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(WITH TWO PLATES)

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FOSSIL VERTEBRATES FROM THE MARINE PLEISTOCENE OF SOUTHEASTERN VIRGINIA

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and

PAUL DREZ
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ABSTRACT

Of 25 kinds of vertebrates recorded from the upper Pleistocene Kempsville Formation near Norfolk, Virginia, 2—the toadfish genus *Opsanus* and the gray seal *Halichoerus grypus*—are recorded for the first time as fossils, and 8—the menhaden *Brevoortia,* the angler *Lophius,* the cod *Gadus,* the sea robin *Prionotus,* the stargazer *Astroscopus,* the gannet *Morus bassanus,* the glaucous gull *Larus hyperboreus,* and the great auk *Pinguinus impennis*—are recorded for the first time as fossils in North America. Immature bones of gannet and gray seal indicate breeding grounds for these species far to the south of their present breeding limits. The walrus, *Odobenus rosmarus,* is recorded well south of its southernmost modern occurrence. The southerly occurrence of the northern species is probably correlated with southerly displacement of climatic belts during Pleistocene glaciation, but the evidence is inconclusive.

INTRODUCTION

Extensive construction work during recent years, especially in connection with the interstate highway program, has resulted in the excavation of large borrow pits as a source of fill in extreme southeastern Virginia, east of the Dismal Swamp, near Norfolk (Figures 1 and 2A). These pits are developed mainly in Pleistocene

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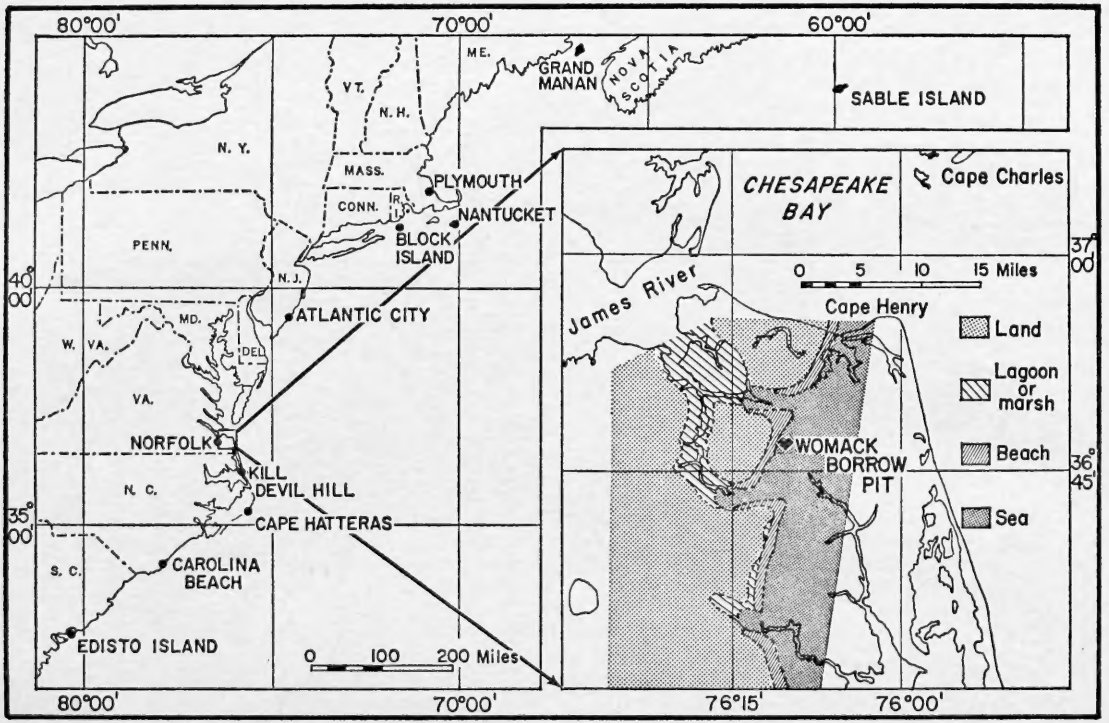
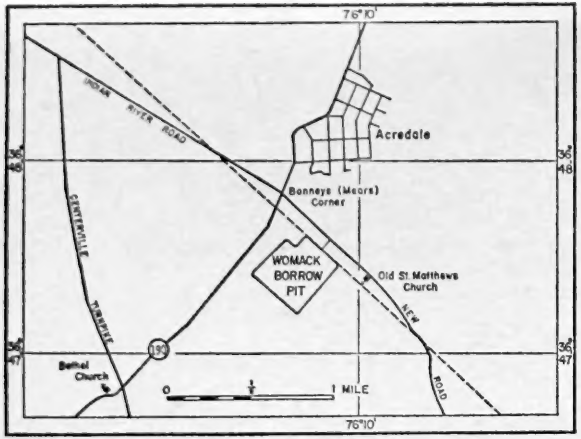


FIGURE 1.—A portion of the east coast of North America showing localities significant in relation to the southerly limits of *Odobenus rosmarus* and *Halichoerus grypus* during Quaternary time. The paleogeography of southeastern Virginia during Kempsville time and the principal fossil locality, the Womack borrow pit, are shown in the inset, adapted from Oaks, 1964, Figure 36, by permission of the author.



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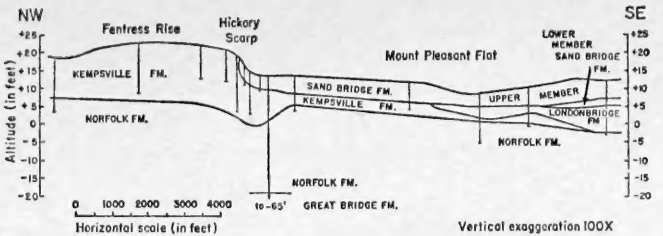

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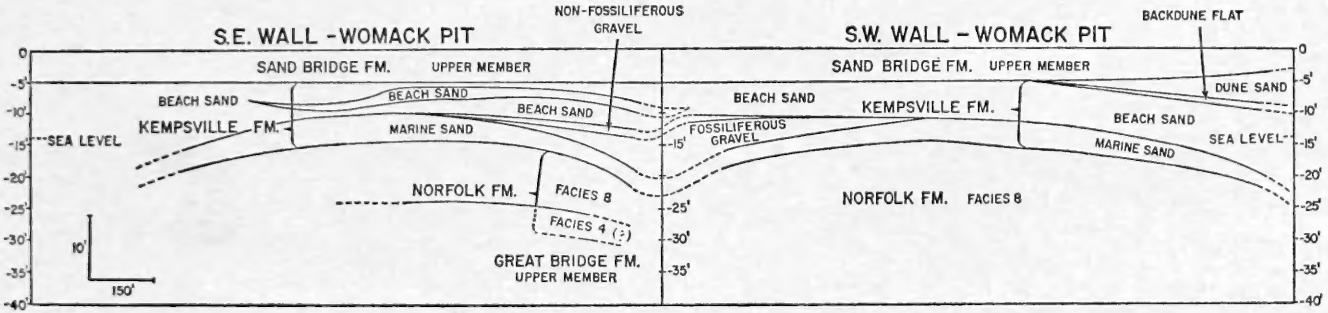

C

FIGURE 2.—**A**, Location of the Womack borrow pit in the Kempsville Quadrangle, Virginia. **B**, Geologic section along the broken line of Figure 2A. Adapted from Oaks, 1964, Figure 35, section II-II′, by permission of the author. **C**, Detailed geologic sections of the southeast and southwest walls of the Womack borrow pit, based on field work by Drez. The strata are described in Table 1.

marine beds of shallow-water deposition. Some of the strata are highly fossiliferous, primarily in marine invertebrates, but including as well remains of marine fishes, birds, and mammals. The purpose of the present communication is to report upon the vertebrate remains, excepting fish otoliths, collected thus far. Drez is responsible for the field work, including collecting and stratigraphic interpretation, carried out during 1966 and 1967; Dunkle is responsible for study of the fishes; Wetmore, the birds; and Ray, the mammals.

Virtually all of the vertebrate fossils were collected in the Womack borrow pit, 36° 47.5′ N., 76° 10.5′ W., located less than one-half mile south of Bonneys (Mears) Corner, in the Kempsville Quadrangle, Princess Anne County, Virginia, U.S. Geological Survey 7.5 minute series (topographic; Figure 2A). A very few specimens were collected in a pit approximately four miles due north of the Womack borrow pit, and one-half mile south-southeast of Davis Corner, also in the Kempsville Quadrangle.

ACKNOWLEDGMENTS

We wish to thank Dr. Robert Q. Oaks, Jr., of Utah State University, for his patient and detailed response to our many requests for assistance in interpreting the complex Pleistocene history of the Norfolk area. We are indebted to Mr. William H. Hale of Portsmouth, Mr. Don Ives of Norfolk, Mr. Warren C. Blow of Churchland, and Dr. Wiley S. Rogers of Old Dominion College for their assistance in adding specimens to the collection. Mr. E. Milby Burton of the Charleston Museum, Dr. E. A. Crawford, Jr., of Hampden-Sydney College, and Dr. Walter H. Wheeler of the University of North Carolina permitted publication upon specimens not previously reported in the literature. Dr. Arthur W. Mansfield of the Fisheries Research Board of Canada and Miss Barbara Lawrence of the Museum of Comparative Zoology provided modern comparative specimens of gray seal. Dr. Oaks and Dr. Frank C. Whitmore, Jr., of the United States Geological Survey have reviewed the manuscript critically. The figures were prepared by Mr. Lawrence B. Isham, scientific illustrator for the Department of Paleobiology, U. S. National Museum.

GEOLOGY

Fortunately, the geology of the Pleistocene deposits of the area has been studied recently in great detail (Oaks, 1964; Oaks and Coch, 1963), making it possible to place the fossils stratigraphically

with precision, and to approach the problems of their possible significance in local geologic history, paleogeography, and paleoecology. A revised report to be published by the Virginia Division of Mineral Resources is near completion at this time (Oaks, 1968, pers. comm.).

The regional setting has been outlined very well by Oaks (1964, p. 96) as follows:

> The exposed and near-surface stratigraphic units in southeastern Virginia consist of thin, widespread, and rather flat-lying unconsolidated sediments that range in age from Miocene to Recent. The top of the Upper Miocene Yorktown Formation serves as a convenient basal reference surface . . . by virtue of several distinctive properties that enable it to be distinguished from younger units in most places.
>
> In addition the Suffolk Scarp forms a natural stratigraphic boundary, separating the post-Miocene units into an older, more weathered, and more deeply dissected marine and nonmarine group in the west, and a younger predominantly marine group in the east . . . .
>
> The top of the Yorktown Formation slopes gently east and lies entirely below sea level east of the Dismal Swamp and Churchland Flat . . . . Above its deeply dissected surface lie six stratigraphic units that record a complex history of relative sea-level changes and shoreline evolution. This history includes three important periods of emergence and five distinct periods of submergence with sea level near or higher than the present one . . . . As such, therefore, each formation is a time-stratigraphic unit of probable substage value. From oldest to youngest the units are: Great Bridge, Norfolk, Kempsville, Londonbridge, Sand Bridge, and Recent.

The Great Bridge, Kempsville, Londonbridge, and Sand Bridge Formations were named by Oaks and Coch (1963), and these and the Norfolk and Recent Formations have been described in detail by Oaks (1964). Field relationships are shown in Figure 2B.

The ages of the five post-Yorktown, pre-Recent formations are as yet imprecisely known. Radiocarbon dates of greater than 40,000 years B. P. have been obtained from the Sand Bridge, Kempsville, and probable equivalents of the Norfolk and Great Bridge (greater than 47,000) Formations, indicating that all are mid-Wisconsin or older in age (Stuiver et al., 1963, p. 321; Oaks, 1964, table 2). Invertebrate faunal evidence indicates that the Norfolk and Great Bridge Formations are Pleistocene in age (Oaks, 1964, p. 198). On the basis of the meager amount of weathering shown in the post-Yorktown formations, Oaks (1964, pp. 202, 223) considered it likely that they are no older than Sangamon in age. He pointed out, however, that the considerable amount of post-Kempsville erosional dissection conflicts with the evidence from weathering and

suggests a possibly pre-Sangamon age for the Kempsville, Norfolk, and Great Bridge Formations.

On the assumption that the submergences responsible for deposition of the marine beds were caused primarily by glacio-eustatic rises in sea level, Oaks (1964, p. 223; Oaks and Coch, 1963, p. 982; Oaks, 1967, pers. comm.) tentatively considered the marine formations to be interglacial in age, deposited during high stands of sea level, and most likely of Sangamon interglacial age. He is, however, fully aware of the complexities of the problem, including the possible modifying influence of crustal warping (1964, p. 185), and he and others continue to study the problem.

Most of the vertebrate fossils, and essentially all of those both closely identifiable and with precise stratigraphic data, were collected from the Kempsville Formation, the type section of which is in the Womack borrow pit (Oaks, 1964, p. 128; Appendix A, p. 8). Our Table 1 applies only to the Womack borrow pit, in particular

TABLE 1.—*Lithology of Pleistocene sediments in the Womack borrow pit, Princess Anne County, Virginia. The described layers correspond to those in Figure 2.*

Sand Bridge Formation, upper member—clayey silt facies:
Dark gray to yellow brown, stiff clay to clayey silt, with some minor sand and gravel near the base. Some mottling can be seen on fresh surfaces.

Kempsville Formation—beach sand layer:
White to light yellow, medium to coarse beach sand, except near the top on the southeast wall, where it grades into light bluish gray sand. Some unoxidized imprints of leached *Spisula* sp. shells occur in the upper part of the light bluish-gray sand. Some fine dune sand occurs in the western part of the pit, at the top of the layer.

Kempsville Formation—beach sand lense:
Light brown medium to coarse sand with some small gravel near the base. Lenses of lighter colored sand are present in places.

Kempsville Formation—dune sand layer:
Yellow, highly oxidized fine to very fine dune sand. Some lenses of peat and lagoon clay occur near the base of the layer.

Kempsville Formation—backdune flat (?) layer:
Medium- to fine-grained brown sand. Small amounts of peat, silt, and plant fragments are intermixed with the sand. Unoxidized imprints of leached shells occur in the bottom part of this layer.

Kempsville Formation—nonfossiliferous gravel layer:
White to light gray, coarse sand and gravel. The texture of the sediments

is coarser at the bottom of this layer, where it grades into the fossiliferous gravel below.

Kempsville Formation—fossiliferous gravel layer:
White, gray to brown, coarse sand and gravel. Invertebrate fossils are generally broken and water-worn, but exceptional, well-preserved specimens are found, especially near the base of the layer. Some burrowing species of pelecypods are found in the base of this layer, in their growing positions. Iron oxidation layers are found here and there throughout the gravel, but become very numerous towards the western end of the layer, where they act as a cementing agent in the gravel.

Kempsville Formation—marine sand layer:
Medium to very coarse, light gray sand with minor gravel. The small, opaque gravel outlines the steep cross laminations in this layer, especially in the southeast wall. The layer is very fossiliferous, especially near the base. The sand is mixed with fine sand and silt, and is nonfossiliferous in the western end of the pit. Only burrowing types of invertebrates are found complete and articulated.

Norfolk Formation—facies 8 (of Oaks, 1964, p. 121):
Light blue gray, fine- to very fine-grained sand with some silt. Highly fossiliferous in the upper part of the bedding. A worm-tube reef occurs in the upper two to four feet throughout most of the pit. Invertebrate fossils are commonly found in their living positions and complete.

(?) Norfolk Formation—facies 4 (of Oaks, 1964, p. 118):
Soft, blue gray, clayey to silty, fine- to very fine-grained sand. Most fossils are found in their living positions and complete. A very restricted, yet sporadically abundant, invertebrate fauna occurs in this facies. (This layer may in fact represent the upper member of the Great Bridge Formation.)

Great Bridge Formation—upper member:
This layer is not presently exposed in this pit, but is known from past dredgings at the bottom of the pit. It is composed of greenish brown, silty clay to clayey silt, with occasional very fine-grained sand. The fauna from this layer is also restricted and is composed of only a few species. Invertebrate fossils occur sporadically, but in certain areas cluster in great numbers.

to the exposures in the southeast and southwest walls, shown in section in Figure 2C. The fish remains occur both in the fossiliferous gravel layer (Figure 2C) and in the marine sand layer, most abundantly in the latter, along with well-preserved fossil crabs. The remains of birds and mammals occur principally in the lower six inches of the fossiliferous gravel layer, which contains also an abundance of coarse shell detritus. The greatest concentration of bones is in the channel indicated on our section (Figure 2C) and

referred to by Oaks (1964, p. 137) as a possible stream channel developed in the top of the Norfolk Formation, possibly during a short post-Norfolk, pre-Kempsville emergent episode. Oaks (1968, pers. comm.) now feels that a marine origin is more probable, possibly as a "tide-rip channel along the base of the beach face, or as a tidal channel just landward of a small emergent beach ridge." One of us (Drez) has observed recently that the worm-tube layer, which occurs only in the upper few feet of the Norfolk Formation, is present at the bottom of the channel, indicating that the channel was developed prior to the close of Norfolk time. Some of the bones in the channel, including long, slender bird bones, were found unbroken in vertical position, suggesting rapid deposition. The existence of the channel may have been responsible for the concentration of debris including the vertebrate remains. Many bones occurring beyond the limits of the channel were found along the bedding plane between the marine sand and beach sand layers.

ANNOTATED LIST

Some 161 fossil specimens have been examined in this study, of which approximately 82 represent fishes, 35 birds, and 44 mammals. Of the total, approximately one third (29 of fishes, 21 of birds, 7 of mammals) have been identified with reasonable assurance, at least to the generic level. Of the 25 kinds of vertebrates that have been recognized, 14 are fishes, 7 are birds, and 4 are mammals. Generic references among the fishes are based on labeled specimens in the osteological collections of the Division of Fishes, U.S. National Museum. Romer (1966) has been followed for classification of the fishes; Grassé (1958) and Romer (1966) in general for their geologic distribution; Bigelow and Schroeder (1948, 1953A, 1953B), Grassé (1958), and Hildebrand and Schroeder (1928) in general for their geographic distribution.

Class CHONDRICHTHYES

Order SELACHII

Family CARCHARIIDAE

Carcharias sp.: Sand shark.

The sand shark is represented by a single lower tooth (USNM 25110). Elsewhere in North America fossil teeth of sand sharks are recorded in marine, coastal sediments of Upper Cretaceous to

Pleistocene age from New Jersey to Florida and Texas, and of Miocene to Pleistocene age in California. Presently in the Western Atlantic they appear to be coastal forms distributed from the Gulf of Maine to the east coast of Florida. In summer the greatest concentration of numbers of individuals has been observed in the area between Cape Cod and Delaware Bay.

Family CARCHARHINIDAE

Carcharhinus sp.: Gray shark.

This genus is represented by one upper (USNM 25112) and two lower teeth (USNM 25111, 25126). The numerous members of this largest family of sharks present a bewildering variation of detail in dental characters, which has always made the identification of dissociated fossil elements difficult. The present generic reference, therefore, is used in its broadest taxonomic sense. The overall geologic range of the family is from the Upper Cretaceous onward. The largest populations of living forms are in the tropical and semi-tropical belts of the earth. In the Western Atlantic several well-defined species of *Carcharhinus* combine habits of incursion into coastal, shoal environments with northern migration during warm seasons as far as Cape Cod.

Order BATOIDEA

Family RAJIDAE

Raja sp.: Skate.

The collection includes a single recurved spine (USNM 25080) such as occurs in batteries on the pectoral fins of the skate. Material evidences of the geologic history of the skates are limited, although well-preserved specimens of *Cyclobatis* from Lebanon demonstrate existence of the family in the Upper Cretaceous. Fragmentary remains attributed to *Raja* are recorded from the Eocene and Miocene of North America. A number of species of skates are normal inhabitants of the coastal waters of Virginia at the present time. Collectively, these have overlapping, temperate distributions from the Gulf of St. Lawrence to Florida.

Family DASYATIDAE

Dasyatis sp.: Sting or whip ray.

A stinging barbel of the tail (USNM 25073) and a pavement tooth (USNM 25074) are assigned to the genus *Dasyatis*. The

barbel probably is derived from the Norfolk Formation, and the tooth probably from the Great Bridge Formation. On a cosmopolitan basis, dasyatid rays appeared in the Lower Cretaceous. In North America their fossil remains have been recognized in a variety of marine to freshwater sediments of Eocene to Pleistocene age. Recent distribution is generally coastal in the tropical and subtropical zones. In warm season migratory appearances several species coexist in any given area between southern New England and Uruguay.

Family MYLIOBATIDAE

Myliobatis sp.: Eagle ray.

Myliobatis is identified on the basis of four of the characteristic crushing teeth of the principal row (USNM 25113). The oldest known eagle rays are of Upper Cretaceous age in both the Eastern and Western Hemispheres, and their fossil remains are of common and widespread occurrence throughout the marine Cenozoic. Two living species of *Myliobatis* inhabit the continental-shelf waters of the Western Atlantic from Cape Cod to Brazil.

Class OSTEICHTHYES

Order CLUPEIFORMES

Family CLUPEIDAE

Brevoortia sp.: Menhaden.

Specimens identified are a preoperculum (USNM 25064) and an operculum (USNM 25065). The genus is known from the Pliocene of North Africa but is previously unrecognized as a fossil in North America. Its Recent distribution in the Western Atlantic is from Brazil to Nova Scotia.

Order BATRACHOIDIFORMES

Family BATRACHOIDIDAE

Opsanus sp.: Toadfish.

The toadfish is included on the basis of a neurocranium (USNM 25114) and a right lower jaw (USNM 25115). The family dates back to the Miocene, but this genus has no detected fossil record. It is presently distributed in the Western Atlantic from the Gulf of Maine to the West Indies.

Order LOPHIIFORMES

Family LOPHIIDAE

Lophius sp.: Angler.

A fragmentary left dentary and a left scapulocoracoid (both USNM 25071) are referred to the angler. *Lophius* has a fossil record in the Eastern Atlantic that dates from the Eocene, but the genus is previously unreported from North America. It presently occurs from Newfoundland to North Carolina in shallow coastal waters and southward to Barbados in colder, deep water.

Order GADIFORMES

Family GADIDAE

Gadus sp.: Cod.

The cod is represented by an essentially complete skeleton (USNM 25079), a right scapulocoracoid (USNM 25076), a right maxilla (USNM 25077), and a right ceratohyal (USNM 25078). The geologic history of this genus dates from the Paleocene of Europe but is previously unreported in the fossil records of North America. It is presently distributed from Greenland to North Carolina in the Western Atlantic.

Order SCORPAENIFORMES

Family TRIGLIDAE

Prionotus sp.: Sea robin.

The genus *Prionotus* is identified on the basis of four fragmentary neurocrania (USNM 25075). In North America a related genus, *Trigla,* is alone known as a fossil from the Pleistocene. *Prionotus* is presently distributed in coastal waters from Massachusetts Bay to the Carolinas.

Order PERCIFORMES

Family LUTIANIDAE

Lutianus sp.: Snapper.

The genus is represented by a right premaxilla (USNM 25066). The family history of the snappers dates back to the Eocene of Europe but is known in North America only by a single representative from

the Oligocene of Florida. In recent distribution *Lutianus* ranges from Brazil to Massachusetts. Occurrences north of Florida, however, are regarded as strays.

Family SCIAENIDAE

Sciaenops sp.: Red drum.

A single right dentary (USNM 25067) is identified as that of the red drum. The oldest occurrences of this genus are of Oligocene age in both Europe and North America. Recent distribution in continental-shelf waters of the Western Atlantic is from Massachusetts to Texas.

Family SPHYRAENIDAE

Sphyraena sp.: Barracuda.

The barracuda is represented by a left dentary (USNM 25063). The genus has been reported from the Eocene of Europe and Africa but is not recognized earlier than the Pleistocene in North America. In its present distribution from Panama to Cape Cod it is only rarely observed north of Florida.

Family URANOSCOPIDAE

Astroscopus sp.: Stargazer.

An otico-temporal portion of a neurocranium (USNM 25068) is referred to the genus *Astroscopus*. The stargazer family has a fossil record that dates from the Eocene of Europe but is previously unreported from North America. A single species, *A. guttata,* presently inhabits coastal waters between New York and Virginia.

Class AVES

Order PODICIPEDIFORMES

Family PODICIPEDIDAE

Podiceps auritus (Linnaeus): Horned grebe.

Three bones represent this grebe: a left tarsometatarsus (USNM 25225), the proximal end of a left tibiotarsus (USNM 25092), and a right humerus with the distal end missing (USNM 25097).

The species is distributed worldwide throughout the temperate regions of the Northern Hemisphere. In modern times it is regular as

a winter visitor in Virginia especially in tidal waters near the coast, less often inland during migrations. As a fossil it has been reported from the Pleistocene of Tennessee and Florida in North America, and from Italy, Hungary, and Mongolia in Europe and Asia.

Order PELECANIFORMES

Family SULIDAE

Morus bassanus (Linnaeus): Gannet.

The gannet, common now as a winter visitor at sea along the present Virginia coast, has the most extensive representation among the birds found in the deposit. The bones recovered include a pelvis, fairly complete, three left humeri, a right ulna (broken), the distal end of a right radius, the shafts of two right femora, and a right tarsometatarsus (USNM 25081-25087). One humerus, obviously adult, has the side of the head broken, but otherwise is fairly complete. Another is of interest in that it is from an immature bird somewhat more than three-quarters grown, but obviously an individual as yet unable to fly. The bone appears somewhat porous, with the articulation at either end not fully developed. The contour and curvature of the shaft are identical with that of the adult, as is the location of the nutrient foramen near the center, so that there is no question as to identification. The third humerus, in which most of the head is lacking, is of adult size and is considerably worn. The surface appears slightly porous under a hand lens, possibly indicating that while from an individual equal in size to an adult, it had only recently grown to that stature. The implication is that the gannet during the time represented in the Pleistocene was a breeding species on the coast of Virginia. At present these birds nest only in the north, on rocky islands along the coasts of Quebec and Newfoundland, and also of Iceland, the Faeroes, and at a few localities around the coasts of the British Isles and Ireland.

While this is the first report of the gannet from the Pleistocene of North America, its bones have been reported from deposits of this epoch in Norway and Denmark.

Family PHALACROCORACIDAE

Phalacrocorax auritus (Lesson): Double-crested cormorant.

A right tibiotarsus (USNM 25093) is complete except for some wear on the articular ends. It is of maximum size for this species, agreeing thus with the modern northern population recognized as the

nominate subspecies. The shaft of another right tibiotarsus (USNM 25094) is considerably worn.

The species has been recorded from the Pleistocene of Oregon, Idaho, California, Nevada, and Florida.

Branta bernicla (Linnaeus): Brant.

A broken pelvic girdle (USNM 25095) includes the fused vertebrae of the synsacrum complete, most of the anterior ends of the two ilia, the complete acetabulum on both right and left sides, and the anterior ends of right and left pubis. The appearance is that of an adult individual similar in its details of form to modern examples.

The brant, of common occurrence in Virginia in the historic period to the end of the 19th century, at present is a regular migrant, but in smaller numbers than formerly. As a breeding species it is found along Arctic coasts of North America and Eurasia. It has been recorded from the Pleistocene of Oregon and California, and from England, Denmark, Malta, and Hungary in Europe. The specific name here is used as including the darker plumaged population of western North America and eastern Asia, at one time considered a separate species.

Order CHARADRIIFORMES

Family LARIDAE

Larus hyperboreus Gunnerus: Glaucous gull.

A right humerus with the distal end missing (USNM 25096) agrees in size and detail with the present species, among the larger members of the family. The glaucous gull now nests from Alaska, Ellesmere Island, northern Greenland, Iceland, and the Arctic coast of Siberia, south to Labrador and southern Greenland. In winter it ranges regularly southward along the eastern coast of the United States to Long Island, and casually to Florida.

The present report is the first for the Pleistocene in North America. In western Europe it is recorded from this epoch at Bohuslänska Tapebank, Sweden.

Family ALCIDAE

Pinguinus impennis (Linnaeus): Great auk.

A right tarsometatarsus (USNM 25089), complete except for the posterior surface of the upper end, another (USNM 25134) some-

what worn, and a right coracoid (USNM 25090), with the upper and lower ends much worn, are of adult size. A second right coracoid (USNM 25135), also with the surface and extremities somewhat eroded, is of smaller size.

The great auk, a flightless marine species, largest of its family, within historic times nested on Funk Island off Newfoundland, on islands on the coast of Iceland, the Faeroes and St. Kilda, probably also (but uncertainly) elsewhere off Greenland, the Orkneys, and other remote islands of this North Atlantic area. Due largely to persecution on its nesting grounds it was reduced in numbers by the beginning of the 18th century. The last known living bird was taken on June 3, 1844, on Eldey south of Iceland.

Bones of the great auk have been found in prehistoric archeological deposits along the Atlantic coast of the United States in Massachusetts and Florida. The present record is the first from the Pleistocene in North America, and also is the first definite report of the species for the State of Virginia. In western Europe it is recorded from the Pleistocene in Norway, Sweden, Denmark, Ireland, Gibraltar, and Italy.

Uria aalge (Pontoppidan) : Common murre.

This species, of wide distribution across the North Atlantic, and also in the North Pacific, is represented by a complete right tibiotarsus (USNM 25091). This is the first record of its occurrence in Virginia. It is known elsewhere in North America from the late Pleistocene of the coast of California, and in western Europe from Ireland, England, Norway, Denmark, and Gibraltar.

In winter it ranges offshore casually to Massachusetts, New York, and New Jersey. There is a record of occurrence in an archeological deposit in Florida dated about 1000 A.D.

Class MAMMALIA

Order CETACEA

A single, incomplete, somewhat water-worn rib, measuring 72.5 mm. in total length, represents a large mysticete whale. The specimen was collected from facies 8 of the Norfolk Formation on the southwest wall of the Womack borrow pit (Table 1 and Figure 2).

An incomplete lumbar vertebra from facies 8 of the Norfolk Formation and a single sternal element from the fossiliferous gravel layer of the Kempsville Formation, both in the Womack borrow pit, pertain to porpoises of some kind, but are not more closely identified.

Order PINNIPEDIA

Family ODOBENIDAE

Odobenus rosmarus (Linnaeus): Atlantic walrus.

The walrus is represented by only one specimen of known provenience: a baculum lacking both extremities (USNM 24864) collected from the fossiliferous gravel layer of the Kempsville Formation in the Womack borrow pit.

A second specimen possibly derived originally from one of the local borrow pits is an incomplete left maxilla with three cheek teeth (USNM 24808). It was found "behind the Princess Anne Plaza shopping center," Virginia Beach, presumably in fill, by a local school boy, who took it to the Department of Geology, Old Dominion College, by whom it was subsequently presented to the U.S. National Museum through the efforts of Dr. Wiley S. Rogers and Mr. Warren C. Blow. The specimen is somewhat water worn, permineralized, blackened surficially, and pitted by marine boring organisms, in all of which it is dissimilar to other mammalian bones from the Kempsville Formation, and similar to many vertebrate fossils, including walruses, dredged off the Atlantic coast.

These specimens as well as many others from the Atlantic coast are not specifically identifiable on strictly morphological grounds, but are referred to *O. rosmarus* on the premises that Atlantic and Pacific walruses are conspecific, and that the fossils are indistinguishable from corresponding elements of the living species. The supposed extinct North Atlantic subspecies described by Kardas (1965) under the name *O. obesus antiquus* is regarded as conspecific with the living *O. rosmarus,* and of doubtful validity as a subspecies.

Remains of walruses definitely referable to the living species are not uncommon near the strand line or on the shallow shelf along the east coast south to southern Virginia and northern North Carolina as far as Kill Devil Hill (Figure 1). Cranial fragments less certainly referred to *O. rosmarus* on morphological grounds are known from off Cape Hatteras (University of North Carolina collections, Wheeler, 1968, pers. comm.), from Carolina Beach (Charleston Museum), and from Edisto Island (collection of E. A. Crawford, Jr.). Other published records for more southerly localities, in South Carolina and Georgia (e.g., Manville and Favour, 1960), are not supportable, as will be shown elsewhere in detail (Ray, MS.).

Although a single southerly fossil record for walrus may be explained away as a wanderer (with difficulty in view of the improb-

ability of discovery), the several records near and to the south of Norfolk indicate that the area was within the normal range of *O. rosmarus* during at least part of the Pleistocene. It may be suggested also that the walrus was a regular member of the fauna off southeastern Virginia during Kempsville time, although more specimens are required to demonstrate the case.

The walrus bred within historic time south to Sable Island (Figure 1), almost 500 miles north of Norfolk. A single live specimen reported at Plymouth, Massachusetts, in 1734 (Allen, 1930), is of little zoogeographic significance since it represents an isolated southerly occurrence.

Family PHOCIDAE

Halichoerus grypus Fabricius: Gray seal, horsehead.

Plates 1 and 2

Some 36 specimens, representing the great majority of mammalian bones in the collection, are definitely referable to the family Phocidae, and of these most are more or less certainly referable to the tribe Phocini. All specimens are from the Womack borrow pit, excepting a third metatarsal and a partial left ulna from the pit near Davis Corner. All specimens of known horizon are from the Kempsville Formation, mostly from the lower six inches of the fossiliferous gravel layer in the channel (Table 1; Figure 2C), excepting a single third metacarpal from facies 8 of the Norfolk Formation near the middle of the northeast wall of the Womack borrow pit. Neither of these metapodials has thus far been definitely identified, owing to the inadequacy of comparative material, although one or both may represent gray seal.

At least one skeleton of every phocid genus (sensu Scheffer, 1958) has been available for comparison. *Halichoerus* is represented in the U.S. National Museum collections by several skulls and by a single, highly incomplete skeleton, USNM 218323, a male, which was available a few years ago but has now been misplaced. Two mandibles and a skull with mandible (now USNM 395049) of juvenile individuals were provided by Dr. Arthur W. Mansfield, and a skeleton of an adult female (Museum of Comparative Zoology no. 51488) was loaned by Miss Barbara Lawrence. However, in view of the immaturity of many of the fossil elements, and in view of the generally great sexual and ontogenetic (and probably individual) variation in seals, even small series of skeletons of each species would hardly be sufficient for positive identification of many specimens.

Possession of the general characters of the tribe Phocini, but exclusion from most Phocini other than *Halichoerus* on the basis of large size and details of morphology, together indicate that most if not all of the phocid remains will probably prove to represent *Halichoerus grypus* when adequate comparative material is available.

Meanwhile, a few cranial elements are referred with confidence to *Halichoerus grypus.* These include a partial left mandibular ramus with the canine of a juvenile individual (USNM 24860), a partial left mandibular ramus lacking teeth (USNM 24861), a left auditory region with squamosal (USNM 24862), and a fragment of the left side of the occiput (USNM 24863).

The specimen of greatest interest is USNM 24860 (Plate 1, figures A, C, and E), which proves to be the jaw of a suckling pup. It is closely comparable to the jaw of USNM 395049 (Division of Mammals), which according to Dr. Mansfield is a one-week-old pup (Plate 1, figures B, D, and F). Also the fossil is almost identical to the jaw of a pup (killed with its mother) illustrated by Ball (1838, pl. III, fig. 7), and to that of a "ganz jungen" individual illustrated by Broch (1914, fig. 3a). Examination of the well-preserved canine of the fossil in the light of the careful studies by Hewer (1964) of development of the inferior canine in *Halichoerus grypus* confirms that the animal must have been a neonate, or at most a few days old. The canine consists of a thin cone, 22 mm. in length, composed of enamel and foetal dentine only, without trace of the pup dentine developed during the nursing period (see Hewer, 1964, fig. 1). That the individual did not die as a foetus is confirmed by the eruption of the permanent teeth (Davies, 1957, p. 307).

The present record seems to be the first report of indisputable Pleistocene fossil material of *Halichoerus,* although a humerus, radius, and ulna from Pleistocene brick clays at Dunbar, Scotland, may be referable to this form (Kellogg, 1922, p. 81). Other prehistoric records are for subfossil and midden remains in Europe (Clark, 1946; Lepiksaar, 1964), and midden remains in North America (Waters, 1967).

In this context may be mentioned a previously unrecorded specimen, representing a large member of the tribe Phocini, and consisting of a partial right innominate bone (Charleston Museum no. 51.23.1; USNM, cast, 19118), rather well preserved but lacking the margins of the everted portion of the iliac blade and the posterior extremities of the ischium and pubis (Plate 2). The specimen was collected at Edisto Island, South Carolina, and is almost certainly Pleistocene in

age. It is well mineralized and mottled black in surface staining but light tan internally on a freshly broken surface.

Members of the tribe Phocini are unique among pinnipeds in the structure of the ilium. In all living Phocini, and in no other pinnipeds, the free iliac blade is powerfully everted anterior to the sacroiliac articulation, and the central area of the everted blade is reduced to a very thin plate, bordered dorsally and ventrally by strong buttresses arising from the body of the ilium anterior to the acetabulum. The combined result of eversion, central thinning, and buttressing is the formation of a deep fossa on the lateral surface of the ilium. In all other pinnipeds the iliac blade remains thick anteriorly, and is everted little (Erignathini, Monachinae, Cystophorinae) or not at all (Otarioidea).

The fossil innominate is larger than that of any modern member of the Phocini examined. It is closely approached in size only by the innominate of USNM 218323, *Halichoerus grypus,* male, with vertebral epiphyses not tight. The minor disparity in size and the few morphological differences separating the two could well be due to ontogenetic or individual variation. The specimen is tentatively referred to *Halichoerus grypus.*

In the western North Atlantic today the gray seal maintains a tenuous southerly breeding outpost on small islets off Nantucket (Baxter, 1963; Hanley, Drury, and Roth, 1964; Drury, 1965; Andrews and Mott, 1967), but otherwise breeds south only to Grand Manan and Sable Islands (Mansfield, 1966, p. 163). Although the present population off Nantucket is marginal and may not have been continuous throughout modern time, the frequency of gray seal remains in archeological sites in southern New England (Waters, 1967) suggests that the natural southern breeding limit in Recent time may have been Long Island Sound.

As with other pinnipeds occasional wanderers turn up far outside the normal limits of distribution, for example single individuals at Atlantic City, New Jersey (Goodwin, 1933), and at Santoña, Province of Santander, in northern Spain (Zulueta, 1962). Single Pleistocene records far south of the present range, such as that based on the tentatively identified innominate bone from Edisto Island, justifiably remain suspect as possibly exceptional occurrences. However, the occurrence of numerous bones certainly or probably referable to gray seal, including remains of very young individuals, one of which is demonstrably a newborn pup, clearly indicates the presence of a breeding colony at the site of the Womack borrow pit during Kemps-

ville time. Gray seal pups are born at the breeding sites, where they remain for two to three weeks or more (Cameron, 1967, p. 171), during which time they grow extremely rapidly, more than doubling their weight (King, 1964, p. 49) and adding the pup dentine to the canines (Hewer, 1964, p. 597) before weaning and dispersal. Thus, the species clearly bred during the Pleistocene in the Norfolk area, approximately 300 miles south of the nearest present breeding ground (off Nantucket).

DISCUSSION

The toadfish genus *Opsanus* and the gray seal *Halichoerus grypus* are here recorded for the first time as fossils. The menhaden *Brevoortia,* the angler *Lophius,* the cod *Gadus,* the sea robin *Prionotus,* the stargazer *Astroscopus,* the gannet *Morus bassanus,* the glaucous gull *Larus hyperboreus,* and the great auk *Pinguinus impennis* are recorded as fossils for the first time in North America, although known previously from Pleistocene or earlier deposits elsewhere.

The gannet and the gray seal are recorded as breeding species, considerably south of their known southerly breeding limits during Recent time. The record for the walrus *Odobenus rosmarus* is well to the south of its southernmost modern occurrence. The essential question implicit in any interpretation of Pleistocene records of living species outside their modern limits of distribution (or breeding) is: why do they no longer occur (or breed) where once they did?

Generally a paleoclimatic explanation is assumed (cf. Davies, 1957, pp. 302-303, figures 3-7). Southerly records in the Northern Hemisphere are supposed to reflect southerly shifting of ranges in correlation with southerly shifting or compression of climatic belts induced by refrigeration and advancing continental glaciers. Breeding of gannet and gray seal and the presence of great auk and walrus near Norfolk during the Pleistocene make the paleoclimatic hypothesis very attractive, and would suggest conditions comparable perhaps to those off Nova Scotia today. Such an interpretation might go unchallenged were it not for the excellent stratigraphic detail available for the collecting area which strongly suggests an interglacial, probably Sangamon, age for the Kempsville Formation. Dr. Oaks is not unalterably committed to this interpretation, however, as he states (1967, pers. comm.), "The Kempsville Formation probably is closely related in age to the Norfolk Formation, but represents a falling stage at the beginning of a glaciation; thus

the water should have been cooler than during Norfolk time." The supposed interglacial age of the Kempsville Formation remains nevertheless a barrier to uncritical acceptance of a paleoclimatic interpretation.

Very little is known in fact about the role of climatic factors in the distribution of large vertebrates. Assumptions as to limiting climatic factors are usually based almost entirely upon observation of where the species occurs today. Application of this procedure alone to the Atlantic walrus in the western North Atlantic would indicate that it is strictly an Arctic species (Loughrey, 1959, Map 1), and might lead to drastic climatic interpretations for Pleistocene records in North Carolina. Yet we know, fortunately, that the walrus bred on Sable Island within historic time and has receded steadily northward from that point and continues to do so. There is no reason to suppose that this restriction is climatically controlled, and much reason to attribute it directly to the activities of Man. Walruses do of course flourish in high latitudes, and climate, notably temperature, unquestionably is a potential limiting factor in (seasonal) distribution (Fay and Ray, 1968; Ray and Fay, 1968), and probably was the critical factor prior to the ascendancy of Man. However, the modern distribution of walruses undoubtedly represents only that fraction of their former wider niche least frequented by their most relentless enemy, Man.

The widespread occurrence of gray seal in Recent middens of southern New England, compared to their present marginal occurrence off Nantucket, where a few survive possibly through recolonization with the waning of Man's vested interest in their destruction and the consequent increasing population pressure from the north, indicates that they found suitable habitat within Recent time in places where they do not now occur.

The possible restrictive influence of Man, including Paleoindians, on the limits of distribution of suitable prey species (walrus, gray seal, gannet), which are highly vulnerable at critical periods in the reproductive cycle, must be considered in attempting to explain phenomena such as the present ones.

Oaks (1967, pers. comm.) has suggested still another possible contributing factor in the northerly retreat of island-breeding vertebrates, as follows: "Possibly the destruction of favorable coastal breeding locations by the stabilization of sea level and subsequent wave action against a coast of unconsolidated sediments could have been as important a factor as Man's actions." He suggests further

(1968, pers. comm.) that, with stabilization, the infilling of lagoons behind barrier islands could have provided easier access for terrestrial predators to these breeding sites, previously well offshore. These certainly could have been factors in the local withdrawal of a species from a given breeding ground such as the Kempsville Island (Figure 1, inset), but islands remain in abundance along most of the northeastern coast.

The fossil fishes are potentially useful paleoclimatic indicators in view of their relative independence from the activities of Man (at least in the past) and from details of coastal geomorphology. Unfortunately, great breadth of distribution (in part seasonal) and the general unfeasibility of specific identification combine to yield an inconclusive picture. The fishes represent a major segment of the Recent marine and brackish-water fauna of Chesapeake Bay and the Virginia coast. This is essentially an intermingling of forms with southern warm affinities with those of more northern distribution. The available fossil sample is insufficient for determining a predominance of either a southern or a northern population, but on the face of our present knowledge, no appreciable difference in temperature is indicated.

In summary, the evidence is conflicting and inconclusive in regard to explanation of the southerly records for northern vertebrates in the Kempsville Formation, although a paleoclimatic interpretation seems most compelling from a biologic point of view. Further work on radiometric dating and on the stratigraphy of the area, as well as study of additional vertebrate and invertebrate fossils from the deposits, may provide a broader base for interpretation.

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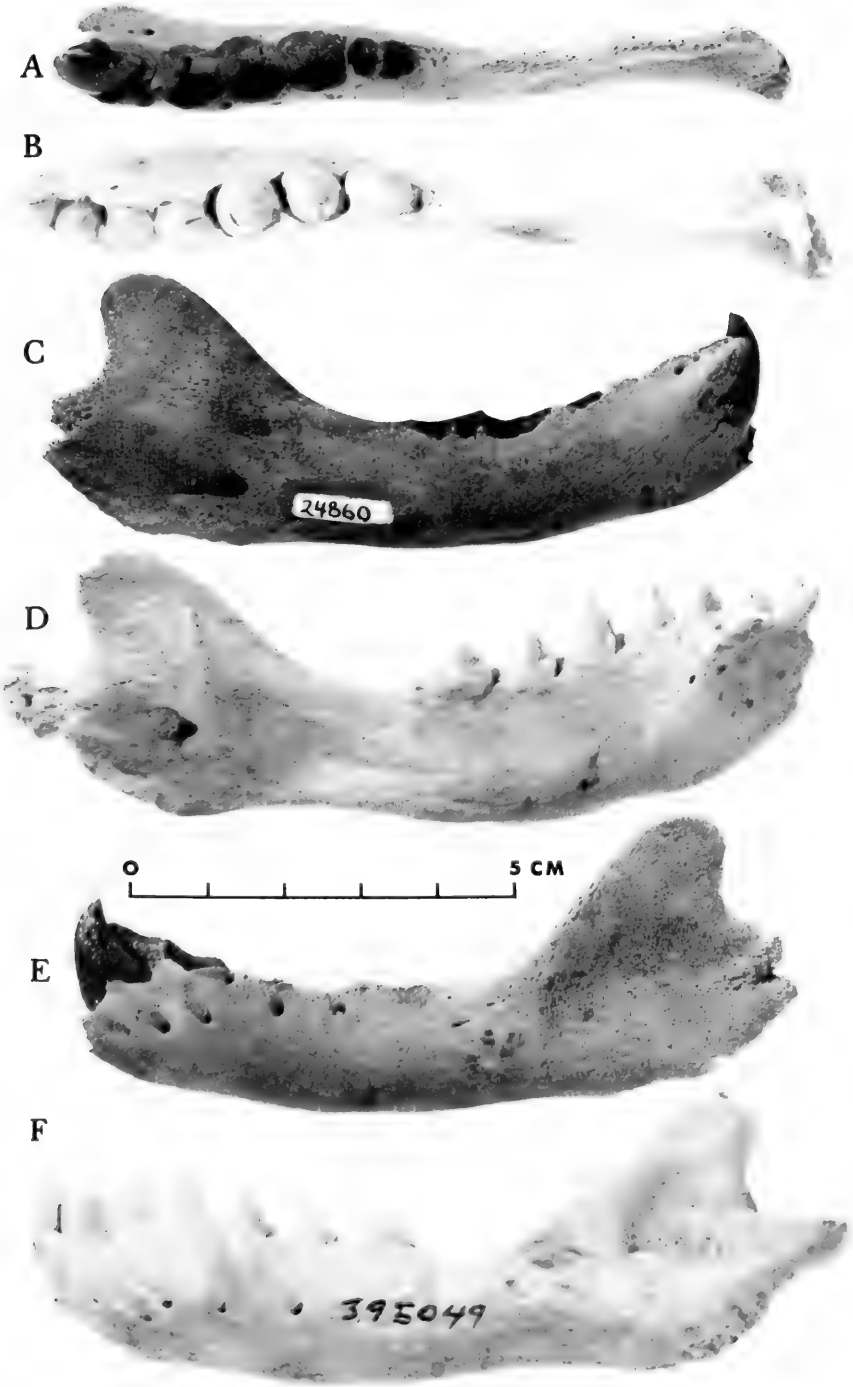

Plate 1.—Left mandibular rami of suckling pups of *Halichoerus grypus*, USNM 24860, the fossil, in dorsal (**A**), medial (**C**), and lateral (**E**) aspects, and USNM 395049, modern (**B, D, F**). Approximately × 1.

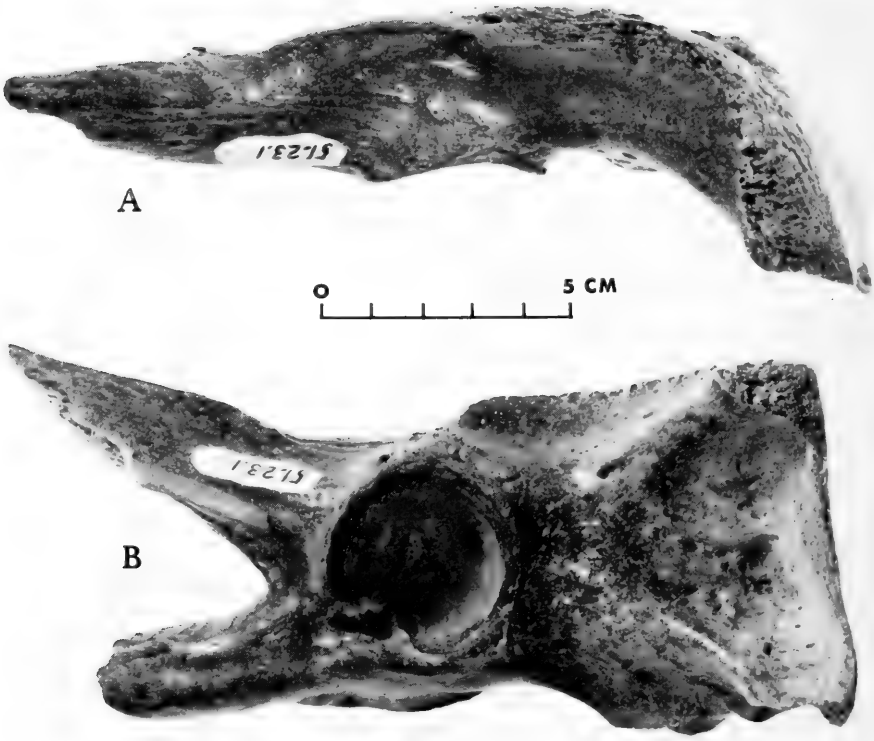

Plate 2.—Partial right innominate from Edisto Island referred tentatively to *Halichoerus grypus,* in dorsal (**A**) and lateral (**B**) aspects, Charleston Museum 51.23.1. Approximately × ⅔.