EMERGENT PLIOCENE AND PLEISTOCENE SEDIMENTS OF SOUTHEASTERN GEORGIA: AN ANOMALOUS, FOSSIL-POOR, CLASTIC SECTION

HELAINE W. MARKEWICH AND CHARLES M. HACKE
U.S. Geological Survey, 6481 Peachtree Industrial Boulevard, Doraville, Georgia 30360
AND
PAUL F. HUDDLESTUN
Georgia Geologic Survey, 19 Martin Luther King Jr. Drive, Room 400, Atlanta, Georgia 30334

ABSTRACT: The surface and near-surface geology of the Atlantic Coastal Plain from Cape Fear, North Carolina to Cape Canaveral, Florida, below 76 m (250 ft) in altitude, comprises Pliocene and Pleistocene fluvial marine, back-barrier, barrier, and shallow-shelf sand, silt, and clay. The fossil content of age-equivalent Pliocene and Pleistocene sediments decreases from the Cape Fear area southward into Georgia. In the Carolinas, fossils are common. Paleontological analyses and isotopic and chemical age determinations, combined with lithostratigraphic studies and geologic mapping, have resulted in the establishment of a regional time-stratigraphic framework. In Georgia, fossils are scarce. Most known fossil localities are in early late Pliocene sediments paleontologically dated between 3.5 and 2.8 Ma. Microfossil data suggest the presence of at least two other Pliocene units—late early Pliocene (4.2–4.0 Ma) and latest late Pliocene (2.4–1.8 Ma). Fossil data are insufficient to differentiate Pleistocene units, but there are distinctive changes in shell morphology and species abundance of foraminifera in sediments topographically above and topographically below 9 m (30 ft) in altitude. No isotopic or paleomagnetic data are available for Pliocene or Pleistocene sediments in Georgia. There has been no detailed geologic mapping. Regional mapping dates to the turn of the century.

The fossil-poor nature of both onshore and offshore Pliocene and Pleistocene Coastal Plain sediments in the Georgia part of the Atlantic Coastal Plain may be due to any one or combination of the following: styles and rates of regional and/or local uplift; sediment load of the numerous rivers that drain this region; freshwater influence on estuarine and nearshore littoral environments; shoreline configuration relative to major ocean currents; dissolution as the result of weathering, and erosion.

INTRODUCTION

General Setting

The area of the Atlantic Coastal Plain from Cape Hatteras, North Carolina, to Cape Canaveral, Florida, is known as the Georgia Bight and includes parts of the Cape Fear arch, the Southeast Georgia embayment, and the Peninsular arch (Fig. 1). In Georgia, the Pliocene and Pleistocene record consists of thin (commonly <12 m [40 ft] thick), repetitious sequences of nearly horizontal siliciclastic fluvial marine, back-barrier, barrier, and/or shelf sediments. The sediments are predominantly fine- and very fine-grained sand. Sandy clay and silt are locally important. Younger sedimentary sequences are topographically lower than, and cut laterally into, older, topographically higher sequences. Each sequence is expressed as a broad trend in a 40- to 80-km wide (25–50 mi), low-altitude, low-relief, topographically "stepped" terrain that lies adjacent and subparallel to the present coast. The area is characterized by sloping plains and broad, whale-back ridges that are cut by wide, asymmetrical river valleys (Fig. 2). Vegetation is dense; water tables are high; outcrops are few; and weathering is intense, rapid, and deep.

Regional Differences

In the Cape Fear area of the Carolinas, fossil-rich, predominantly transgressive barrier and back-barrier sand and clay with locally thick carbonate-rich deposits compose the Pliocene and Pleistocene section. In southeastern South Carolina and Georgia, Pliocene and Pleistocene sediments are predominantly fossil-poor, transgressive, regressive and/or prograding barrier, and back-barrier sand.

Stacked sequences of somewhat fossiliferous to abundantly fossiliferous Pliocene and Pleistocene sediments are common in the Cape Fear area of the Carolinas. In localized channels, fossil-rich sediments can be thick, such as the 30 to 43 m (100–140 ft) of upper Pliocene shell beds presently being quarried near the town of Conway in northeastern South Carolina. The abundance of fossils in this area has resulted in numerous isotopic, biogeochemical (amino-acid racemization), and/or paleontologic analyses. Age data from these analyses have been integrated with lithostratigraphic data, resulting in a stratigraphic framework for Pliocene and Pleistocene sediments on the south limb of the Cape Fear arch (McCartan and others, 1982, 1984, 1990; Owens, 1989).

This framework has been difficult to extend into the Southeast Georgia embayment. Data from outcrop and cores, in an area from the Edisto River in southeastern South Carolina to the Satilla River in southeastern Georgia (Fig. 3), suggest that: (1) Pliocene and Pleistocene sediments are thin, carbonate poor, and largely nonfossiliferous; and (2) each late Pliocene and Pleistocene transgression was highly erosive and removed almost all underlying Pliocene and/or Pleistocene sediments. Stacked sequences of Pliocene and Pleistocene deposits in the central part of the Southeast Georgia embayment are uncommon. Generally, a 3- to 15-m-thick (9–50 ft) Pliocene or Pleistocene unit overlies substrata of early to middle Miocene sand, silt, or clay. Locally, the Miocene substrata are within 3.5 m (10 ft) of the land surface.

Southeastern Georgia

In Georgia, sediments thought to be early late Pliocene are not geomorphically expressed at the land surface. The geomorphic expression of latest late Pliocene and Pleistocene sequences in southeastern Georgia varies from north to south. In the Savannah River area, latest late Pliocene sediments define a broad gently sloping plain. South of the Altamaha River, a wide, long, beach ridge of probable latest late Pliocene age is the most prominent feature in the landscape. Pleistocene barriers are short and drumstick-

Quaternary Coasts of the United States: Marine and Lacustrine Systems, SEPM Special Publication No. 48

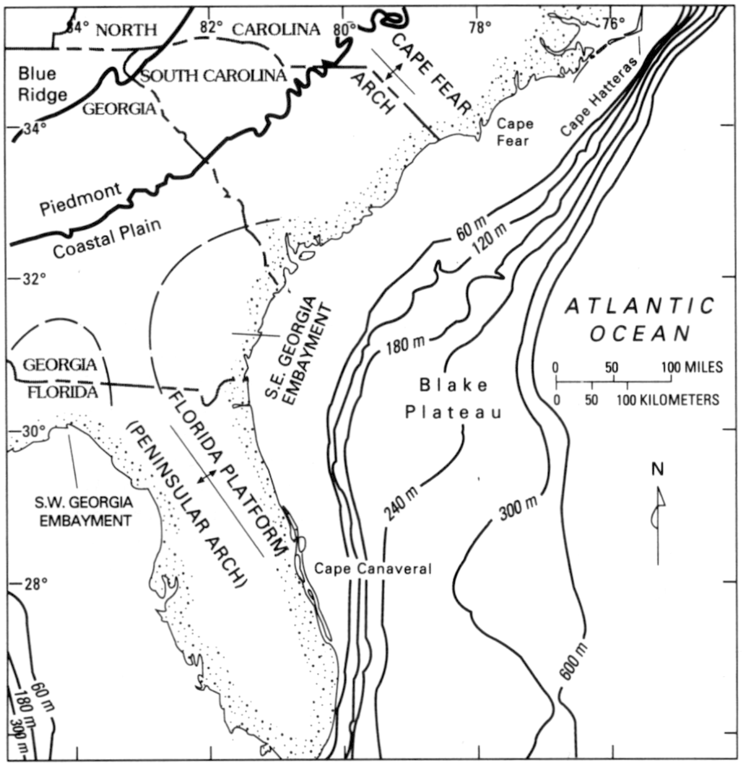


FIG. 1.—Map showing state boundaries, major physiographic provinces, and structural features of the southeastern United States (modified from Paul and Dillon, 1979).

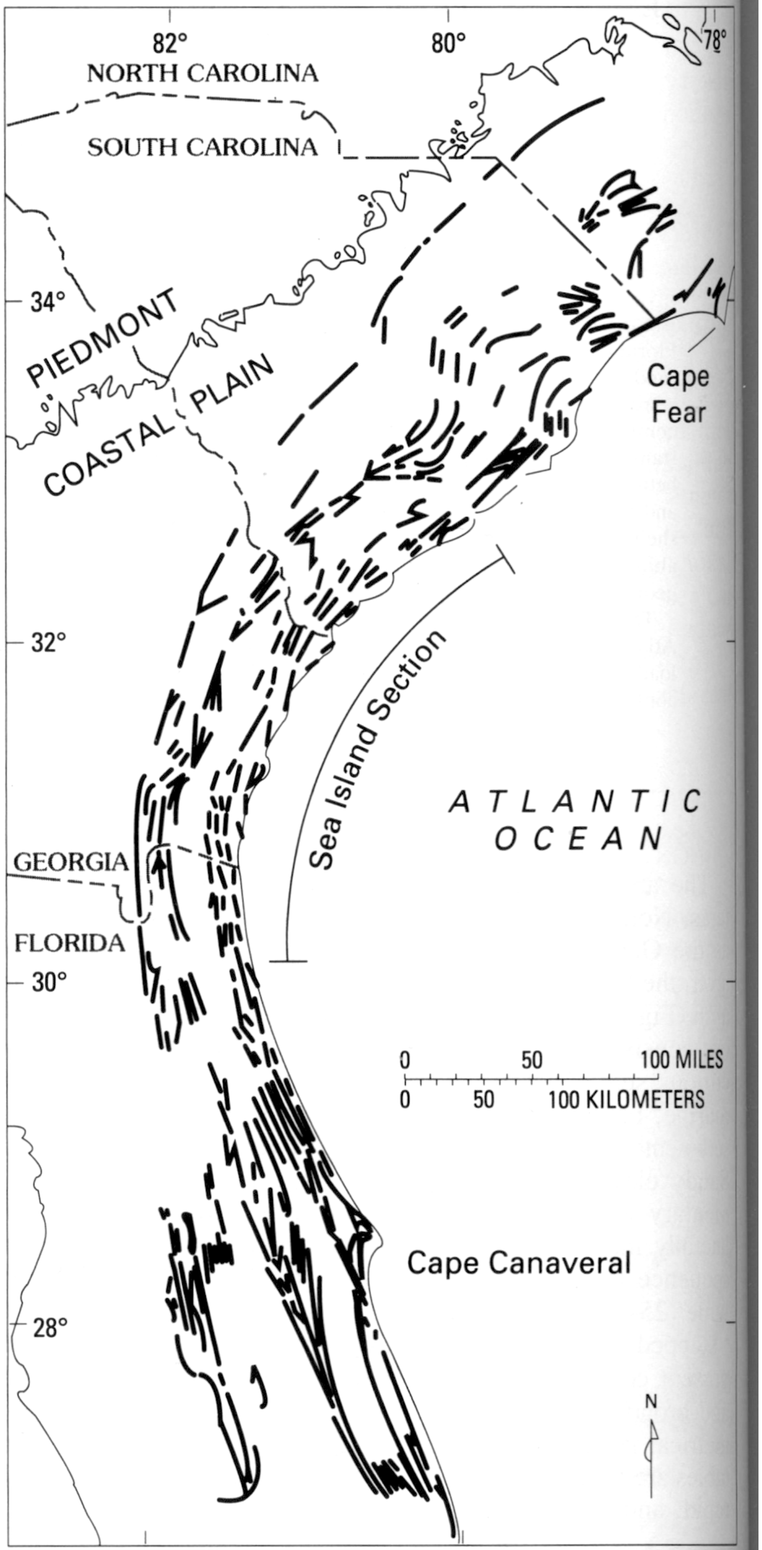


FIG. 2.—Map showing the trend of shoreline features (scarps, beach ridges, and barriers) in the southeastern United States that parallel or subparallel the present coast and are cut by southeastward-trending river valleys. FLA, Florida; GA, Georgia; SC, South Carolina; NC, North Carolina (modified from Winker and Howard, 1977).

shaped or long and linear. Back-barrier sediments may or may not be present. Three sets of welded, Pleistocene barriers define the south half of a large Savannah River paleodelta. The age-equivalent paleodelta of the Altamaha River is not well defined. In this area southward to the St. Marys River, Pleistocene barriers are expressed as low, north-northeast-trending, closely spaced, linear ridges surrounded by back-barrier sediments.

Emergent Pliocene and Pleistocene sediments in southeast Georgia are largely nonfossiliferous and locally dominated by fluvial components. Most deposits are undated because of the low-fossil content. The few fossil-bearing outcrops are small, isolated lenses of marl, shell hash, or shells in a matrix of organic-rich sand or clay. Microfossil data from cuttings and cores, which are quite extensive near the Georgia coast (Herrick and Wait, 1955; Herrick, 1961; Herrick and Vorhis, 1963; unpublished data from Georgia Geologic Survey), indicate the presence of late early, early late, and latest late Pliocene strata. Most fossils are from sediments considered to be biostratigraphically equivalent to the Duplin Formation (3.5–2.8 Ma) in the Cape Fear area of the Carolinas. Fossils from pre-Wisconsinan Pleistocene sediments are not common. Where present, they generally represent a back-barrier assemblage with minimal species diversity.

Purpose and Scope

The purposes of this paper are to (1) present the available paleontologic data for the emergent Pliocene and Pleistocene strata of southeastern Georgia and adjacent parts of southeastern South Carolina (fossil localities are shown on Fig. 4; data are given in Fig. 5); (2) discuss the stratigraphic relations of these units as seen in the field and in cores; and (3) discuss possible mechanisms that would account for the lack of fossils in Pliocene and Pleistocene sediments in this area of the southeastern Atlantic Coastal Plain. It is our intent to draw attention to a large area of the southeastern

Atlantic Coastal Plain for which few age data are available. It is an area that is critical to unravelling the late Cenozoic history of the southeastern United States, particularly the relations between the Gulf of Mexico and the Atlantic Ocean.

PREVIOUS WORK AND AVAILABLE DATA

Since the early 1900s, numerous geologists have studied the late Cenozoic geology of the Atlantic Coastal Plain in the southeastern United States. Some of early regional publications include those by Veatch and Stephenson (1911), Clark and others (1912), Cooke (1936, 1943, 1945), Cooke and Mossom (1929), and a map of Tertiary and Quaternary formations in Georgia (MacNeil, 1947). Although some early publications referred to fossils in Miocene and younger sediments (Hodgson, 1846; Dall, 1896, 1898; Aldrich, 1911; Richards, 1943; Edwards, 1944; and others), most correlations of units and/or shorelines were based solely upon their topographic and geomorphic positions within the landscape (Cooke, 1936, 1943).

The hiatus in publications in the middle and late 1940s was largely the result of World War II. Interest in the

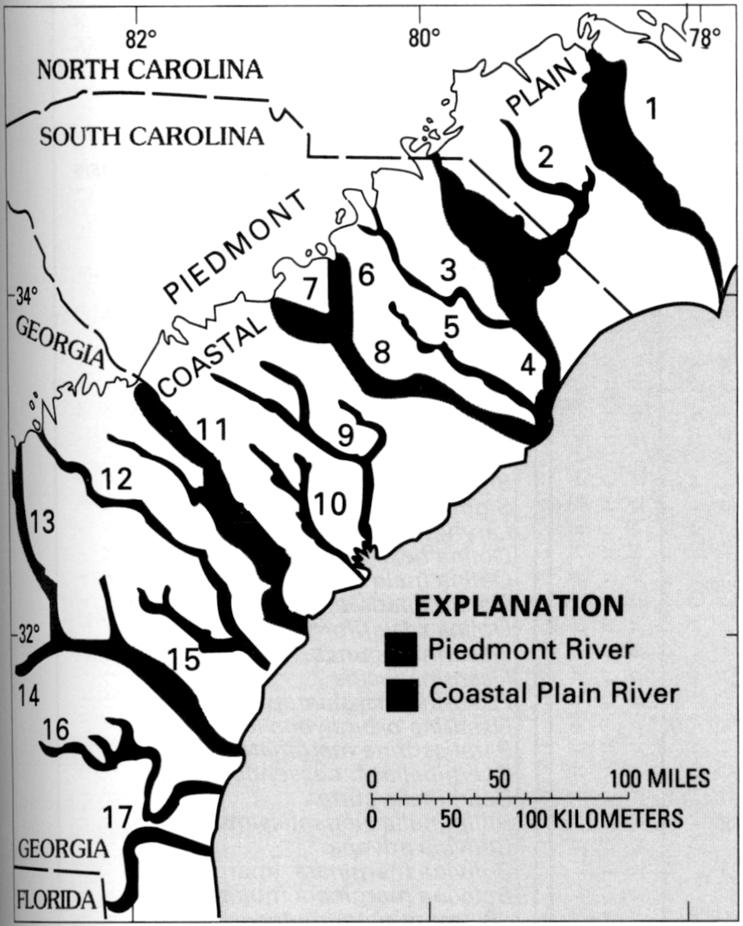


FIG. 3.—Map showing the major eastward- and southeastward-flowing streams in the southeastern United States: (1) Cape Fear; (2) Little Pee Dee and (3) Lynches that form (4) Great Pee Dee; (5) Black; (6) Wateree and (7) Congaree that form (8) Santee; (9) Edisto; (10) Combahee; (11) Savannah; (12) Ogeechee; (13) Oconee and (14) Ocmulgee that form (15) Altamaha; (16) Satilla; (17) St. Marys. Stipled pattern shows river valley that drains part of the Blue Ridge and/or Piedmont physiographic provinces as well as the Coastal Plain. Black shows river valley that drains only the Coastal Plain (modified from Hayes, 1989).

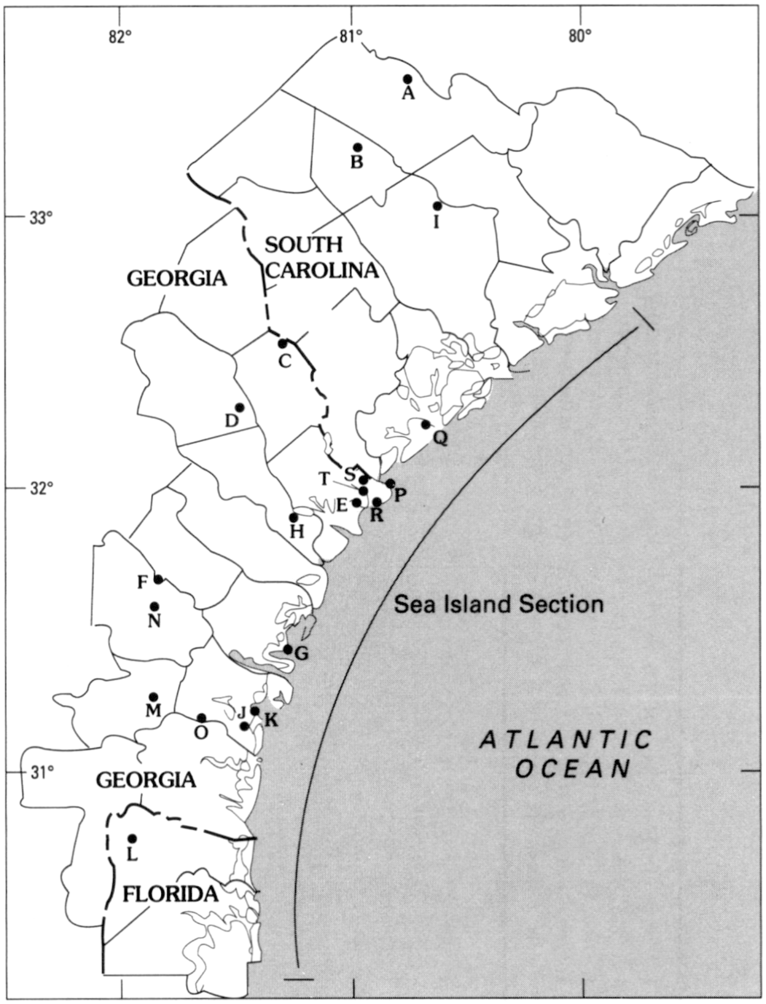


FIG. 4.—Location of fossil localities referred to in the text and in other figures. Counties outlined in black. (A) Outcrop, Orangeburg County, South Carolina, N 33°32′12″, W 80°46′24″ (Pooser, 1965; Colquhoun, 1965). (B) Outcrop, Bamberg County, South Carolina, N 33°17′54″, W 81°01′06″ (new data). (C), Outcrop, Porters Landing, Effingham County, Georgia, N 32°34′24″, W 81°21′39″ (Veatch and Stephenson, 1911; new data). (D) Outcrop, Bulloch County, Georgia, N 32°20′31″, W 80°30′24″ (new data). (E) Core, CH1, Chatham County, Georgia, N 31°59′47″, W 81°02′51″ (Huddlestun, 1988; new data). (F) Outcrop, Doctortown, Wayne County, Georgia, N 31°39′19″, W 81°49′49″ (Veatch and Stephenson, 1911; Herrick, 1976; new data). (G) Core, Sapelo Island, McIntosh County, Georgia, N 31°23′46″, W 81°16′32″ (Woolsey, 1976). (H) Core, BR1, Bryan County, Georgia, N 31°51′20″, W 81°12′45″ (new data) (I) Outcrop, Colleton County, South Carolina, N 33°06′01″, W 80 39′57″ (Cooke, 1936; Blackwelder and Ward, 1979). (J) Dredgings, Turtle River, Glynn County, Georgia, N 31°11′31″, W 81°32′24″ (Veatch and Stephenson, 1911; new data). (K) Dredgings, Brunswick Canal, Glynn County, Georgia, N 31°13′16″, W 81°30′14″ (Veatch and Stephenson, 1911). (L) Core, Cassidyl, Nassau County, Florida, N 30°38′10″, W 81°56′05″ (Huddlestun, 1988). (M) Outcrop, Brantley County, Georgia, N 31°03′31″, W 81°51′30″ (Veatch and Stephenson, 1911). (P) Five wells, Chatham County, Georgia: 1) core, PC1, Petit Chou Island, N 31°56′39″, W 80°55′39″ (Huddlestun, 1988; new data); 2) cuttings, GGS-772, Fort Screven, N 32°01′22″, W 80°51′01″ (Huddlestun, 1988); 3) cuttings, GGS-381, Fort Pulaski, N 32°01′51″, W 80°54′04″ (Huddlestun, 1988); 4) core, House Creek, N 31°57′40″, W 80°54′51″, (Huddlestun, 1988); 5) core, CH10, Tybee Island, N 31°59′16″, W 80°51′05″ (Huddlestun, 1988; new data). (Q) Cuttings, BFT-315, Hilton Head Island, Beaufort County, South Carolina, N 32°15′58″, W 80°43′13″ (Herrick, 1976; Huddlestun, 1988). (R) Core CH13, Chatham County, Georgia, N 30°58′26″, W 80°59′54″ (Huddlestun, 1988; new data). (S) Core CH14, Chatham County, Georgia, N 32°04′29″, W 80°09′17″ Huddlestun, 1988). (T) Three outcrops, Chatham County, Georgia: 1) southwest side of Skidaway Island on Burnside River, N 31°55′12″, W 81°04′25″; 2) east side of Isle of Hope, Skidaway River, N 31°58′53″, W 81°03′18″; 3) intersection, White Bluff Road and White Bluff Creek, N 31°59′03″, W 81°07′48″ (Veatch and Stephenson, 1911).

Locations:	Early Pliocene (PL1, N18-19)					Late Pliocene (PL3, N19-21)									Late Pliocene (PL5, N20-22)				Pleistocene (N23)								
FAUNA Foraminifer	Q. Well No. BFT-315, Beaufort Co., SC	5. Well No. Ch 10, Chatham Co., GA	4. Well, House Ck., Chatham Co., GA	3. Well No. GGS-381, Chatham Co., GA	P.2. Well No. GGS-772, Chatham Co., GA	J. Turtle River, Glynn Co, GA	I. Outcrop, Colleton Co., SC	G. Test Hole, McIntosh Co., GA	F. Outcrop, Wayne Co., GA	E. Test Hole, CH 1, Chatham Co., GA	D. Outcrop, Bulloch Co., GA	C. Outcrop, Effingham Co., GA	B. Outcrop, Bamberg Co., SC	A. Outcrop, Orangeburg Co., SC	S. Core, CH 14, Chatham Co., GA	N. Core, Wayne #1, Wayne Co., GA	M. Outcrop, Brantly Co., GA	L. Core, Cassidy #1, Nassau Co., FL	3. Outcrop, Chatham Co., GA	2. Outcrop, Chatham Co., GA	T.1. Outcrop, Chatham Co., GA	R. Core, CH 13, Chatham Co., GA	P.1. Well No. PC 1, Chatham Co., GA	O. Outcrop, Glynn Co., GA	K. Brunswick Canel, Glynn Co. GA	J. Turtle River, Glynn Co., GA	H. Core, Bryan Co., GA
Textularia articulata	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Textularia candeiana	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Textularia gramen	X	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Textularia mayori	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Nodosaria catesbyi	-	-	-	X	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Lagena clavata	X	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Lagena costata amphora	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lagena laevis	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lagena perlucida	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Lagena semistriata	-	-	-	-	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Lagena substriata	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lagena sulcata	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lagena tenuis	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lagena sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-
Lenticulina americana	X	-	-	X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lenticulina mayi	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Robulus (=Lenticulina) cf. *nikobarensis*	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Plectofrondicularia cf. *longistriata*	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Globulina caribaea	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Globulina gibba	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Globulina inaequalis	X	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Guttulina austriaca	X	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Guttulina caudata	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Guttulina pseudocostatula	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Guttulina sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-
Pseudopolymorphina rutila	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Pseudopolymorphina sp.	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sigmomorphina pearceyi	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sigmomorphina terquemiana	X	-	-	X	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Sigmomorphina undulosa	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sigmomorphina williamsona	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Laryngosigma williamsoni	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oolina hexagona scalariformis	X	-	-	X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oolina melo	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Oolina quadrata	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Oolina scalariforma	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Fissurina lacunata	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Fissurina lucida	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fissurina marginatoperforata	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Fissurina orbignyana lacunata	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parafissurina marginata	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buliminella cf. *bassendorfensa*	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Buliminella curta	X	-	-	X	X	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Buliminella elegantissima	X	-	-	-	X	-	-	-	X	-	-	-	-	X	X	-	-	-	-	-	-	X	-	-	-	-	-
Bolivina advena	X	-	-	-	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Bolivina marginata (marginata)	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Bolivina marginata multicostata B. (marginata) *multicostata*	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Bolivina paula	-	-	-	X	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Bolivina plicatella	X	-	-	-	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Bolivina cf. *suteri*	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bolivina sp.	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cassidulinoides bradyi	-	-	-	-	X	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Nodogenerina (=Stilostomella) *advena*	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bulimina elongata	X	-	-	X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

FIG. 5.—Pliocene and Pleistocene fossil data from localities in southeastern South Carolina, southeastern Georgia, and extreme northeastern Florida. New data on ostracodes, macrofossils, diatoms, and foraminifera. Other fossil data from references, given by locality in Figure 4.

Q.	5.	4.	3.	P.2.	J.	I.	G.	F.	E.	D.	C.	B.	A.	S.	N.	M.	L.	3.	2.	T.1.	R.	P.1.	O.	K.	J.	H.	
-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Bulimina marginata*
-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Reusella spinulosa*
X	-	-	X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Uvigerina auberiana*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Uvigerina canariensis*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Uvigerina parvula*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Uvigerina suberiana*
X	-	-	X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Uvigerina subperegrina*
X	-	-	X	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Angulogerina* (=Trifarina) *occidentalis* A. (=T.) *occidentala*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	*Angulogerina* (=Trifarina) sp.
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Discorbis duplinensis*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Discorbis terquemis*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Discorbis turritis*
-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Discorbis valvulatus*
-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Discorbis vilardeboanus*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Buccella depressa*
X	-	-	X	X	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	*Buccella mansfieldi*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	*Bucella* sp.
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Conorbina orbicularis*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Rosalina floridana*
X	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Rosalina subaraucana*
X	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Rosalina turrita*
X	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cancris* (sagra) *sagra*
-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cancris sagra communis* C. (sagra) *communis*
X	-	-	X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Valvulineria* sp.
X	-	-	X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	*Ammonia beccarii*
-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Elphidium advena* E. *advenum*
X	-	-	X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Elphidium clavatum*
X	-	-	-	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Elphidium gunteri*
-	-	-	-	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Elphidium incertum*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Elphidium limatulum*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Elphidium matagordanum*
X	-	-	-	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Elphidium poeyanum*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Elphidium varium*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	*Elphidium* sp.
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Chiloguembelina cubensis*
-	X	X	X	X	-	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-	X	X	-	-	-	-	*Hastigerina aequilateralis aequilateralis* *Globigerinella siphonifera* (=H. aequilateralis ...)
-	X	X	X	X	-	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-	X	X	-	-	-	-	*Globigerinella* (=Hastigerina) *aequilateralis praesiphonifera*
-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Hastigerina* sp.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	*Globorotalia inflata*
X	X	X	X	X	-	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	*Globorotalia menardii menardii* (dextral) G. *menardii*
-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	*Globorotalia menardii menardii* (sinistral)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	*Globorotalia menardii miocenica*
-	X	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Globorotalia margaritae margaritae*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	*Globorotalia puncticulata*
-	X	X	X	X	-	-	-	-	X	-	-	-	-	-	X	-	X	-	-	-	-	X	-	-	-	-	*Globigerina apertura*
-	X	X	X	X	-	-	-	-	-	-	-	-	X	-	X	-	X	-	-	-	X	-	-	-	-	-	*Globigerina bulloides*
-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Globigerina* cf. *bulloides*
-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	*Globigerina calida*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	*Globigerina decorapertura*
-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	*Globigerina* cf. *decorapertura*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	*Globigerina falconensis*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	X	-	-	-	-	*Globigerina* cf. *falconensis*
-	X	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Globigerina nepenthes*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	*Globigerina quinqueloba*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	*Globigerina rubescens*
-	X	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	*Globigerina* cf. *rubescens*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Globigerina triloculinoides* (=Globigerinoides quadrilobatus quadrilobatus)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	*Globigerinoides conglobatus*
-	X	X	X	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Globigerinoides* cf. *conglobatus*
-	X	X	X	X	-	-	X	-	X	-	-	-	-	-	X	-	X	-	-	-	-	X	-	-	-	-	*Globigerinoides obliquus obliquus*
-	X	X	X	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Globigerinoides obliquus extremus*
-	X	X	X	X	-	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-	X	X	-	-	-	-	*Globigerinoides quadrilobatus quadrilobatus*
-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	*Globigerinoides quadrilobatus sacculiferus*
X	-	-	-	X	-	-	X	X	X	-	-	-	-	-	X	-	X	-	-	-	X	X	-	-	-	-	*Globigerinoides ruber* G. *rubra*
-	X	X	X	X	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Globoquadrina altispira*

FIG. 5.—Continued.

Q.	5.	4.	3.	P.2.	J.	I.	G.	F.	E.	D.	C.	B.	A.	S.	N.	M.	L.	3.	2.	T.1.	R.	P.1.	O.	K.	J.	H.	
X	X	X	X	X	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Neogloboquadrina* (acostaensis)*acostaensis*
																											Globorotalia acostaensis
-	X	X	X	X	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Neogloboquadrina* (acostaensis) *humerosa*
																											Globoquadrina humerosa
-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*N. ... humerosa,* aberant form
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	X	-	-	-	-	*Neogloboquadrina dutertrei*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	*Neogloboquadrina* cf. *dutertrei*
																											Sphaeroidinella cf. *dehiscens*
-	X	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Sphaeroidinellopsis seminulina*
-	-	-	X	X	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Sphaeroidinellopsis subdehiscens*
																											(=paenedehiscens)
-	X	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	*Orbulina universa*
-	X	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	*Globigerinita glutinata*
-	X	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Globigerinata uvula*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Eponides antillarum*
-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Eponides* cf. *regularis*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Eponides repandus*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Poroeponides lateralis*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Amphistegina lessonii*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Amphistegina* sp.
X	-	-	X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Planulina depressa*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Planulina* cf. *depressa*
X	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cibicides americanus*
X	-	-	X	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cibicides duplinensis*
X	-	-	X	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cibicides lobatulus*
X	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C. *lobatulus* var.
-	-	-	-	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cibicides sapeloensis*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cibicidella variabilis*
-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Planorbulina mediterranensis*
X	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cymbaloporetta squamossa*
-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Virgulina* (=Fursenkoina) *fusiformis*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Virgulina* (=Fursenkoina) *gunteri*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Virgulina* (=Fursenkoina) *pontoni*
X	-	-	-	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Virgulina* (=Fursenkoina) *punctata*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	*Virgulinella gunteri*
X	-	-	X	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cassidulina crassa*
X	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cassidulina laevigata laevigata*
-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cassidulina laevigata carinata*
																											C. *carinata*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cassidulina subglobosa*
X	-	-	-	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Nonion grateloupi*
X	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Nonion pizarrense*
-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Astrononion glabrellum*
-	-	-	X	X	-	-	-	X	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	*Florilus atlantica*
																											Nonionella atlantica
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Gyroidina orbicularis*
X	-	-	X	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Hanzawaia concentrica*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Robertina* cf. *subteres*
																											Coelenterata
-	-	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Septastrea crassa*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Astrangia* sp.
																											Bryozoa
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Lunulites* (=Trochopora) sp.
																											Pelecypoda
-	-	-	-	-	-	-	-	X	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Nucula proxima*
-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Nuculana acuta*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Leda acuta (=Nuculana acuta)*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Arca improcera*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Arca incongrua*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Arca lienosa*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Arca limula*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Arca plicatura*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Arca transversa*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Arca* sp.
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Arca* (=Barbatia) cf. *marylandica*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	*Barbatia adamsi*
-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Anadara improcera*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	*Glycymeris americana* G. *parilis*
-	-	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	X	-	*Glycymeris subovata subovata*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Glycymeris subovata plagia*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	*Glycymeris* sp.
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Mytilus* sp.

Fig. 5.—Continued.

Q.	5.	4.	3.	P.2.	J.	I.	G.	F.	E.	D.	C.	B.	A.	S.	N.	M.	L.	3.	2.	T.1.	R.	P.1.	O.	K.	J.	H.	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	*Modiolaria* (=Musculus) sp.
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Atrina* sp.
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Pteria colymbus*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Amusium mortoni*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Amusium* cf. *mortoni*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Pseudamusium* (=Palliolum) sp.
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Chlamys* sp.
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Argopecten vicenarius* (?)
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Leptopecten irremotis*
-	-	-	-	-	-	-	-	X	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Carolinapecten eboreous*
																											Pecten eboreus
-	-	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Chesapecten jeffersonius jeffersonius*
																											Pecten jeffersonius
-	-	-	-	-	X	-	-	-	-	X	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Chesapecten jeffersonius septenarius*
																											Pecten septenarius
																											Chlamys jeffersonia septenaria
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Chesapecten madisonius*
																											Pecten madisonius
-	-	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Pecten* n. sp.
-	-	-	-	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Plicatula marginata*
-	-	-	-	-	-	-	-	X	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Anomia simplex*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Placuanomia* (=Placunanomia) sp.
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Placunanomia plicata*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Phacoides* (=Lucina) *amiantus*
-	-	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Phacoides* (=Lucina) *anodonta*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Phacoides* (=Lucina) *cribarius*
-	-	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Phacoides* (=Lucina) *multilineatus*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Phacoides* (=Lucina) *radians*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Lucinisca cribrarius*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Bellucina tuomeyi*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Stewartia* (=Megaxinus) *anodonta*
-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Parvilucina crenulata*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Parvilucina multilineata*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cavilinga trisulcata*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Diplodonta acclinis*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Chama congregata*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Chama striata*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Echinochama* (=Arcinella) *arcinella*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Pseudochama corticosa*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	*Crassostrea virginica*
-	-	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Ostrea disparilus*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Ostrea raveneli*
-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Ostrea raveneliana*
-	-	-	-	-	-	-	-	X	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Conradostrea sculpturata*
																											Ostrea sculpturata
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Carditamera arata
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Carditamera* sp.
-	-	-	-	-	X	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cyclocardia granulata*
																											Venericardia granulata
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Pleuromeris decemcostata*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Pleuromeris decemcostata* ssp.?
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Venericardia perplano*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Venericardia tridentata*
-	-	-	-	-	X	-	-	X	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Astarte concentrica*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Astarte cuneformis*
-	-	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Astarte distans* var. *floridana*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Astarte undulata* var.
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Astarte undulata* var. *vaginulata*
-	-	-	-	-	X	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Marvacrassatella undulata*
																											Crassatella undulata
																											Crassatellites undulata
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Marvacrassatella* cf. *undulata*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Crassatellites* sp.
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Crassinella dupliniana*
-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Crassinella duplinensis* (?)
-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Crassinella lunulata*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cardium robustum*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cardium* sp.
-	-	-	-	-	X	-	-	X	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Mulinia congesta*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Mulinia congesta* var. *contracta*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Mulinia congesta* var. *elongata*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Mulinia lateralis*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Mulinia* sp.
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Rangia clathrodon*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	*Rangia cuneata*

FIG. 5.—Continued.

Q.	5.	4.	3.	P.2.	J.	I.	G.	F.	E.	D.	C.	B.	A.	S.	N.	M.	L.	3.	2.	T.1.	R.	P.1.	O.	K.	J.	H.	
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Tellina declivis*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Tellina* (Angulus) *umbra*
-	-	-	-	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Tellina* sp.
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Strigilla* sp.
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Donax* sp.
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Semelina* sp.
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Venus tridacnoides*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Venus tridacnoides* var. *rileyi*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Gouldia metastriata*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Transennella caloosana*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Dosinia* sp.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	*Gemma purpurea*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Chione alveata*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Chione athleta*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Chione cancellata*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Chione* aff. *cortinaria*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Chione latilirata*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Lirophora* (=C. Lirophora) sp.
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Mercenaria mercenaria*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Mercenaria rileyi*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Mercenaria tridacnoides*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Mercenaria* sp.
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Sphenia dubia*
-	-	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Corbula inaequalis*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Caryocorbula conradi*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Caryocorbula cuneata*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Gastrochaena* sp.
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Pandora* sp.
																											Gastropoda
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	*Neritina* sp?
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Calliostoma armillatum*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Calliostoma mitchelli*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Calliostoma tuomeyi* (?)
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Calliostoma* sp.
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Fissuridea* (=Diodora) *carolinensis*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Fissuridea* sp.
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Diodora nucula*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Turbonilla* sp.
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Epitonium leai* (?)
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Scala* (=Epitonium) ssp.
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Neverita duplicata*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	*Neverita* sp?
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	*Potamides cancelloides*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	*Potamides saltillensis*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	*Amnicola expansilabris*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	*Amnicola georgiensis*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	*Amnicola saltillensis*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Polinices duplicatus*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Calyptraea* sp.
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Crucibulum* sp.
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Crepidula fornicata*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Solarium* (=Architectonica) *granulatum*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Omphalius* (=Cassiope) *exoletus*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Turritella duplinensis*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Turritella plebeia*
-	-	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Turritella variablilis*
-	-	-	-	-	-	-	-	X	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Turritella* sp.
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Nassa* (=Buccitriton) *acuta*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Nassa* (=Buccitriton) *vibex*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Ilyanassa obsoleta*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Fulgur carica* (=Busycon *caricum*)
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Columbella avara* var
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Astyris lunata*
-	-	-	-	-	X	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Ecphora quadricostata*
-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Ecphora* sp.
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Ptychosalpinx* sp.
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Marginella contracta*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Marginella* sp.
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Olivella mutica*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Oliva canaliculata*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Oliva literata*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Terebra* (=Strioterebrum) *dislocata*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Drillia abundans*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Conus* sp.

FIG. 5.—Continued.

Q.	5.	4.	3.	P.2.	J.	I.	G.	F.	E.	D.	C.	B.	A.	S.	N.	M.	L.	3.	2.	T.1.	R.	P.1.	O.	K.	J.	H.	
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Acteocina canaliculata*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	*Planorbis antiquatus*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	*Paludestrina plana*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Longchaeus suturalis*
																											Scaphopoda
-	-	-	-	-	-	-	-	X	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cadulus thallus*
-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Dentalium carolinense*
																											Ostracoda
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Haplocytheridea bassleri*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Hulingsina rugipustulosa*
-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Hulingsina* sp.
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cytherura forulata*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cytherura* sp.
-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cytheropteron yorktownensis*
-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Paracytheridea altila*
-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Peratodytheridea* sp.
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Proteoconcha gigantica*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Proteoconcha tuberculata*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Aurila conradi conradi*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Campylocythere laeva*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Loxoconcha* cf. L. *edentonensis*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Loxoconcha reticularis*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cytheromorpha newportensis*
-	-	-	-	-	-	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Cytheromorpha warneri*
-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Malzella conradi*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Malzella evexa*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Actinocythereis captionis* (large form)
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Murrayina barclayi*
-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	*Murrayina martini*
-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Orionina vaughni*
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Puriana carolinensis*
-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Puriana rugipunctata*
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Puriana* sp.
-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Pumilocytheridea* sp.
-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Pseudocytheretta* (=Pseudocythereis) sp.
-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Tetracytherura* (=Eocytheropterinae) *choctawhatcheensis*
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Muellerina* cf. *ohmerti*
-	-	-	-	-	-	-	-	X	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Bensonocythere* ssp.
-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Balanus* ssp.
																											Chondrichphyes
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	*Lamna* sp.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	*Galeocerdo* sp.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	*Carcharodon* sp.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	*Dasyatis* sp.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	*Pastinacea* sp.
-	-	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-	X	X	-	-	(shark ssp)
																											Reptilia
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	*Chelonia couperi*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	*Terrapene canaliculata*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	*Crocodylus* sp.
																											Mammalia
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	*Physter ? vetus* or *Physterula ? neolassicus*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	*Castoroides ohioensis*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	X	-	-	*Elephas columbi*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	X	X	-	*Mammut americanum*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	*Mammut floridanum*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	X	-	*Bison* cf. *bison*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	*Cervus* sp.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	*Tapirus haysii*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	*Megatherium americanum*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	X	-	*Megatherium mirabile*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	X	-	-	*Mylodon harlani*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	*Chelonia couperi*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	*Equus complicatus*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	*Equus leidyi* (=fraternus)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	*Equus littoralis*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	*Equus tau?*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	*Equus* sp.

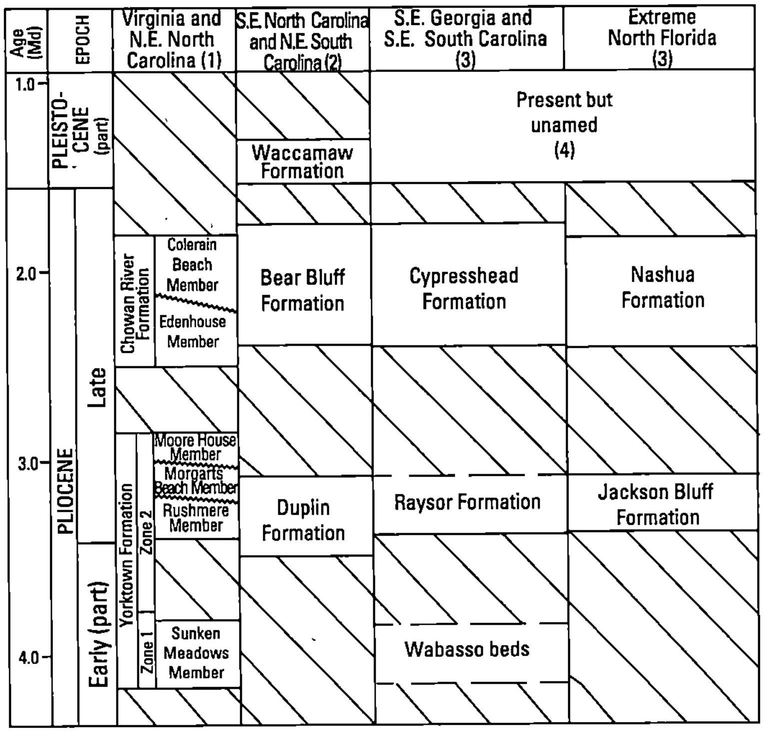
FIG. 5.—Continued.

	H.	J.	K.	O.	P.1.	R.	T.1.	.2.	3.	A.	B.	C.	D.	E.	F.	G.	I.	J.	L.	M.	N.	S.	P.2.	3.	4.	5.	Q.
Cetacea sp.	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(mammal remains)	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FLORA																											
Diatomaceae																											
Cussia sp.	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhaphoneis amphiceros	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhaphoneis angularis	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhaphoneis cf. *angularis*	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhaphoneis rhombica	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhaphoneis surirella	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Actinocyclus ochotensis	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Actinocuclus octonarius	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Actinocyclus tenellus	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Actinoptychus minutus	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Actinoptychus senarius	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Actinoptychus splendens	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulacodiscus argus	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cocconeis sublittoralis	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coscinodiscus eccentricus	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coscinodiscus marsinatus	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coscinodiscus nitidus	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coscinodiscus perforatus	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coscinodiscus radiatus	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coscinodiscus stellaris	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyclotella striata	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyclotella sp.	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cymatosira cf. immunis	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cymatosira sp.	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diploneis bombus	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eupodiscus radiatus	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Melosira granulata	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Navicula clavata	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Navicula hennedyii	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitzschia angularis	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitzschia granulata	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitzschia plana	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Opephora sp.	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralia sulcata	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Podosira stelliger	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thalassiosira spp.	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triceratium farus	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triceratium sp.	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Biddulphia seticulosa	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

FIG. 5.—Continued.

southeastern Coastal Plain revived: Richards (1950); DuBar (1962, 1971, 1974); Pooser (1965); Hoyt and Hails (1967, 1974); Herrick (1961, 1964, 1965, 1976); Colquhoun (1965, 1974); Colquhoun and Pierce (1971); Colquhoun and Brooks (1986); and Colquhoun and others (1968, 1987). Each of these studies added data from, and interpretation of, Pliocene and Pleistocene sediments in the region.

In the late 1970s numerous researchers began using combinations of paleontologic, geomagnetic, chemical, and isotopic analyses to date and correlate Pliocene and Pleistocene deposits in the southeastern Atlantic Coastal Plain, resulting in time-stratigraphic data for much of the Cape Fear area of the Carolinas (Akers, 1972; Akers and Koeppel, 1973; Liddicoat and others, 1979, 1981; Cronin and Hazel, 1980; Liddicoat, 1982; McCartan and others, 1982, 1984; Wehmiller and Belknap, 1982; Cronin and others, 1984; Colquhoun and Brooks, 1986; Huddlestun, 1988; Ward and Huddlestun, 1988; Wehmiller and others, 1988; Owens, 1989; Dowsett and Poore, 1990; McCartan and others, 1990; Cronin, 1990; and others). The lack of fossil material in Pliocene and Pleistocene sediments in southeastern South Carolina and Georgia, however, has resulted in relatively few late Cenozoic time-stratigraphic data for the Southeast Georgia embayment.



(1) T.M. Cronin (written communication, 1990), L.W. Ward (written communication, 1990)
(2) McCartan and others (1982, 1984), Owens (1989)
(3) Huddlestun (1988), Ward and Huddlestun (1988)
(4) Satilla Formation of Huddlestun (1988) and Veatch and Stephenson (1911)

FIG. 6.—Pliocene and Pleistocene stratigraphy from southeastern Virginia to extreme northern Florida.

STRATIGRAPHY

A compilation of identified Pliocene and early Pleistocene units in southeastern Virginia, North Carolina, South Carolina, and Georgia is given in Figure 6. Time-stratigraphic data for Pliocene and Pleistocene sedimentary sequences in southeastern Georgia are insufficient to make definitive correlations with named units in other Atlantic Coast states. Some isolated deposits of fossiliferous Pliocene sediments, however, have been biostratigraphically correlated to named units in the Carolinas and in southeastern Virginia.

In the following sections we briefly discuss the stratigraphy of Pliocene and Pleistocene sediments in the Atlantic Coastal Plain of southeastern South Carolina and Georgia. We give a general description of the sediments and discuss some of the similarities and differences between probable age-equivalent deposits in this area and in the Cape Fear region of the Carolinas. Due to the paucity of fossil data, the lack of isotopic, geomagnetic, and biogeochemical-age data, and the limited geologic mapping, we do not at this time suggest the use of specific formation names for Pliocene and Pleistocene sedimentary sequences in this part of the Southeast Georgia embayment. Current and future mapping and age determinations in the area should result in a stratigraphic framework that can be compared to the framework already established for the Cape Fear region of the Carolinas (McCartan and others, 1982, 1984, 1990; Owens, 1989).

Pliocene

Wabasso Beds.—

Three different ages of Pliocene marine sediments have been paleontologically identified in the Atlantic Coastal Plain of Georgia. The oldest sediments include variably phosphatic and calcareous sand with intermittent clay beds. Available samples are from cores (18–23 m [60–75 ft] depths) from several of the coastal islands from Beaufort, South Carolina to Little Tybee Island, Georgia (Fig. 4, loc. P and Q). Woolsey (1976) and Herrick (1976) considered these beds to be a facies of the early late Pliocene Duplin Formation. Huddlestun (1988) informally named the sediments the Wabasso beds and suggested that the foraminifera were indicative of a fully open-marine environment and a late early Pliocene age. The presence of *Globigerina nepenthes* in these sediments suggests an age no younger than 4.2–4.0 Ma. The presence of *Globigerina margaritae margaritae* suggests that the Wabasso beds are no older than about 5.7 Ma (J. E. Hazel, pers. commun., 1991). Huddlestun (1988, p. 100) concluded that "the co-occurrence of *Globigerina nepenthes* and *Globigerina margaritae margaritae* is indicative of Zone PL1 of Berggren (1973)."

The age range and environment of deposition of the Wabasso beds suggest that these sediments represent a major late early Pliocene transgression, and that they are probably time equivalent to the Sunken Meadows Member of the Yorktown Formation of southeastern Virginia and northeastern North Carolina (Fig. 6). Available data, however, do not preclude the possibility that the Wabasso beds are upper Miocene.

Duplin and Raysor Formations.—

The Duplin Formation was first described as the Duplin beds of Miocene age from an area near the Cape Fear River in Duplin County, North Carolina (Dall, 1898). Veatch and Stephenson (1911) first used the name in Georgia. Cooke (1936) proposed the name Raysor Marl for sediments in southeastern South Carolina thought to be older than Duplin; he later abandoned the name Raysor and included the sediments in the Duplin (Cook, 1945). Mansfield (1944) thought that Duplin sediments south of central North Carolina were equivalent to the youngest part of his uppermost unit (zone 2) of the Yorktown Formation in southern Virginia.

In the middle 1970s the Duplin was recognized to be definitely Pliocene (Akers, 1972; Woolsey, 1976). The name Raysor was reinstated by Blackwelder and Ward (1979), who at the same time abandoned the name Duplin and replaced it with the Yorktown Formation in eastern North Carolina and South Carolina, with the Raysor in south-central and southeastern Georgia, and with the Jackson Bluff Formation (Puri and Vernon, 1964) in Florida. Owens (1989), citing the need for more detailed mapping of the area between southern Virginia (type area of the Yorktown) and the Cape Fear region, reinstated the name Duplin for southeastern North Carolina and northeastern South Carolina.

Huddlestun (1988) and Ward and Huddlestun (1988) assigned an early late Pliocene age to the Raysor, which they considered consistent with Zone PL3 of Berggren (1973). Although the Duplin and Raysor Formations may, and probably do, include sediments deposited during several depositional cycles, these cycles cannot presently be differentiated either by paleontologic analysis or by stratigraphic position. Therefore, we consider sediments in southeastern Georgia that contain fossils consistent with Zone PL3 of Berggren (1973) to be equivalent wholly or in part to the Duplin and Raysor Formations and to the Rushmere Member of the upper part of the Yorktown Formation (Ward and Huddlestun, 1988; Cronin, and others, 1984; T. M. Cronin, pers. commun., 1990; L. W. Ward, pers. commun., 1990), and to the Jackson Bluff Formation of the eastern Gulf Coastal Plain of Florida (Huddlestun, 1988) (Fig. 6).

As applied in Georgia (Veatch and Stephenson, 1911), the Duplin was restricted to the unconformably bound, tan to white marl, shells, and clay exposed along the right bank of the Savannah River between Porters Landing and Cedar Bluff Landing about 80 km (50 mi) upstream from the river mouth (Fig. 4, loc. C). Veatch and Stephenson (1911) also referred to Duplin fossils from dredged spoil near the mouth of the Altamaha River (Fig. 4, loc. J and K) in southeastern Georgia (also discussed by Darby and Hoyt, 1964) and from an outcrop of organic-rich clay near Doctorstown, about 64 km (40 mi) upstream from the mouth of the Altamaha River (Fig. 4, loc. F). Recently, early late Pliocene fossils have been identified from organic-rich sand present as spoil adjacent to a stock pond in Bulloch County, Georgia, about 80 km (50 mi) upstream from the mouth of the Ogeechee River (Fig. 4, loc. D). The fossiliferous Raysor Formation has been reported from 15 to 16 m (49–52 ft) depth in the Chatham 1 core (Fig. 4 , loc. E) in eastern Chatham County, where it was described as a "richly foraminiferal, phosphatic, argillaceous, finely sandy, calcarenitic limestone" (Huddlestun, 1988, p. 114).

The majority of probable early late Pliocene sediments in Georgia are nonfossiliferous. The shell beds between Cedars Landing and Porters Landing on the Savannah River, in Bulloch County along the Ogeechee River, and at Doctorstown on the Altamaha River, crop out between 26 and 30 m (85 and 100 ft) in altitude and can be traced upstream for several kilometers where they grade laterally into fine- to medium-grained, well-sorted, well-rounded, quartz sand with thin lenses of carbonaceous, micaceous silt and clay. Also, a fine-grained, well-sorted, well-rounded, quartzose marine sand crops out between 46 and 64 m (150 and 210 ft) in altitude in the highly dissected terrain between the Ogeechee and Savannah Rivers, and at the surface and in the shallow subsurface in south-central Georgia, near the apex or western limit of the Southeast Georgia embayment. In the area between the Ogeechee and the Savannah Rivers, the marine sand is unconformably overlain by cross-bedded, medium- and coarse-grained, subangular, fluvial quartz sand and pebbles. In south-central Georgia, the marine sand is exposed at the surface, except near the Ocmulgee and Altamaha Rivers, where it is overlain by fluvial sands and gravels.

Lack of exposures, limited subsurface data, and truncation by younger geomorphic features (i.e., wave-cut scarps) prohibit definitive correlation, but we tentatively suggest that: (1) the fossil-rich early late Pliocene sediments that crop out along the Savannah and the Altamaha Rivers grade updip into a nonfossiliferous marine sand; and (2) the outcropping nonfossiliferous marine sand present throughout southeastern Georgia (exposed at altitudes between 46 and 64 m [150–210 ft]) is the updip equivalent of the isolated fossil-bearing early late Pliocene deposits identified on Figure 4.

The Cypresshead and Bear Bluff Formations.—

Latest late Pliocene sediments that are stratigraphically above the Duplin Formation have been referred to as the Bear Bluff Formation in the Carolinas (Dubar, 1971; Dubar and others, 1974; McCartan and others, 1982; Owens, 1989) and the Cypresshead Formation by Huddlestun (1988) in Georgia. The Bear Bluff Formation was defined by DuBar (1971) from a locality in northeastern South Carolina; its definition was later modified by Dubar and others (1974) and again by Owens (1989) to include a variety of marine facies. It is commonly fossiliferous, especially in channel deposits where fossil-rich carbonate sediments can be 20 to 45 m thick.

In Georgia, Huddlestun (1988, p. 119) gave the name Cypresshead Formation to fossil-poor sediments that are stratigraphically above his Raysor Formation (Fig. 6). He described the Cypresshead as "a prominently thin- to thick-bedded and massive, planar- to cross-bedded, variably burrowed and bioturbated, fine-grained to pebbly, coarse-grained sand formation in the terrace region of eastern Georgia." He called the Cypresshead a regionally extensive unit composed primarily of quartz sand with prominent clay beds that are locally dominant.

The mineralogy of latest late Pliocene sediments in southeastern South Carolina and Georgia is variable. Sediments are arkosic near the Savannah and Altamaha Rivers and quartzose away from the rivers. That part of the Cypresshead Formation between 30 and 49 m (100–160 ft) in altitude includes quartzose to arkosic fluvial marine, back-barrier, barrier, and shelf sediments and is probably lithostratigraphically and chronostratigraphically equivalent to the Bear Bluff Formation, as described by Owens (1989).

McCartan and others (1982) placed the age of the Bear Bluff Formation in east-central Carolina between 2.4 and 1.8 Ma. Huddlestun (1988) reported a planktonic foraminiferal assemblage from the Nashua Formation (probable Cypresshead equivalent) in northeastern Florida just south of the Georgia line (Fig. 4, loc. L). He considered the assemblage to be equivalent to Zone PL5 of Berggren (1973) and to the Bear Bluff Formation in northeastern South Carolina (Fig. 6).

No age data are available for Cypresshead sediments in Georgia outcrops. Subsurface microfossil data are from pods or discontinuous lenses of sediment overlain by Pleistocene barrier and/or back-barrier deposits. These data include: (1) a small assemblage of juvenile planktonic foraminifera from depths of 16.3 to 17.0 m (53.5–56.0 ft) in a core from Wayne County, Georgia (Fig. 4, loc. N), which suggests an age no younger than Pliocene based upon the presence of *Glogigerina apertura* and *Globigerinoides obliquus* (Huddlestun, 1988); (2) the presence of the benthic foraminifer *Virgulinella gunteri* between 12 and 14 m (39 and 45 ft) depths in the Chatham 14 core (Fig. 4, loc. S) in eastern Chatham County, also indicating a Pliocene age; and (3) a diatom assemblage at 14 to 18 m (45–59 ft) depths in the Bryan 1 core (Fig. 4, loc. H) in eastern Bryan County, suggesting a probable latest late Pliocene to early Pleistocene age. The assemblage consists of fairly typical Pleistocene forms with possible Pliocene forms in the genus *Rhaphoneis*.

Assuming that the samples from these cores represent the same stratigraphic unit, then the age of the Cypresshead in southeastern Georgia ranges from the latest late Pliocene into early Pleistocene. At present, however, we consider the Cypresshead to be latest late Pliocene and age equivalent (wholly or in part) to the Bear Bluff Formation in northeastern South Carolina (Fig. 6).

Pleistocene

Pleistocene sediments in southeastern Georgia comprise sequences of largely nonfossiliferous fluvial marine, back-barrier, barrier, and shallow-shelf sand with minor amounts of clay. Generally, the sediments are micaceous, burrowed, and highly weathered. Historically, Pleistocene units have been differentiated on the basis of concepts and/or models that relate mode of deposition to preserved landform (Cooke, 1930a, b, 1931, 1943; Hoyt, 1967; Hoyt and Hails, 1974). Veatch and Stephenson (1911) proposed that fluvial and marine Pleistocene sediments in southeastern Georgia be referred to as the Satilla Formation, a name of discontinued use in succeeding years. Herrick (1965) thought that Pleistocene sediments in southeastern Georgia belonged to one deltaic sequence and should include all near-surface and surface sediments below 82 m (270 ft). He did not name the unit. Huddlestun (1988) also concluded that there should be a "one formation" designation for all Pleistocene units. He reintroduced the name Satilla Formation, restricted it to marine and marginal-marine sediments, and expanded the age range to include both Pleistocene and Holocene deposits. Recent field work by the first author suggests an alternative to the "one-formation" concept that more closely agrees with the stratigraphy given by McCartan and others (1984, 1990) for the Charleston area of South Carolina.

Paleontologic, isotopic, and paleomagnetic data are available for Pleistocene sediments in the Cape Fear area of the Carolinas northeast of the Edisto River (Richards, 1936, 1943; DuBar and Chaplin, 1963; DuBar and Furbunch, 1965; Colquhoun and others, 1968; Liddicoat and others, 1979, 1981; Liddicoat, 1982; McCartan and others, 1982, 1984; Szabo, 1985; Owens, 1989). Few fossil data are available from probable age-equivalent sediments between the Edisto and St. Marys Rivers. Richards (1969, p. 9) commented on the lack of Pleistocene fossils from Georgia: "While only 15 species (of mollusks) have been found in the Pleistocene deposits of Georgia, mostly near Savannah, a much more extensive fauna is known to occur in both South Carolina and Florida, and presumably lived in the Pleistocene seas of Georgia." Despite numerous investigations since the 1960s, only a few additional Pleistocene fossil localities have been identified in this area.

Published data on Pleistocene invertebrate fossils in Georgia include well locations and locations of drainage ditches and road cuts from in and near Savannah. Richards (1969) commented that by that time no fossils could be seen in the ditches near Savannah, but fossils could be seen along the Skidaway River southeast of Savannah. Fossiliferous outcrops, which are currently being studied, may be age equivalent to those along the Skidaway River. Data on Pleistocene invertebrate fossils are given in Figure 5.

Pleistocene sediments near the coast in southeastern Georgia have yielded a variety of vertebrate fossils (a partial list is given in Fig. 5). Cooke (1943) suggested that the bone beds recognized in Georgia might be equivalent to what was then referred to as the Melborne bone bed in Florida. In the Savannah area, bones of a giant ground sloth (*Megatherium*) were found in 1823 and reported by Hodgson (1846) and Lyell (1855). Hay (1923) included a faunal list based upon fossil bones from the Brunswick Canal. Cooke (1943) reprinted Hay's species list, which included giant beaver, elephant, mastodon, buffalo, deer, tapir, horses, ground sloths, crocodiles, and several types of fish. Cooke (1943) noted that several of the species found at Brunswick, and some not reported from Brunswick, such as the box tortoise *Terrapene canaliculata,* had been reported from the Savannah area. Cooke (1943) also mentioned a fossil-bone locality at Hayners Bridge near Savannah, 4 km (2.5 mi) west of Isle of Hope, that contained *Mammut americanum* (mastodon) and *Mylodon harlani* (sloth). Hurst (1957) summarized known occurrences, to that date, of vertebrate fossils from coastal Georgia and included fossils from the Brunswick canal.

Differences in vertebrate and invertebrate faunal and/or floral assemblages have not been sufficient to differentiate Pleistocene units. Differences in species abundance and shell morphology are evident in foraminifera associated with sedimentary sequences above and below 9 m (30 ft) in altitude. Foraminifera from surface and near-surface sediments located below 9 m (30 ft) are more delicate, glassy, and less encrusted than the thicker, more calcitic foraminifera associated with older Pleistocene and late Pliocene sediments. The work of McCartan and others (1982, 1984, 1990) and Owens (1989) suggests that deposits associated with surfaces between 6 and 9 m (20 and 30 ft) in altitude in the South Carolina Coastal Plain are about 200 ka. Weathering and soil-profile data from similar deposits, in the same altitude range, in the Savannah area suggest an age around 500 ka. More data are needed to determine the age(s) of these sediments in Georgia. Until such data are available, changes in species abundance and shell morphology of foraminifera can be used to differentiate between Pleistocene sediments older and younger than 500 ka.

DISCUSSION

Herrick (1965, p. 6) observed: "Except for the extreme coastal area, the Pleistocene deposits of Georgia are uniformly nonfossiliferous." Despite numerous investigations since then, that statement still stands. It is also true of the Pliocene, except possibly for the early late Pliocene sediments. The question is, "Why?". In this section we suggest some factors that may control or contribute to the differences in depositional history and fossil content of age-equivalent Pliocene and Pleistocene sediments in the Atlantic Coastal Plain of the Carolinas and Georgia.

Local Drainages

Outcrop and subsurface data from the latest late Pliocene Cypresshead Formation and younger sediments in Georgia indicate a significant freshwater or fluvial influence on unit lithology and faunal composition. As discussed by Hayes (1989), the coastal area of southeastern South Carolina and Georgia form the head or apex of the Georgia Bight, the arcuate stretch of coastline that extends from Cape Hatteras, North Carolina, to Cape Canaveral, Florida. The head of the bight is locally referred to as the Sea Islands area and extends from the Edisto River, South Carolina, to the St. Marys River on the Florida/Georgia line (Fig. 3), which is roughly the width of the Southeast Georgia embayment (Fig. 1). Compared to the flanks of the Georgia Bight, the Sea Islands area has an order of magnitude higher freshwater discharge and suspended-sediment influx. This is manifest in the high turbidity of coastal waters and the "brown" beaches that are common to the Sea Islands area. The relatively low-wave height and high-tidal range of this area also contribute to the high turbidity of nearshore waters. We suggest that from the latest late Pliocene to the present, the combination of high turbidity and relatively low salinity (particularly at time of high discharge from the region's rivers) has restricted the number and variety of invertebrate marine fauna common to the area.

Regional and Local Structures

We also suggest that the large fluvial input to the area's ecosystems has, in large part, been controlled or affected by slow uplift associated with local and regional geologic structures (Winker and Howard, 1977; Cronin, 1981; Markewich, 1985; Markewich and others, 1986; Soller, 1988; Dowsett and Cronin, 1990). Although sediment load cannot be directly related to warping or regional uplift, styles and rates of deformation of both regional and local structures can affect stream orientation, drainage density, shoreline configuration, and direction of longshore currents.

In the southeastern Atlantic Coastal Plain, prominent regional structures that have affected Cenozoic sediment distribution include the Cape Fear arch, Peninsular arch, and the Southeast Georgia embayment (Fig. 1; Gohn, 1988). Smaller structures, not identified on Figure 1, have also been important. The Beaufort arch is a coastal "high" that has affected the distribution of Cenozoic sediments in the area between Beaufort, South Carolina, and Savannah, Georgia (Heron and Johnson, 1966; Colquhoun and others, 1969; Woolsey, 1976). Data suggest that these structures have also influenced local drainages throughout the Pliocene and Pleistocene. The southward migration of the Pee Dee and Savannah Rivers throughout the Pleistocene and Holocene (Markewich, 1985, and in prep.; and Soller, 1988) has been in response to the Cape Fear and the Beaufort arches, respectively. The Beaufort arch may also have deflected south-flowing longshore currents seaward. Both the southward migration of the rivers and the deflection of currents would have maintained, and/or increased through time, the length of barrier-protected shoreline that is dominated by fine-grained, micaceous, fluvial marine sediments.

Erosion

Another possible reason for the lack of fossiliferous material in Pliocene and Pleistocene sediments of southeastern South Carolina and Georgia is the pattern of marine erosion. Rarely are there stacked sequences of Pliocene and/or Pleistocene sediments in this part of the emergent southeastern Atlantic Coastal Plain. There are no known Pleistocene fossil localities seaward of Pleistocene barriers in this part of the Georgia Bight. Therefore, there are no data on the assemblages of marine invertebrates indigenous to the shallow shelf during the Pleistocene. This lack of Pleistocene open-marine, nearshore marine invertebrates suggests either that the invertebrates were never present, or that they were removed by a subsequent transgression(s).

Weathering

Weathering has greatly affected the preservation of shells in the near-surface sediments. Minimum depths of oxidation range from about 3 m (10 ft) in marine sand younger than 50 ka to about 12 m (40 ft) in uppermost Pliocene fluvial marine sands and clayey sands, to about 19 m (60 ft) in early late Pliocene marine sands. Most of the area's surface and near-surface waters have a low pH (3.5–5.5) and a high organic content (unpublished data). In this area, there is no near-surface limestone to buffer the low-pH shallow ground water. Modification of the pH of near-surface ground water and/or protection from the effects of ground water are needed for preservation of fossils. Most shell-bearing sediments were originally deposited near the surface, or they are remnant of older units that have been truncated and shallowly buried. The shallow depth of burial has resulted in dissolution of the shells or local dolomitization. Dissolution can occur quickly once the sediments are above the local water table. Individual thin halves of shells or "ghosts" of shells that can be seen in drainage ditches when first dug are often not evident six months later.

Shoreline Evolution

As seen in Figure 5, most fossiliferous material has been collected from early late Pliocene sediments. We do not believe that this is an artifact of sampling. Field evidence suggests that both the shoreline configuration and the spatial distribution of streams discharging into the Atlantic were different in early late Pliocene time. We suggest that: (1) the drainage density of the eastern part of the Atlantic Coastal Plain was less in the early late Pliocene than during the latest late Pliocene and Pleistocene; (2) the shoreline distance between the paleodeltas of the region's large rivers (such as the Pee Dee and the Savannah) was greater in the early late Pliocene than in the latest late Pliocene and Pleistocene; (3) in the early late Pliocene the Atlantic Ocean and Gulf of Mexico were connected by a shallow platform across south-central Georgia and north-central Florida; and (4) when the Atlantic and Gulf were connected, the Oconee and Ocmulgee rivers (Fig. 3) had not yet joined to form the Altamaha River. Some of these ideas date to the turn of the century. Some are new. They are presently being tested by ongoing field mapping and sample analyses.

Data are insufficient to comment on the paleogeography of the late early Pliocene. The Wabasso beds provide the only record of that period in this area of the Southeast Georgia embayment.

SUMMARY

Pliocene and Pleistocene sediments in southeastern Georgia are largely nonfossiliferous barrier and back-barrier fine- and very fine-grained quartz sand with minor amounts of silt and clay. Emerged, repetitious sedimentary sequences are embayed one into another and define a "stepped" low-altitude, low-relief terrain characterized by barrier ridge, back-barrier flats, and shallow-shelf plains. Some of the sedimentary sequences have been recognized as formations, but few data are available on which correlations can be made with probable age-equivalent sediments in the Cape Fear area of the Carolinas. The fossil-poor character of the sediments is largely the result of environmental influences that have been active in the area since the latest Pliocene. These influences include: (1) a large freshwater influence resulting from the numerous rivers that empty into this part of the Atlantic Coast; (2) the effects of local and regional geologic structures on the area's drainages and nearshore currents; (3) the erosive nature of Pliocene and Pleistocene transgressive events; and (4) the intensity and rapidity of weathering. Sediment type and fossil content have also been affected by changes in shoreline configuration, drainage pattern, and drainage density during the Pliocene and Pleistocene.

ACKNOWLEDGMENTS

The authors extend their thanks to the following individuals for their cooperation and help: T. M. Cronin, U.S. Geological Survey, Reston, Virginia, identified ostracodes from recently sampled localities in the area; L. W. Ward, Curator of Invertebrate Paleontology, Virginia Museum of Natural History, Martinsville, identified many of the macrofossils; W. H. Abbott, formerly with Mobile Oil Corporation, Houston, Texas, provided unpublished data on diatoms; J. E. Hazel, Louisiana State University, Baton Rouge, freely discussed the difficulties in identifying lower Pliocene sediments in the southeastern Atlantic Coastal Plain; J. P. Owens, U.S. Geological Survey, Reston, Virginia, and D. J. Colquhoun, University of South Carolina, Columbia, shared their knowledge of the Pliocene and Pleistocene of the area. Lyle Campbell of the University of South Carolina, Spartenburg, freely discussed the taxonomy and stratigraphy of marine invertebrates in the southeastern Atlantic Coastal Plain. We also thank T. M. Cronin, J. P. Owens, and E. D. Kuzmin for their constructive suggestions on earlier versions of the manuscript and M. J. Hogan for drafting the included figures.

REFERENCES

AKERS, W. H., 1972, Planktonic foraminifera and biostratigraphy of some Neogene formations, northern Florida and Atlantic Coastal Plain: Tulane Studies in Geology and Paleontology, v. 9, p. 1–139.

AKERS, W. H., AND KOEPPEL, P. E., 1973, Age of some Neogene formations, Atlantic Coastal Plain, United States and Mexico, *in* Smith, L. A., and Hardenbol, J., eds., Proceedings of Symposium on Calcareous Nannofossils, Gulf Coast Association of Geological Sciences and Gulf Coast Section, Society of Economic Paleontologists and Mineralogists, 23rd Annual Convention, Houston, Texas, 1973, p. 80–93.

ALDRICH, T. H., 1911, Notes on some Pliocene fossils from Georgia, with descriptions of new species: Nautilus, v. 24, p. 131–132 and 138–140.

BERGGREN, W. A., 1973, The Pliocene time scale: calibration of planktonic foraminiferal and calcareous nannoplankton zones: Nature, v. 243, p. 391–397.

BLACKWELDER, B. W., AND WARD, L. W., 1979, Stratigraphic revision of the Pliocene deposits of North and South Carolina: South Carolina State Development Board, Division of Geology, Geologic Notes, v. 23, p. 33–49.

CLARK, W. B., MILLER, B. L., STEPHENSON, L. W., JOHNSON, B. L., AND PARKER, H. N., 1912, The Coastal Plain of North Carolina: North Carolina Geologic and Economic Survey, v. 3, 552 p.

COLQUHOUN, D. J., 1965, Terrace sediment complexes in central South Carolina: Atlantic Coastal Plain Geological Association Field Conference Guidebook, University of South Carolina, Columbia, 62 p.

COLQUHOUN, D. J., 1974, Cyclic surficial stratigraphic units of the middle and lower Coastal Plains, central South Carolina, *in* Oaks, R. Q., Jr., and DuBar, J. R., eds., Post-Miocene Stratigraphy, Central and South Atlantic Coastal Plain: Utah State University Press, Logan, p. 179–190.

COLQUHOUN, D. J., AND BROOKS, M. J., 1986, New evidence from the southeastern U.S. for eustatic components in the late Holocene sea levels: Geoarchaeology: An International Journal, v. 1, p. 275–291.

COLQUHOUN, D. J., FRIDDELL, M. S., WHEELER, W. H., DANIELS, R. B., GREGORY, J. P., MILLER, R. A., AND VAN NOSTRAND, A. K., 1987, Quaternary Geology, Savannah 4° × 6° Quadrangle, United States, *in* Richmond, G. M., Fullerton, D. S., and Weede, D. L., eds., Quaternary Geologic Atlas of the United States: U.S. Geological Survey Miscellaneous Investigations Series Map I-1420 (NI-17).

Colquhoun, D. J., Heron, S. D., Jr., Johnson, H. S., Jr., Pooser, W. K., and Siple, G. E., 1969, Up-dip Paleocene-Eocene stratigraphy of South Carolina reviewed: South Carolina State Development Board, Division of Geology, Geologic Notes, v. 13, p. 1–26.

Colquhoun, D. J., Herrick, S. M., and Richards, H. G., 1968, A fossil assemblage from the Wicomico Formation in Berkeley County, South Carolina: Geological Society of America Bulletin, v. 79, p. 1211–1220.

Colquhoun, D. J., and Pierce, W., 1971, Pleistocene transgressive-regressive sequences on the Atlantic Coastal Plain: Quaternaria, v. 15, p. 35–50.

Cooke, C. W., 1930a, Correlation of coastal terraces: Journal of Geology, v. 38, p. 577–589.

Cooke, C. W., 1930b, Pleistocene shorelines: Washington Academy of Sciences Journal, v. 20, p. 389–589.

Cooke, C. W., 1931, Seven coastal terraces in the southeastern states: Washington Academy of Sciences Journal, v. 21, p. 503–513.

Cooke, C. W., 1936, Geology of the Coastal Plain of South Carolina: U.S. Geological Survey Bulletin 867, 196 p.

Cooke, C. W., 1943, Geology of the Coastal Plain of Georgia: U.S. Geological Survey Bulletin 941, 121 p.

Cooke, C. W., 1945, Geology of Florida, Florida Geological Survey Bulletin 29, 339 p.

Cooke, C. W., and Mossom, S., 1929, Geology of Florida, Florida Geological Survey 20th Annual Report, 1927–1928, p. 29–227.

Cronin, T. M., 1981, Rates and possible causes of neotectonic vertical crustal movements of the emerged southeastern United States Atlantic Coastal Plain: Geological Society of America Bulletin, v. 92, p. 812–833.

Cronin, T. M., 1990, Evolution of Neogene and Quaternary marine Ostracoda, United States Atlantic Coastal Plain: evolution and speciation in Ostracoda, IV: U.S. Geological Survey Professional Paper 1367-C, 43 p.

Cronin, T. M., Bybell, L. M., Poore, R. Z., Blackwelder, B. W., and Liddicoat, J. C., 1984, Age and correlation of emerged Pliocene and Pleistocene deposits, U.S. Atlantic Coastal Plain: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 47, p. 21–51.

Cronin, T. M., and Hazel, J. E., 1980, Ostracode biostratigraphy of Pliocene and Pleistocene deposits of the Cape Fear Arch region, North and South Carolina, *in* Shorter contributions to paleontology, 1979: U.S. Geological Survey Professional Paper 1125-B, 25 p.

Dall, W. H., 1896, Diagnosis of new Tertiary fossils from the southern United States: U.S. National Museum Proceedings, v. 18, p. 31–46.

Dall, W. H., 1898, A table of North American Tertiary horizons, correlated with one another and those of Europe with annotations: U.S. Geological Survey 18th Annual Report, part 2, p. 323–348.

Darby, D. G., and Hoyt, J. H., 1964, An upper Miocene fauna dredged from tidal channels of coastal Georgia: Journal of Paleontology, v. 38, p. 67–73.

Dowsett, H. J., and Cronin, T. M., 1990, High eustatic sea level during the middle Pliocene: evidence from the southeastern U.S. Atlantic Coastal Plain: Geology, v. 18, p. 435–438.

Dowsett, H. J., and Poore, R. Z., 1990, A new planktic foraminifera transfer function for estimating Pliocene–Recent paleoceanographic conditions in the North Atlantic: Marine Micropaleontology, v. 16, p. 1–23.

DuBar, J. R., 1962, New radiocarbon dates for the Pamlico Formation in South Carolina and their stratigraphic significance: South Carolina Development Board, Division of Geology, Geologic Notes, v. 6, p. 21–24.

DuBar, J. R., 1971, Neogene stratigraphy of the lower Coastal Plain of the Carolinas: Atlantic Coastal Plain Geological Association, 12th Annual Field Conference Guidebook, Myrtle Beach, South Carolina, 128 p.

DuBar, J. R., 1974, Summary of the Neogene stratigraphy of southern Florida, *in* Oaks, R. Q., and DuBar, J. R., eds., Post-Miocene Stratigraphy, Central and Southern Atlantic Coastal Plain: Utah State University Press, Logan, p. 206–231.

DuBar, J. R., and Chaplin, J. R., 1963, Paleoecology of the Pamlico Formation (late Pleistocene), Nixonville Quadrangle, Horry County, South Carolina: Southeastern Geology, v. 4, p. 127–165.

DuBar, J. R., and Furbunch, H. W. C., 1965, The Waccamaw Formation (Pliocene?) and its microfauna, Intracoastal Waterway, Horry County, South Carolina: South Carolina Development Board, Division of Geology, Geologic Notes, v. 9, p. 1–24.

DuBar, J. R., Johnson, H. S., Jr., Thom, B., and Hatchell, W. O., 1974, Neogene stratigraphy and morphology, south flank of the Cape Fear arch, North and South Carolina, *in* Oaks, R. Q., Jr., and DuBar, J. R., eds., Post-Miocene Stratigraphy, Central and Southern Atlantic Coastal Plain: Utah State University Press, Logan, p. 139–173.

Edwards, R. A., 1944, Ostracoda from the Duplin marl (upper Miocene): Journal of Paleontology, v. 18, p. 505–528.

Gohn, G. S., 1988, Late Mesozoic and early Cenozoic geology of the Atlantic Coastal Plain: North Carolina to Florida, *in* Sheridan, R. E., and Grow, J. A., eds., The Geology of North America, The Atlantic Continental Margin, U.S.: Geological Society of America, Decade of North American Geology, v. I-2, p. 107–130.

Hay, O. P., 1923, The Pleistocene of North America and its vertebrated animals from the sites east of the Mississippi River and from the Canadian Provinces east of longitude 95°: Carnegie Institute of Washington Publication 322, 307 p.

Hayes, M. O., 1989, Modern clastic depositional environments, South Carolina: 28th International Geological Congress Field Trip Guidebook T371, Charleston to Columbia, South Carolina: American Geophysical Union, Washington, D.C., 85 p.

Heron, S. D., and Johnson, H. S., Jr., 1966, Clay mineralogy, stratigraphy, and structural setting of the Hawthorn Coosawatchie District: Southeastern Geology, v. 7, p. 51–53.

Herrick, S. M., 1961, Well logs of the Coastal Plain of Georgia: Georgia Geological Survey Bulletin 70, 462 p.

Herrick, S. M., 1964, Foraminiferal fauna of late Miocene age from Georgia and South Carolina (abs.), *in* Abstracts for 1964: Geological Society of America Special Paper 82, p. 301–302.

Herrick, S. M., 1965, A subsurface study of Pleistocene deposits in coastal Georgia: Georgia Geological Survey Information Circular 31, 8 p.

Herrick, S. M., 1976, Two foraminiferal assemblages from the Duplin marl in Georgia and South Carolina: Bulletin of American Paleontology, v. 70, p. 125–163.

Herrick, S. M., and Vorhis, R. C., 1963, Subsurface geology of the Georgia Coastal Plain: Georgia Geological Survey Information Circular 25, 78 p.

Herrick, S. M., and Wait, R. L., 1955, Interim report on the results of test drilling in the Savannah area, Georgia and South Carolina: U.S. Geological Survey Open-File Report 55, 38 p.

Hodgson, W. B., 1846, Memoir on the *Megatherium* and other extinct gigantic quadrapeds of the coast of Georgia, with observations on its geologic features: Bartlett and Welford, New York, 47 p., 3 pl.

Hoyt, J. H., 1967, Barrier island formation: Geological Society of America Bulletin, v. 78, p. 1125–1136.

Hoyt, J. H., and Hails, J. R., 1967, Deposition and modification of Pleistocene shoreline sediments in coastal Georgia: Science, v. 155, p. 1541–1543.

Hoyt, J. H., and Hails, J. R., 1974, Pleistocene stratigraphy of southeastern Georgia, *in* Oaks, R. Q., Jr., and DuBar, J. R., eds., Post-Miocene Stratigraphy, Central and Southern Atlantic Coastal Plain: Utah State University Press, Logan, p. 191–205.

Huddlestun, P. F., 1988, A revision of the lithostratigraphic units of the Coastal Plain of Georgia: the Miocene through Holocene: Georgia Geologic Survey Bulletin 104, 162 p.

Hurst, V. J., 1957, Prehistoric vertebrates of the Georgia Coastal Plain: Georgia Mineral Newsletter, v. 10, p. 77–93.

Liddicoat, J. C., 1982, Paleomagnetic and amino acid dating of sediment in the Atlantic Coastal Plain: Geological Society of America Abstracts with Programs, v. 14, p. 546.

Liddicoat, J. C., Blackwelder, B. W., Cronin, T. C., and Ward, L. W., 1979, Magnetostratigraphy of upper Tertiary and Quaternary sediment in the central and southeastern Atlantic Coastal Plain: Geological Society of America Abstracts with Programs, v. 11, p. 187.

Liddicoat, J. C., McCartan, L., Weems, R. E., and Lemon, E. M., 1981, Paleomagnetic investigation of Pliocene and Pleistocene sediments in the Charleston, South Carolina area: Geological Society of America Abstracts with Programs, v. 13, p. 12–13.

Lyell, C., Jr., 1855, A second visit to the United States of North America, 3rd ed., v. 1: John Murray, London, p. 313–314.

MANSFIELD, W. C., 1944, Stratigraphy of the Miocene of Virginia and the Miocene and Pliocene of North Carolina, *in* Gardner, J., ed., Mollusca from the Miocene and Lower Pliocene of Virginia and North Carolina, Part 1: Pelecypoda: U.S. Geological Survey Professional Paper 199-A: p. 1–19.

MARKEWICH, H. W., 1985, Geomorphic evidence for Pliocene-Pleistocene uplift in the area of the Cape Fear Arch, North Carolina, *in* Morisawa, M., and Hack, J. T., eds., Tectonic Geomorphology: Allen and Unwin, Boston, p. 279–298.

MARKEWICH, H. W., PAVICH, M. J., MAUSBACH, M. J., STUCKEY, B. N., JOHNSON, R. G., AND GONZALEZ, V., 1986, Soil development and its relation to the ages of morphostratigraphic units in Horry County, South Carolina: U.S. Geological Survey Bulletin 1589-B, 61 p.

MACNEIL, F. S., 1947, Geologic map of the Tertiary and Quaternary formations of Georgia: U.S. Geological Survey Oil and Gas Investigations Preliminary Map 72.

MCCARTAN, L., LEMON, E. M., JR., AND WEEMS, R. E., 1984, Geologic map of the area between Charleston and Orangeburg, South Carolina: U.S. Geological Survey Miscellaneous Investigations Series Map I-1472.

MCCARTAN, L., OWENS, J. P., BLACKWELDER, B. W., SZABO, B. J., BELKNAP, D. F., KRIAUSAKUL, N., MITTERER, R. M., AND WEHMILLER, J. F., 1982, Comparison of amino acid racemization geochronometry with lithostratigraphy, biostratigraphy, uranium-series coral dating, and magnetostratigraphy in the Atlantic Coastal Plain of the southeastern United States: Quaternary Research, v. 18, p. 337–359.

MCCARTAN, L., WEEMS, R. E., AND LEMON, E. M., JR., 1990, Quaternary stratigraphy in the vicinity of Charleston, South Carolina, and its relationship to local seismicity and regional tectonism: U.S. Geological Survey Professional Paper 1367-A, 39 p.

OWENS, J. P., 1989, Geologic map of the Cape Fear region, Florence 1° × 2° Quadrangle and northern half of the Georgetown 1° × 2° Quadrangle, North Carolina and South Carolina: U.S. Geological Survey Miscellaneous Investigations Series Map I-1948-A.

PAUL, C. K., AND DILLON, W. P., 1979, The subsurface geology of the Florida-Hatteras shelf, slope and inner Blake Plateau: U.S. Geological Survey Open-File Report 79-448, 96 p.

POOSER, W. C., 1965, Biostratigraphy of Cenozoic Ostracoda from South Carolina: Arthropoda, Article 8: University of Kansas Publications, Lawrence, p. 1–80.

PURI, H. S., AND VERNON, R. O., 1964, Summary of the Geology of Florida and a guidebook to the classic exposures: Florida Geologic Survey Special Publication 5 (revised ed.), 312 p.

RICHARDS, H. G., 1936, Fauna of the Pleistocene Pamlico Formation of the southern Atlantic Coastal Plain: Geological Society of America Bulletin, v. 47, p. 1611–1656.

RICHARDS, H. G., 1943, Pliocene and Pleistocene fossils from the Santee-Cooper area, South Carolina: Academy of Natural Sciences, Philadelphia, Notulae Naturae, v. 118, 7 p.

RICHARDS, H. G., 1950, Geology of the Coastal Plain of North Carolina: Transactions of the American Philosophical Society, v. 4, part 1, p. 1–83.

RICHARDS, H. G., 1969, Illustrated fossils of the Georgia Coastal Plain: reprint of paper written in the 1950s for the Georgia Mineral Newsletter, Georgia Department of Mines, Mining and Geology, 47 p.

SOLLER, D. R., 1988, Geology and tectonic history of the lower Cape Fear River valley, southeastern North Carolina: U.S. Geological Survey Professional Paper 1466-A, 60 p.

SZABO, B. J., 1985, Uranium-series dating of fossil corals from marine sediments of southeastern United States Atlantic Coastal Plain: Geological Society of America Bulletin, v. 96, p. 398–406.

VEATCH, O., AND STEPHENSON, L. W., 1911, Preliminary report on the geology of the Coastal Plain of Georgia: Georgia Geological Survey Bulletin 26, 466 p.

WARD, L. W., AND HUDDLESTUN, P. F., 1988, Age and stratigraphic correlation of the Raysor Formation, late Pliocene, South Carolina: Tulane Studies in Geology and Paleontology, v. 21, p. 59–75.

WEHMILLER, J. F., AND BELKNAP, D. F., 1982, Amino acid age estimates, Quaternary Atlantic Coastal Plain: comparisons with U-series dates, biostratigraphy, and paleomagnetic control: Quaternary Research, v. 18, p. 311–336.

WEHMILLER, J. F., BELKNAP, D. F., BOUTIN, B. S., MIRECKI, J. E., RAHAIM, S. D., AND YORK, L. L., 1988, A review of the aminostratigraphy of Quaternary mollusks from United States Atlantic Coastal Plain sites, *in* Easterbrook, D. J., ed., Dating Quaternary Sediments: Geological Society of America Special Paper 227, p. 69–110.

WINKER, C. D., AND HOWARD, J. D., 1977, Correlation of tectonically deformed shorelines on the southern Atlantic Coastal Plain: Geology, v. 5, p. 123–127.

WOOLSEY, J. R., JR., 1976, Neogene stratigraphy of the Georgia coast and the inner continental shelf: Unpublished Ph.D. Dissertation, University of Georgia, Athens, 222 p.