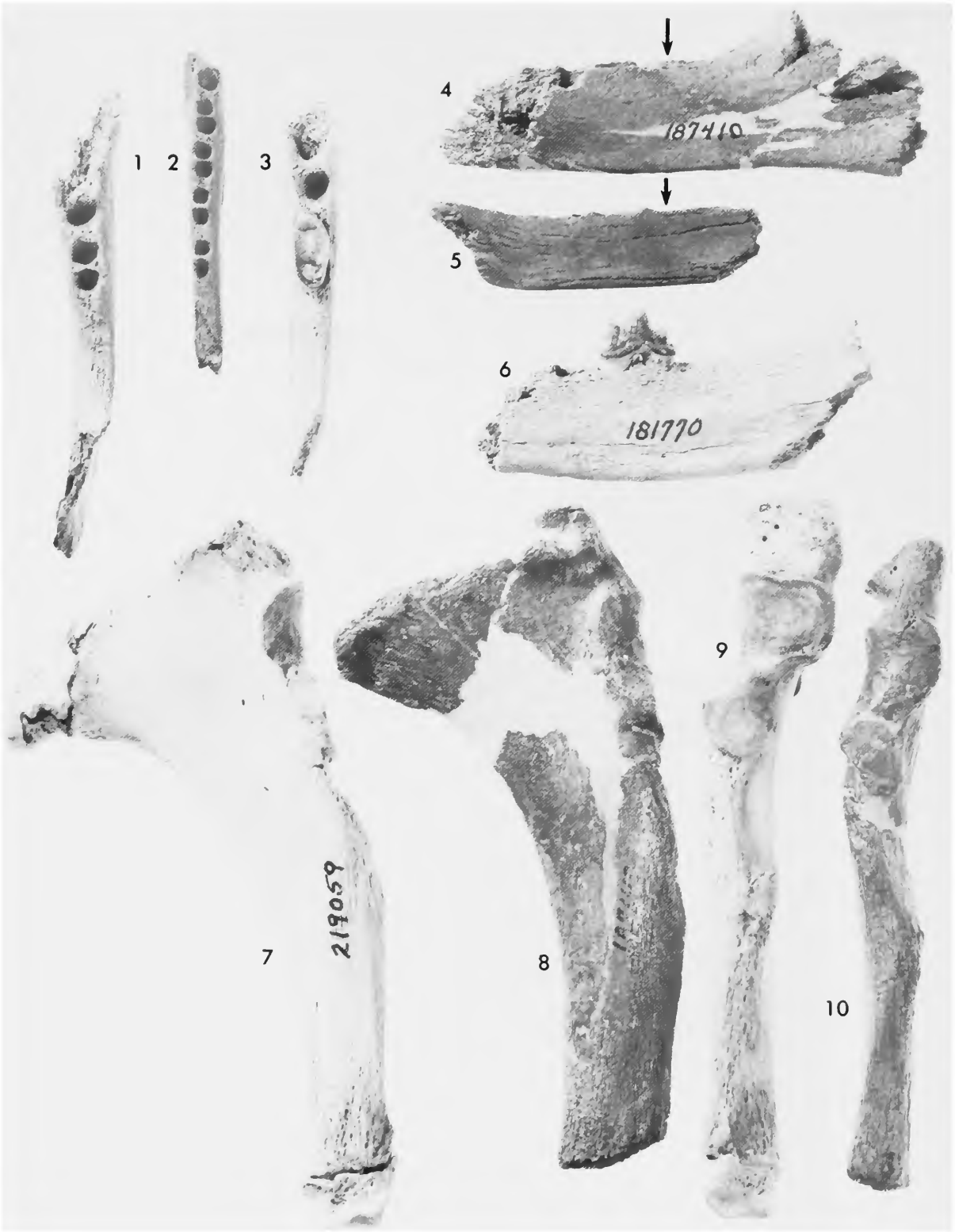

PLATE 5.—Right mandibular rami and left ulnae of some Monachine seals (× 0.75): 1, 4, *Monotherium? wymani,* incomplete right mandibular ramus, in occlusal and lingual aspects, USNM 187410 (part) (arrow in figure 4 indicates posteriormost alveolar border); 2, 5, *Leptophoca lenis,* incomplete right mandibular ramus, in occlusal and lingual aspects, private collection of Derek Siddons, from beach at Stratford Hall Plantation, Virginia, Calvert? Formation (arrow in figure 5 indicates posteriormost alveolar border); 3, 6, *Callophoca obscura,* referred, Yorktown Formation of North Carolina, incomplete right mandibular ramus with fifth postcanine, in occlusal and lingual aspects, USNM 181770; 7, 9, *Monachus monachus,* left ulna, in medial and cranial aspects, USNM 219059; 8, 10, *Monotherium? wymani,* left ulna, lacking distal epiphysis, in medial and cranial aspects, USNM 187410 (part).

PLATE 6.—Left tibiae and fibulae of some monachine seals in cranial aspect (× 0.75): 1, *Monotherium? wymani,* associated tibia and fibula, lacking distal epiphyses, and the fibula lacking part of shaft, USNM 187410 (part); 2, *Monotherium? wymani,* cast of distal fragment of fibula, USNM 214650; 3, *Monachus monachus,* tibia and fibula (fused proximally) USNM 219059.

PLATE 7.—Left tibiae and fibulae of some monachine seals in caudal aspect (× 0.75): 1, *Monotherium? wymani,* cast of distal fragment of fibula, USNM 214650; 2, *Monotherium? wymani,* associated tibia and fibula, lacking distal epiphyses, and the fibula lacking part of shaft, USNM 187410 (part); 3, *Monachus monachus,* tibia and fibula (fused proximally), USNM 219059.

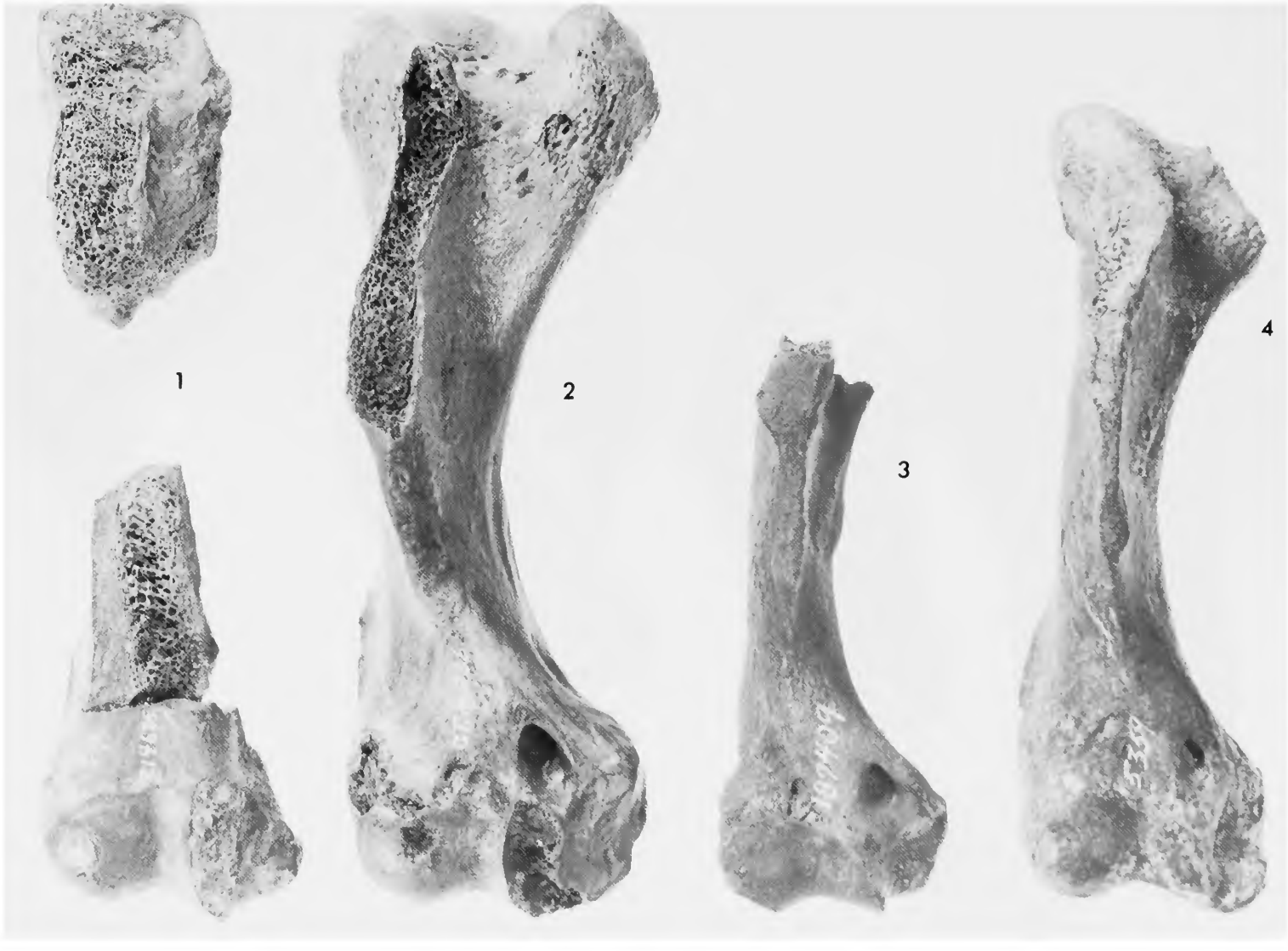

PLATE 8.—Right humeri of some phocid seals in cranial aspect (× 1): 1, *?Monotherium aberratum*, Gay Head Greensand, Martha's Vineyard, USNM 214625; 2, *Monotherium aberratum*, Diestian, Antwerp Basin, Institut Royal des Sciences Naturelles de Belgique, No. Ct. M. 266; 3, *Leptophoca lenis*, referred, lacking proximal end, Ballard Street locality, Richmond, Virginia, USNM 187409; 4, *Leptophoca lenis*, holotype, USNM 5359.

PLATE 9.—Right humeri of some phocid seals in lateral aspect (× 1): 1, *?Monotherium aberratum*, Gay Head Greensand, Martha's Vineyard, USNM 214625; 2, *Monotherium aberratum*, Diestian, Antwerp Basin, Institut Royal des Sciences Naturelles de Belgique, No. Ct. M. 266; 3, *Leptophoca lenis*, referred, lacking proximal end, Ballard Street locality, Richmond, Virginia, USNM 187409; 4, *Leptophoca lenis*, holotype, USNM 5359.

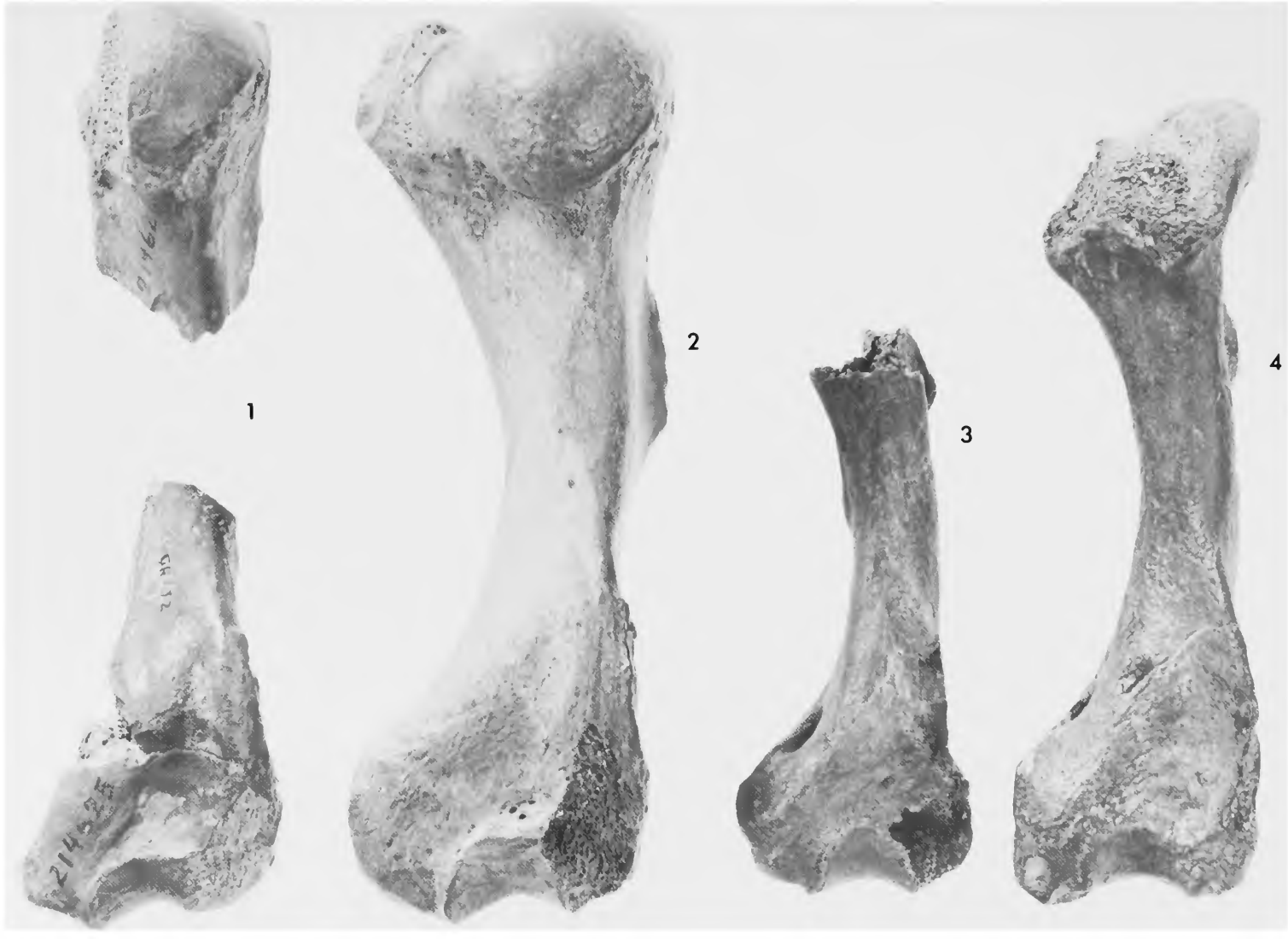

PLATE 10.—Right humeri of some phocid seals in caudal aspect (× 1): 1, *?Monotherium aberratum,* Gay Head Greensand, Martha's Vineyard, USNM 214625; 2, *Monotherium aberratum,* Diestian, Antwerp Basin, Institut Royal des Sciences Naturelles de Belgique, No. Ct. M. 266; 3, *Leptophoca lenis,* referred, lacking proximal end, Ballard Street locality, Richmond, Virginia, USNM 187409; 4, *Leptophoca lenis,* holotype, USNM 5359.

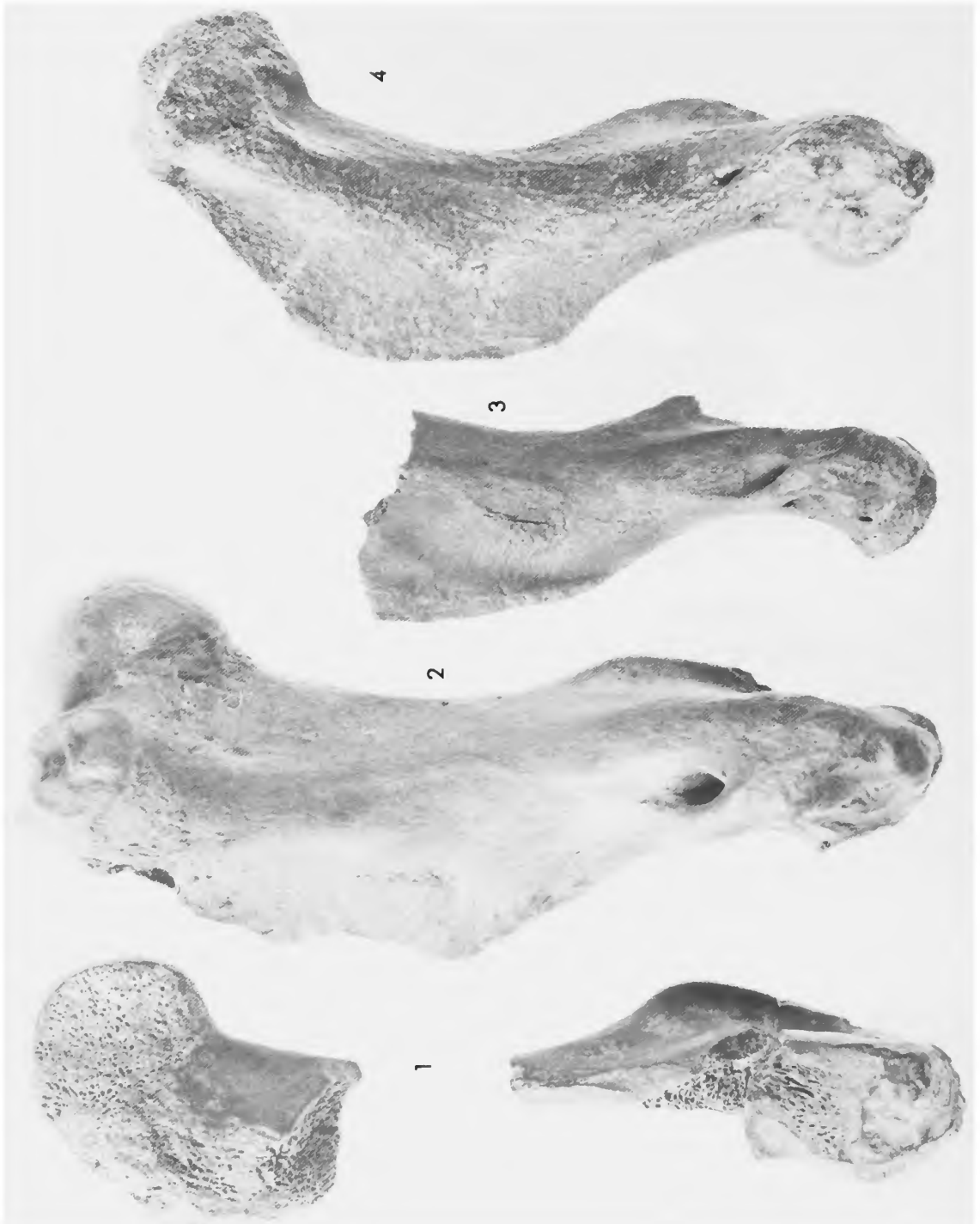

PLATE 11.—Right humeri of some phocid seals in medial aspect (× 1): 1, *?Monotherium aberratum*, Gay Head Greensand, Martha's Vineyard, USNM 214625; 2, *Monotherium aberratum*, Diestian, Antwerp Basin, Institut Royal des Sciences Naturelles de Belgique, No. Ct. M. 266; 3, *Leptophoca lenis*, referred, lacking proximal end, Ballard Street locality, Richmond, Virginia, USNM 187409; 4, *Leptophoca lenis*, holotype, USNM 5359.

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