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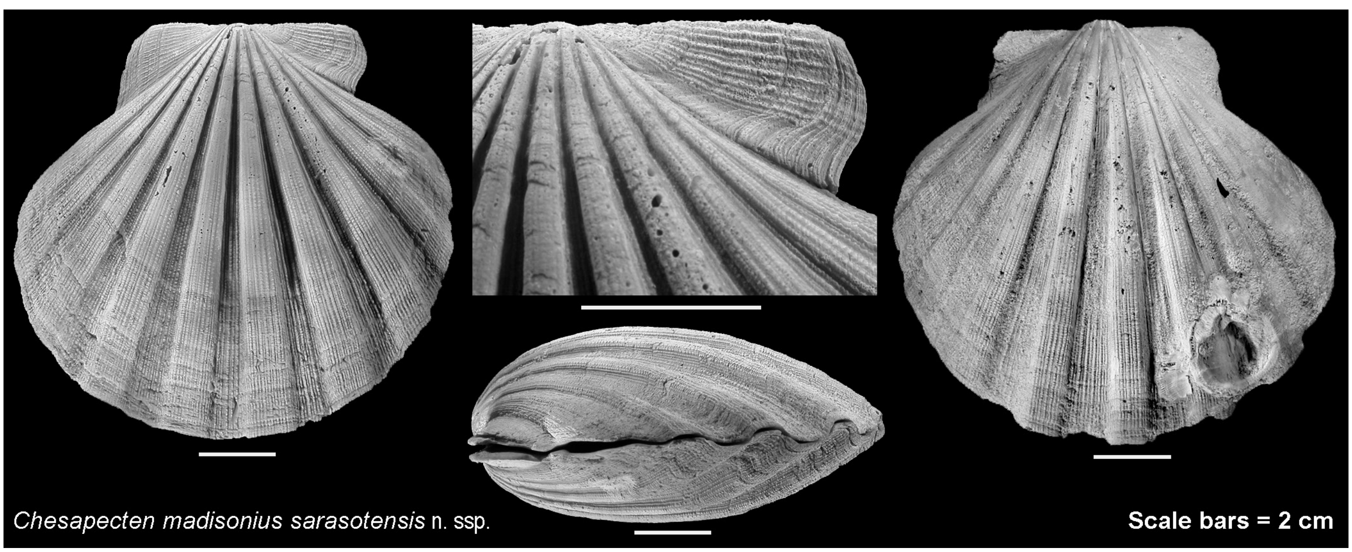
SYSTEMATICS AND BIOSTRATIGRAPHY OF *CHESAPECTEN* AND *CAROLINAPECTEN* (MOLLUSCA: BIVALVIA: PECTINIDAE) IN THE UPPER MIOCENE AND PLIOCENE "LOWER TAMIAMI FORMATION" OF SOUTHWESTERN FLORIDA

Thomas R. Waller



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SYSTEMATICS AND BIOSTRATIGRAPHY OF *CHESAPECTEN* AND *CAROLINAPECTEN* (MOLLUSCA: BIVALVIA: PECTINIDAE) IN THE UPPER MIOCENE AND PLIOCENE "LOWER TAMIAMI FORMATION" OF SOUTHWESTERN FLORIDA

Thomas R. Waller[1]

ABSTRACT

The position of the Miocene-Pliocene boundary in the highly leached marine sediments of the southwestern Florida Peninsula has been debated for more than a half century. A systematic revision of well-preserved calcitic shells of fossil scallops in the genera *Chesapecten* and *Carolinapecten* in these deposits and comparisons to known Miocene and Pliocene taxa in the Mid-Atlantic Coastal Plain indicate that the boundary lies between the Murdock Station Member of the Peace River Formation in Charlotte County, Florida, and the basal Units 11 and 12 exposed in pits near Sarasota. Both genera display stratigraphically successive morphologies that permit the construction of pectinid interval zones that should prove useful in future studies of upper Miocene and Pliocene leached deposits in the Florida Peninsula. In Charlotte County the *Chesapecten* succession begins with *Ch. middlesexensis hunterae* n. ssp., followed by *Ch. middlesexensis bayshorensis* n. ssp.; the *Carolinapecten* succession begins with *Ca. corpulentus* n. sp. followed by *Ca. murdockensis* n. sp. The latter is subdivided into three successive chronological subspecies: *Ca. murdockensis druidwilsoni* n. ssp., *Ca. murdockensis murdockensis* n. ssp., and *Ca. murdockensis parawatsonensis* n. ssp. *Chesapecten* and *Carolinapecten* in Charlotte County are accompanied by other calcitic fossils that are strong indicators of a late Miocene age, including broad-ribbed *Ecphora* in the *E. gardnerae* complex and non-auriculate oysters in the *Mansfieldostrea compressirostra* complex. In the basal units of the Sarasota pits in Sarasota County, the first *Chesapecten* to appear is *Ch. quinarius* n. sp., a form previously confused with *Ch. jeffersonius* (Say) or *Ch. septenarius* (Say). The new species occurs with *Ch. madisonius sarasotensis* n. ssp. and *Carolinapecten eboreus watsonensis* (Mansfield) in a fauna that is Pliocene, including *Ecphora quadricostata* and auriculate oysters in the *Mansfieldostrea compressirostra* complex. Contrary to previous studies, the early Pliocene species *Ch. jeffersonius* (Say) is not present in these areas, and the Murdock Station Member of Charlotte County does not correlate biostratigraphically with Unit 11 in the Sarasota area.

Key words: taxonomy, biostratigraphy, Bivalvia, Pectinidae, *Chesapecten*, *Carolinapecten*, Miocene, Pliocene, Florida, Peace River Formation, new species, new subspecies.

[1]Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, MRC-121, Washington, DC 20013-7012 <wallert@si.edu>

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INTRODUCTION

The placement of the Miocene-Pliocene boundary in highly leached, near-surface, shallow marine sediments in the southwestern Florida Peninsula has long been controversial, because these deposits lack age-diagnostic foraminifera and aragonitic macrofossils and have been beyond the reach of radiometric and isotopic dating methods. Hunter (1968) named and described these strata as the Bayshore Clay and Murdock Station members of the "lower Tamiami Formation" in Charlotte and Sarasota counties (Fig. 1) and used the dissolution-resistant, calcitic shells of pectinid bivalves for correlation with the better known biostratigraphic units of the Mid-Atlantic Coastal Plain in Virginia and North Carolina.

In the ensuing years, concepts of the stratigraphic ranges of guide fossils as well as their taxonomy have changed. The species determined by Hunter (1968) to be *Pecten jeffersonius* Say, 1824, which at that time was regarded as of late Miocene age, is now placed in *Chesapecten* Ward and Blackwelder, 1975, and is widely regarded as a guide fossil for the early Pliocene (Zanclean, Sunken Meadow Member of the Yorktown Formation) in the Mid-Atlantic Coastal Plain (Ward and Blackwelder, 1980). However, Hunter's species determination, at least for specimens from the basal beds exposed in pits in Sarasota County, has now been changed to a species or species-complex known to be of later Pliocene age (later Zanclean to early Piacenzian; Krantz, 1991; Campbell, 1993), and the existence of any near-surface Zanclean deposits in the southwestern Florida Peninsula has been questioned (Ward, 1993:87).

The present study reexamines the stratigraphic succession and taxonomy of *Chesapecten* and *Carolinapecten* Ward and Blackwelder, 1987, in the Bayshore Clay and Murdock Station members of Hunter (1968) in the Port Charlotte area and in Unit 11 of Petuch (1982) in the Sarasota area. Particular attention is paid to the position of the Miocene-Pliocene boundary and to correlation with biostratigraphic units that are now well documented in the Mid-Atlantic Coastal Plain (Ward and Blackwelder, 1980; Campbell, 1993; Campbell and Campbell, 1995). The resulting inferred morphological and stratigraphic sequences of *Chesapecten* and *Carolinapecten* species and subspecies outlined here provide a new and more detailed basis for constructing biozones and drawing time lines through the lithologically complex late Miocene to Pliocene marine sediments in the southwestern Florida Peninsula.

BACKGROUND

In the 1960s and early 1970s, excavations for canals and shell pits in the southwestern Florida Peninsula exposed previously unknown fossiliferous marine strata. In the Port Charlotte-Murdock area, Charlotte County (Fig. 1), Hunter

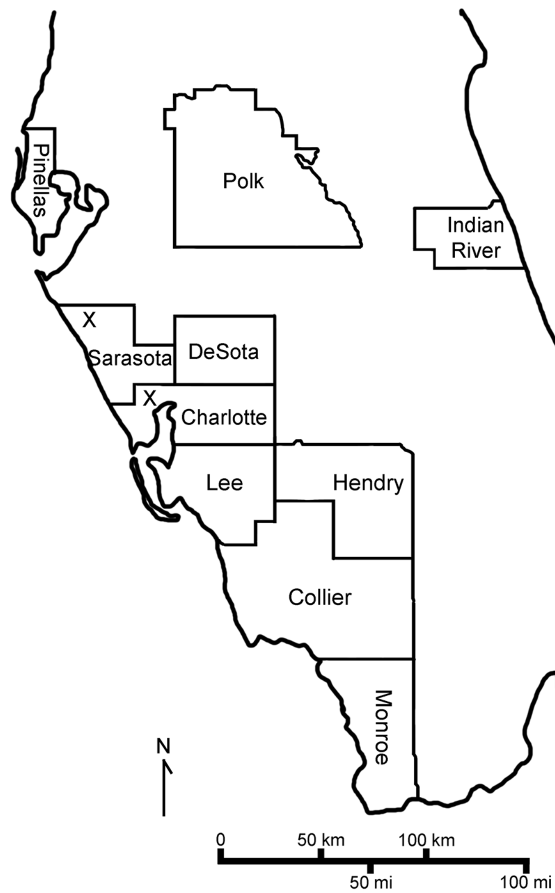


Figure 1. Outline map of the southern Florida Peninsula showing counties mentioned in the text. The Port Charlotte area in Charlotte County and the area of pits near Sarasota in Sarasota County are marked by X.

(1968) reported marine fossils from the "Tamiami Formation" that appeared to be older than any previously known from that formation in southern Florida. Using pectinid bivalves as guide fossils, because of their dissolution-resistant, largely calcitic composition, distinctive morphology, and non-overlapping stratigraphic ranges, she set up two biozones in these highly leached strata. These were named the *Pecten santamaria middlesexensis* zone and the *P. jeffersonius* zone, occurring respectively in her newly named Bayshore Clay and overlying Murdock Station members of the "lower Tamiami Formation." She regarded both of these members as Miocene in age. A third biozone, the *P. tamiamiensi*s zone, was applied to already well-known younger strata of Pliocene age occurring in the Sarasota area. These younger units comprise the Buckingham Limestone, Ochopee Limestone, and Pinecrest Sand members, which Hunter (1968) regarded as time-equivalent facies of the "upper Tamiami Formation." *Pecten tamiamiensis* Mansfield, 1932a, now placed in the genus *Interchlamys* Waller, 2011, is a late Pliocene (Piacenzian) tropical to subtropical species that is not known to extend into the Mid-Atlantic Coastal Plain and is not treated in the present study.

Hunter (1968) provided minimal descriptions of her guide fossils and no illustrations or museum voucher numbers. *Pecten santamaria middlesexensis* Mansfield, 1936, now known as *Chesapecten middlesexensis* (see Ward and Blackwelder, 1975:12), was said to be represented in the Bayshore Clay Member of the lower Tamiami Formation by young specimens agreeing "in detail with both the type and specimens from Mansfield's working collection at the U.S. National Museum [= National Museum of Natural History, Smithsonian Institution] and apparently constitut[ing] a new locality record for the subspecies" (Hunter, 1968:446) in southwestern Florida. On this basis, Hunter correlated her *P. santamaria middlesexensis* zone with "Zone 2 of the St. Marys formation near Urbanna, in Middlesex County, Virginia" (Hunter, 1968:447-448), a unit now placed in the Cobham Bay Member of the Eastover Formation of late Miocene (late Tortonian) age (Ward and Blackwelder, 1980:D25; Blackwelder, 1981c:96). *Carolinapecten*, referred to by Hunter 1968:447) as the "*Pecten eboreus* group," was not reported by her in this unit but was said to first occur in the overlying Murdock Station Member.

Hunter (1968) reported *P. jeffersonius* (= *Chesapecten jeffersonius*) in both the lower and upper beds of the Murdock Station Member of the lower Tamiami Formation, describing those in the upper bed as "the typical 10- to 11-ribbed variety."

She placed these beds in her *P. jeffersonius* zone, which she correlated with Mansfield's (1944) Zone 1 of the Yorktown Formation in Virginia, then regarded as late Miocene in age. Zone 1 is now placed in the Sunken Meadow Member of the Yorktown Formation, and *Ch. jeffersonius* is regarded as a reliable indicator of early Pliocene (Zanclean) age (Ward and Blackwelder, 1975, 1980:D31; Blackwelder, 1981b:5).

If Hunter's (1968) determinations of *Chesapecten middlesexensis* and *Ch. jeffersonius* were correct, modern concepts of the stratigraphic ranges of these species would place the Miocene-Pliocene boundary between the Bayshore Clay and Murdock Station members. That position of the boundary, however, is contradicted by other statements in the same paper that suggest placing the Miocene-Pliocene boundary above the Murdock Station Member. Hunter (1968), for example, thought that the Murdock Station Member is equivalent to the Red Bay Formation (= *Arca* faunizone, Choctawhatchee Formation) of the Florida Panhandle, a biozone now dated as late Miocene (Tortonian) based on planktonic foraminifera (Huddlestun and Wright, 1977, top of Zone N16 or base of N17 of Blow, 1969) and clearly older than the early Pliocene *Ch. jeffersonius* zone in the Mid-Atlantic Coastal Plain. Furthermore, Hunter (1968:447) referred to the presence in the Murdock Station Member of specimens of the calcitic gastropod *Ecphora* Conrad, 1843, having "wide, sometimes T-shaped, ridges" and stated that these "agree in all ways with specimens from the St. Mary's formation in Virginia," a unit now placed in the Cobham Bay Member of the Eastover Formation also of late Miocene age (Ward and Blackwelder, 1980).

Hunter (1978) later discussed lithologic units along the Caloosahatchee River. As shown in her Figure 3, the upper Tamiami Formation is represented along the river by the Buckingham Limestone Member and the supposed laterally equivalent Pinecrest Sand Member. These were given an approximate age of three million years (Pliocene, Piacenzian) and were shown to be bounded by two unconformities: the upper one separates these units from the Caloosahatchee Formation; the lower one represents a hiatus of much greater duration and separates the units from the Labelle Clay and Ortona Sand members, tentatively regarded by Hunter as laterally equivalent to one another and to represent the lower Tamiami Formation with an age of late Miocene (questionably 8 Ma). Hunter (1978:82) reported that the Ortona Sand Member yielded only a few fossils, but these included both "*Pecten jeffersonius*" and broad-ribbed *Ecphora*.

Many later studies are relevant to an understanding of the position of the Miocene-Pliocene boundary in the southwestern Florida Peninsula. Peck et al. (1979) summarized studies of cuttings from wells in Lee and Hendry counties (Fig. 1) that placed the Miocene-Pliocene boundary at a stratigraphic discontinuity that they concluded may correlate with the boundary between Hunter's (1968) *P. jeffersonius* and *P. tamiamiensis* zones, thus relegating the so-called *P. jeffersonius* zone to the Miocene. They elaborated on the micropaleontological evidence for the ages of beds that bracket the discontinuity, concluding that the discontinuity is preceded by planktonic foraminifera and calcareous nannoplankton that collectively indicate Zone N17 of Blow (1969), late Miocene, and is succeeded by indicators of late Pliocene age.

Weisbord (1981:97–98) presented a previously unpublished composite stratigraphic section measured by Hunter in 1970 in the then new Warren Brothers Pit in the Sarasota area. Hunter assigned the basal unit of the section to the Murdock Station Member, noting "abundant *Pecten jeffersonius* and fragments of Murdock barnacles." Clearly Hunter regarded the specimens that she identified as *P. jeffersonius* in the Murdock Station Member in the Port Charlotte area to be conspecific with pectinids at the base of the section in the Sarasota pit, thereby implying (based on the present concept of a Zanclean age for *Chesapecten jeffersonius*) that the Miocene-Pliocene boundary is somewhere below the "basal unit" in the Sarasota pits.

Petuch (1982) measured a section in the Macasphalt Newburn Pit Mine (formerly Warren Brothers Pit and APAC Pit) in the Sarasota area consisting of twelve units (Units 0-11, numbered from top to bottom) that has become a standard reference section. In contrast to Hunter (in Weisbord, 1981), however, he identified the *Chesapecten* present in the basal part of the section (his Unit 11) as *Chesapecten septenarius* (Say, 1824), an index species for lower Zone 2 Yorktown in the Mid-Atlantic Coastal Palin (Campbell, 1993:25). Although the upper Yorktown (Zone 2) is mainly late Pliocene (Piacenzian) in age, numerous studies indicate that at least the lower part of the Rushmere Member is early Pliocene (late Zanclean) in age (Cronin et al., 1984:fig. 8; Cronin, 1991:fig. 2; Krantz, 1991:fig. 6; Campbell, 1993:fig. 1). Nevertheless, Petuch (1982:19) surmised that Unit 11 may be late Miocene in age.

Tedford and Hunter (1984) examined Miocene marine-nonmarine correlations based on land mammals in the Atlantic and Gulf coastal plains of North America. In central and southern Florida, these correlations involve the Bone Valley and Tamiami formations, the latter presumably including the five members placed in the formation by Hunter (1968). They concluded that a strong disconformity within the Bone Valley Formation that separates the Lower and Upper Bone Valley Faunas appears to be equivalent to the discontinuity in the Tamiami Formation that approximates the Miocene-Pliocene boundary. This discontinuity is apparently the unconformity separating the Murdock Station Member from overlying units as reported by Hunter in DuBar (1974:215). The Murdock Station Member, however, contains Hunter's (1968) *P. jeffersonius* zone. As *Ch. jeffersonius* is now established as an early Pliocene species (Ward and Blackwelder, 1980:D35), this contradicts either the placement of the Miocene/Pliocene boundary at this horizon, or Hunter's identification of "*P. jeffersonius*."

Tedford et al. (1987) examined the succession of vertebrate faunas in central and southern Florida and their relationship to marine deposits in greater detail. They again emphasized the strong disconformity between the lower and upper parts of the Bone Valley Formation, correlating the lower Bone Valley with the Miocene Alum Bluff Group of Florida and the upper Bone Valley with the Pliocene upper part of the Tamiami Formation. However, they did not cite Hunter (1968), and it is unclear how the parts of the Bone Valley Formation relate to Hunter's stratigraphic units.

Scott (1988) proposed the name Peace River Formation (a name preoccupied by that of a Cretaceous formation in Canada) to combine phosphate-bearing siliciclastics, clays, and carbonates of the upper Hawthorn Group, the Bone Valley Formation (reduced to member status within the Peace River Formation), and the Bayshore Clay and Murdock Station members of Hunter (1968). Scott's stratigraphic cross-sections and well cores demonstrate the interfingering relationship between the Bone Valley Member and the undifferentiated Peace River Formation but do not specifically pinpoint the stratigraphic positions of Hunter's Bayshore Clay and Murdock Station members within the Peace River Formation. Nevertheless, the land mammal fossils of the Bone Valley provide clues to the possible ages of interfingering marine members. As pointed out by R. C. Hulbert, Jr. (pers. comm.), the "lower Bone Valley" includes two vertebrate faunas: the older Bradley Fauna (late Barstovian) and the younger Agricola Fauna (late early Clarendonian), both of middle Miocene (Serravallian) age (Webb and Hulbert, 1986; Tedford et al., 1987). The "upper Bone Valley" is represented by the Palmetto Fauna, which is regarded as latest Hemphillian (Hh4), 5.7 to 4.75 Ma (Tedford et al., 2004). On the 2012 time scale of Gradstein et al. (2012), this age range is Miocene (latest Messinian) to Pliocene (earliest Zanclean).

Petuch (1988:120) named Unit 11 at the APAC Pit near Sarasota the Sarasota Member of the Hawthorn Formation. In contrast to Petuch (1982), he identified the *Chesapecten* present in this unit as *Ch. middlesexensis*, noting its co-occurrence with *Carolinapecten urbannaensis* (Mansfield, 1929), a guide fossil for the Miocene Eastover Formation in the Mid-Atlantic Coastal Plain now regarded as late Miocene (Tortonian) (Ward and Blackwelder, 1980). Later, however, Petuch and Roberts (2007:67) retracted these occurrences, saying that these species actually came from the older Bayshore Formation (= Bayshore Clay Member) rather than "the Zanclean-aged Sarasota Member." They then re-identified the pectinids in Unit 11 as "*Chesapecten jeffersonius* subspecies (intermediate between *C. jeffersonius* and *C. septenarius*)" without mentioning any *Carolinapecten* in the unit. Their age determination was given as "late Zanclean Pliocene."

Ward (1990) reported a "Bed 12" stratigraphically below Petuch's Unit 11 at the base of the section in the APAC Pit in the Sarasota area and identified the *Chesapecten* present in both "Bed 12" (referred to herein as Unit 12) and Unit 11 as *Ch. septenarius*, in agreement with Petuch (1982), although in his Table 1, Ward referred to the Unit 11 form as "*Chesapecten septenarius*/*madisonius* complex." Ward also mentioned the presence of *Carolinapecten eboreus watsonensis* (Mansfield, 1936) in both Units 11 and 12 and correlated both of these units with the Rushmere Member of the Yorktown Formation in Virginia and the basal Raysor Formation in South Carolina. The lower Rushmere Member and lower Raysor Formation are regarded by some authors as late Zanclean in age (Cronin et al., 1984:fig. 8; Cronin, 1991:fig. 2; Krantz, 1991:fig. 6; Campbell, 1993: fig.1). Ward (1990) reported that in Unit 12 aragonitic mollusks are so poorly preserved that they are not identifiable except for one, *Cyclocardia granulata* (Say, 1824), a species that first appears in the Zanclean Sunken Meadow Member of the Yorktown Formation in the Mid-Atlantic Coastal Plain and extends into the later Pliocene (Ward, 1992b:82).

Zullo (1990:83), in the same volume as Ward (1990), cited a personal communication (1990) from Ward saying that in addition to *Ch. septenarius* in Unit 11, there is also "an early form of *Ch. madisonius* (Say, 1824) which is restricted to the lower part of Zone 2 [of the Yorktown Formation]." However, in the same volume, Waldrop and Wilson (1990) identified the two species of *Chesapecten* in Unit 11 as *Ch. jeffersonius* and "a five-ribbed *Chesapecten*." They observed that the two species co-occur in the upper part of Unit 11 but that only the five-ribbed species occurs in the lower part. They further noted that this succession is the reverse of the stratigraphic sequence of *Ch. jeffersonius* and *Ch. septenarius* in the Mid-Atlantic Coastal Plain.

Waldrop and Wilson (1990:201) reported that in the 1970s Waldrop observed interfingering of the "Tamiami and Bone Valley Formations" at several localities in Polk and Sarasota counties and correlated the vertebrate assemblages with the late Hemphillian Mammal Age, latest Miocene to earliest Pliocene. The Tamiami limestone was described as highly leached, containing *Chesapecten jeffersonius* and *Ecphora quadricostata* (Say, 1824), and having a lithology similar to that of the "*Chesapecten jeffersonius* Bed and unlike that of the overlying beds in the Macasphalt Shell Pit" in the Sarasota area (Waldrop and Wilson, 1990:202). Collections from these localities having specimens of *Ecphora* and *Chesapecten* have not been found by the present author during visits to FLMNH, with one exception, Sommer's Pit in Sarasota County (Appendix, locality SO061). At this locality Waldrop and Wilson (1990:202) reported that "late Hemphillian vertebrate fossils rested unconformably on a leached indurated calcareous phosphatic sand containing *Chesapecten jeffersonius* (Say) and *Ecphora quadricostata* (Say)." Collections of marine invertebrates from this locality examined by the author contain *Chesapecten madisonius sarasotensis* n. ssp. and other calcitic taxa permitting correlation with Unit 11 of the Macasphalt Pit located approximately three miles (4.8 km) to the west of Sommer's Pit.

DuBar (1991:598) concluded that the Murdock Station Member is late Pliocene based on four species of bivalve. However, three of these, *Glycymeris subovata* (Say, 1824), *Eucrassatella meridionalis* (Dall, 1903), and *Panopea reflexa* (Say, 1824), are aragonitic forms not known from the leached Murdock Station Member in its type area in Charlotte County, where only calcitic shells are preserved. The fourth species, listed by DuBar as *Chesapecten madisonius* (Say, 1824), is likewise not known from the type Murdock Station Member, as will be demonstrated below. It appears that DuBar based his age determination not on the type Murdock Station Member in Charlotte County but rather on the supposedly correlative Unit 11 in the Sarasota pits.

Jones et al. (1991) examined the geochronology of the APAC Pit in the Sarasota area in detail, combining dating methods based on fossil ostracodes, land mammals, paleomagnetism, and strontium isotopes. They noted that Unit 4 of Petuch (1982) has an important vertebrate fauna that places it in the late Blancan Land Mammal Age (2.5 to 2.0 Ma, early Pleistocene, Gelasian based on the 2012 geologic time scale of Gradstein et al., 2012). Based on ostracodes and extrapolation to planktonic foraminiferal zones, Units 6-10 were estimated to be about 3 ± 0.5 Ma and to correlate with the Duplin and Raysor formations of the Carolinas and with the Jackson Bluff Formation of the Florida panhandle. Unfortunately Unit 11 provided no age-diagnostic ostracodes, land mammals, or paleomagnetic data, and strontium isotopes indicated only that Units 3 to 11 are "analytically inseparable" within an age range of 2.5 to 5 Ma. This at least suggests that Unit 11 is no older than Pliocene, although its position within the Pliocene could not be determined.

Lyons (1991) reviewed the biostratigraphy and ages of marine deposits in southern Florida, concentrating on the Pliocene and Pleistocene. He placed the Miocene-Pliocene boundary between Hunter's (1968) Bayshore Clay and Murdock Station members of the Tamiami Formation, apparently basing this on Hunter's (1968) identifications of *Ch. middlesexensis,* a Miocene indicator, in the Bayshore Clay and *Ch. jeffersonius*, a Pliocene indicator, in the Murdock Station Member.

Zullo and Harris (1992:33) remarked on the apparent conflict in ages of strata based on the co-occurrence in Unit 11 of two species of *Chesapecten: Ch. jeffersonius*, an indicator of early Pliocene (Zanclean) age, and *Ch. septenarius*, known to be of Pliocene age in the Mid-Atlantic Coastal Plain and to be derived from *Ch. jeffersonius* (Ward and Blackwelder, 1975, 1980; Gibson, 1987). They decided that the first occurrence of *Ch. septenarius* is chronologically more important than the last occurrence of its probable ancestor, *Ch. jeffersonius*, and therefore opted for a late Pliocene age for Unit 11, equivalent to the upper Yorktown Formation of the Mid-Atlantic Coastal Plain. However, they also correlated Unit 11 with the Murdock Station Member of the Port Charlotte area, apparently based on Hunter's (1968) incorrect identification of *Ch. jeffersonius* in both units.

Ward (1992a:163) repeated his identification of *Ch. septenarius* in Unit 11 of the APAC Pit in Sarasota, but in his Table 1 listed the species as the "*Chesapecten septenarius/madisonius* complex (Say)", still correlating these units with the upper Yorktown Formation of late Pliocene (Piacenzian) age. Ketcher (1992:172), based on a personal communication from Ward, referred to "a continuum from *C. septenarius* to *C. madisonius*" in Unit 11 in the Sarasota pits, thus reinforcing the conclusion that *Ch. jeffersonius* is not present in this unit.

Ward (1993:87) stressed that no molluscan assemblages indicating correlation with the early Pliocene (Zanclean) Sunken Meadow Member of the Yorktown Formation are known south of the Lee Creek Mine in Aurora, Beaufort County, North Carolina, and that "numerous reports of the presence of *Chesapecten jeffersonius* [in more southerly areas] have been based on misidentifications of the *Chesapecten middlesexensis* [sic, *madisonius*]-*C. septenarius* complex," thereby implying that Hunter's (1968) *Ch. jeffersonius* in the Port Charlotte area is one of these species. Deposits of Zanclean age, however, are indeed present in the subsurface of the Florida Peninsula. Huddlestun (1988) introduced the informal name Wabasso beds for sediments in the shallow subsurface of Indian River County (eastern Florida Peninsula, Fig. 1) that he determined to be of Zanclean age (Zone PL1 of Berggren, 1973) based on planktonic foraminifera. He stated that these beds, although thin and discontinuous in Georgia and South Carolina, are thick and widespread in the subsurface of eastern and southern Florida. Furthermore, Dodd and Morgan (1992), in a study of fossil sea turtles, proposed a Zanclean age for the Palmetto vertebrate fauna (= Upper Bone Valley) in the phosphate district, which has intertonguing marine deposits, and postulated that marine Zanclean was once widespread in southern Florida south of Polk County.

Morgan (1994:249) named the marine mammal assemblage from Unit 11 in the Sarasota pits the "Bee Ridge Local Fauna" and noted its similarity to the Palmetto Fauna of late Hemphillian age in Polk County. However, in view of the later Pliocene (Piacenzian) age of the marine invertebrates in Unit 11, Morgan concluded that the vertebrate fauna is "early Blancan, early Piacenzian, 3.5-3.0 Ma." Later, however, Morgan (2005:279) provided evidence based on terrestrial vertebrates in a predominantly marine section that the Bee Ridge Local Fauna is early late Blancan in age (2.2 to 2.7 Ma), straddling the Pliocene-Pleistocene boundary.

Petuch (1994:9) identified but did not illustrate the *Chesapecten* species in Unit 11 of the APAC Pit near Sarasota as *Ch. jeffersonius* and *Ch. palmyrensis* (Mansfield, 1936), the latter being an upper Yorktown (post-Sunken Meadow Member) species originally described from northern North Carolina and not previously reported from Florida. He regarded Unit 11 as Pliocene (Piacenzian) in age and commented (p. 1), "Zanclian-aged fossiliferous sediments are missing in Florida."

Waller (1996:942) regarded the so-called *Chesapecten jeffersonius* of Unit 11 of the APAC Pit to be an early form of *Ch. madisonius* and agreed with Ward (1992a) that the unit correlates with the Pliocene upper Yorktown Formation. Waller stated that *Ch. septenarius* is also present, but could find no evidence for intergradation between *Ch. septenarius* and *Ch. madisonius* in Smithsonian collections from the pit.

Petuch (2004:16, 18) elevated the Bayshore Clay and Murdock Station members of the lower Tamiami Formation of Hunter (1968) to formational status and also illustrated an assemblage of fossils said to be characteristic of the upper beds of the Bayshore Formation. These illustrated specimens, said to be *Ch. middlesexensis* (his Plate 41C) and *Carolinapecten urbannaensis* (his Plate 41D), were purported to be evidence of correlation with the Miocene Eastover Formation of the Mid-Atlantic Coastal Plain. Ward (2008:328), however, pointed out that these and other illustrated specimens in Petuch's (2004) Plate 41 are misidentified and that all are from the "upper Pliocene Pinecrest Formation (=upper Yorktown Formation)." According to Ward, Petuch's illustrated *Ch. middlesexensis* is actually *Ch. madisonius*, and the so-called *Ca. urbannaensis* is actually *Ca. eboreus* (Conrad, 1833). In the overlying Murdock Station Formation, Petuch (2004:141) reported the presence of *Ch. jeffersonius*, "large and common" *Ch. palmyrensis*, *Ch. madisonius carolinensis* (Conrad, 1873), and an unnamed subspecies of *Ca. eboreus*.

Petuch and Roberts (2007:fig. 1.2) placed the Bayshore and Murdock Station formations in the Hawthorn Group on the basis of their high phosphate content, following the lithostratigraphic nomenclature put forth by Scott (1988:79). Petuch and Roberts (2007:63) also regarded Unit 11 of the Sarasota pits as the upper member (named the Sarasota Member) of the Murdock Station Formation. They dated this member as Zanclean based on the presence of *Ch. jeffersonius*, even though Ward (1990, 1992a) had already determined that this species is not present in this unit in the Sarasota pits.

Petuch and Roberts (2007:53–54) informally proposed new members in both the Bayshore and Murdock Station formations. They did not list any pectinids in the lower Cocoplum Member of the Bayshore Formation, but for the upper Port Charlotte Member of this formation they re-illustrated the same specimens identified by Petuch (2004:pl. 41) as *Ch. middlesexensis* and *Ca. urbannaensis* and found by Ward (2008:328) to be misidentified Pinecrest species. For the upper Jupiter Waterway Member of the Murdock Station Formation, Petuch and Roberts (2007:63) listed *Ch. jeffersonius*, *Ch. palmyrensis*, and *Ca. yorkensis* (Conrad, 1867), although Gibson (1987:51) had earlier determined that the probable lectotype of *Ca. yorkensis* appears to fall within the range of variation of *Ca. eboreus eboreus*. For the Sarasota Member, Petuch and Roberts (2007:67) listed "*Chesapecten jeffersonius* subspecies (intermediate between *Ch. jeffersonius* and *Ch. septenarius*)" and in the legend for Figure 3.12 enlarged upon this, saying this unnamed subspecies "is intermediate between the older *Chesapecten jeffersonius* with 8 to 11 ribs and the younger *Chesapecten septenarius* with 5 to 7 ribs. The Sarasota subspecies differs from *C. septenarius* in having narrower, lower ribs with more rounded sides."

Beginning in the 1990s, several papers examined the lithostratigraphy and sequence stratigraphy of subsurface deposits in the southern Florida Peninsula and the Florida Keys (e.g., Cunningham et al., 1998, 2001, 2003; Missimer, 1999, 2002). These studies provided valuable dating information based on planktonic foraminifera, calcareous nannofossils, and strontium isotopes, but it is difficult to transfer these findings to leached surface outcrops that lack nanno- and microfossils, and it is not possible in these publications to recognize biozones based on macrofossils in the well sections. There is evidence, however, that deposits of Zanclean age are present. Cunningham et al. (2003) concluded that the entire Peace River Formation ranges from late middle Miocene (12.9 Ma, mid-Serravallian) to late early Pliocene (3.9 Ma, late Zanclean). In wells in Charlotte and Lee counties, Covington (1993) reported nannofossils of early Pliocene age at well depths above 45.6 m (Zone CN11 of Okada and Bukry, 1980) overlain by late Pliocene indicators. Missimer (1999) concentrated on wells penetrating the Peace River Formation in southwestern Florida. Although he did not mention Hunter's (1968) Bayshore Clay and Murdock Station members that were included in the original definition of the Peace River Formation by Scott (1988), he concluded that the entire Peace River Formation was deposited during an interval from 11 to 4.3 Ma, with its uppermost part early Pliocene (early Zanclean).

Clearly these studies spanning nearly 50 years have not resolved the position of the Miocene-Pliocene boundary with respect to the pectinid biozones of Hunter (1968). Although there is now a consensus that her "*Pecten tamiamiensis* zone" is late Pliocene and that her "*Pecten middlesexensis* zone" is late Miocene, there are conflicting results for the "*Pecten jeffersonius*" zone with respect to this boundary. In the present study, this conflict is partially resolved by a revised taxonomy of *Chesapecten* and *Carolinapecten* in the Port Charlotte and Sarasota areas.

METHODS AND MATERIALS

This study is based on collections from the southwestern Florida Peninsula housed in three museums: National Museum of Natural History, Smithsonian Institution, Department of Paleobiology, Washington, D.C. (NMNH); Division of Invertebrate Paleontology, Florida Natural History Museum, Gainesville, Florida (FLMNH); and the Paleontological Research Institution, Ithaca, New York (PRI). Most of the NMNH material (see Appendix) was collected in the 1950s and 1960s mainly by the late Druid Wilson (USGS), with less extensive collections contributed by Muriel Hunter, Axel Olsson, Evelyn and Ernest Bradley, and the author. The FLMNH material includes collections made by Muriel Hunter, Druid Wilson, John Waldrop, Jules DuBar, Roger W. Portell, and others ranging from the 1960s to 2016. Collectively these collections span more than 100 sites and include hundreds of specimens.

With the exception of some material from the Sarasota pits, most of these collections are from spoil banks in shell pits and along canals and waterways (Fig. 2). Clearly this creates a problem in that spoil bank collections do not permit direct observations of stratigraphic provenance and sequence. However, based on the original observations of stratigraphic sequences, lithologies, and faunal changes by Hunter (1968) in the Port Charlotte area, it is possible to infer stratigraphic relationships.

Fortunately, the NMNH collections were never cleaned, and adhering sediment, particularly if it is present between the closed valves of articulated bivalves and in the apertures of gastropods, can be valuable for determining stratigraphic provenance and whether specimens derive from the same bed. The basal surface deposits in the Port Charlotte and Sarasota areas are highly leached, whereby aragonite in shells is partially or completely dissolved, but calcitic shell layers remain. These basal deposits also have abundant detrital grains of phosphate, which vary in size, sorting, and color among strata. Many grains are the remnants of reworked small bones and teeth, whereas others are the eroded remains of reworked authigenic phosphorite. In contrast, higher beds in the sequence have well-preserved aragonitic shells. Bimineralic calcitic shells in these later deposits, e.g., the Pinecrest beds, have well-preserved arago-

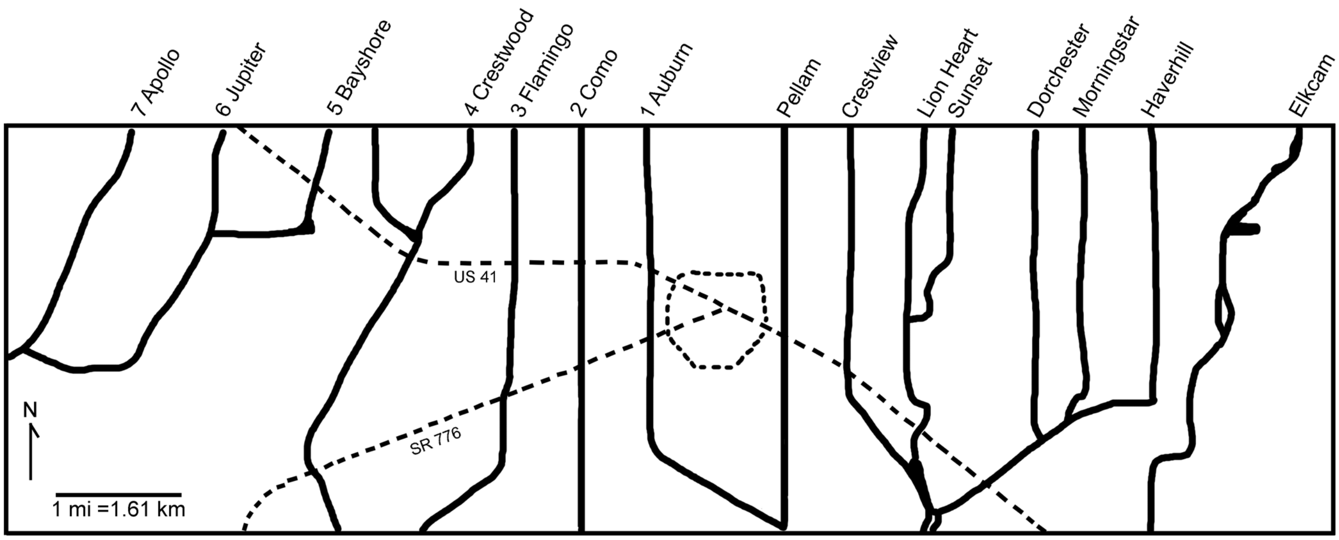


Figure 2. Outline map of the Murdock area of Port Charlotte showing the approximate positions of waterways indicated in collection localities in the Appendix. The intersection of US 41 and SR 776 has been referred to as Murdock, Murdock Station, or Port Charlotte Station. The numbering system of canals west of Murdock is that used by M. E. Hunter. The Cocoplum Waterway, not shown, runs parallel to the top of the rectangle, which approximates the boundary between Charlotte and Sarasota counties.

nitic myostracal layers, whereas in the basal beds these layers are either very poorly preserved or dissolved.

Morphological terms used in taxonomic descriptions are defined in the *Treatise on Invertebrate Paleontology* (Cox, 1969:N102) or in the author's previous studies of Pectinidae, most recently Waller (2011). Examination of specimens was by means of a Wild M5 binocular microscope. Digital TIFF images were taken with a Nikon CoolPix 4500 camera and processed with Adobe Photoshop. Photographed specimens were coated lightly with ammonium chloride to enhance contrast.

Decisions on taxonomic rank, whether species or subspecies, depend primarily on evidence for intergradation among samples and/or on historical precedent. Use of the subspecies rank implies intergradation among samples; while the species rank implies a morphological gap between species in the same genus.

Abbreviations

ANSP: Academy of Natural Sciences of Philadelphia (now of Drexel University).

CH: FLMNH localities in Charlotte County, Florida.

DE: FLMNH localities in DeSoto County, Florida.

FLMNH: Florida Museum of Natural History, Gainesville, Florida.

FLMNH-IP: FLMNH Invertebrate Paleontology Division.

Ht: height of shell, measured along a line perpendicular to hinge passing through beak.

L: length of shell, measured along a line parallel to hinge.

Ma: millions of years before present.

NMNH: National Museum of Natural History, Smithsonian Institution, Washington, DC.

PRI: Paleontological Research Institution, Ithaca, New York.

PZ: pectinid interval zone.

SO: FLMNH localities in Sarasota County, Florida.

SR: state road.

US: federal highway.

USGS: United States Geological Survey and Cenozoic Locality Register, Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, DC.

USNM: catalog of type specimens of the Department of Paleobiology National Museum of Natural History, Smithsonian Institution, Washington, DC.

SYSTEMATIC PALEONTOLOGY

Phylum MOLLUSCA CUVIER, 1797
Class BIVALVIA LINNAEUS, 1758
Subclass AUTOBRANCHIA GROBBEN, 1894
Superorder PTERIOMORPHIA BEURLEN, 1944
Order PECTINIDA GRAY, 1854
Superfamily PECTINOIDEA RAFINESQUE, 1815
Family PECTINIDAE RAFINESQUE, 1815
Subfamily PECTININAE RAFINESQUE, 1815
Tribe AEQUIPECTININI NORDSIECK, 1969
Genus *CHESAPECTEN* WARD AND BLACKWELDER, 1975

Chesapecten Ward and Blackwelder, 1975:7; Gibson, 1987:69; Campbell, 1993:25.

Chesapecten (*Chesapecten)* Ward and Blackwelder, 1975. Ward, 1992b:68.

Type species.—*Chesapecten nefrens* Ward and Blackwelder, 1975, by original designation; Choptank Formation, middle Miocene, zone 19 of Shattuck (1904), Chesapeake Bay cliffs, Calvert County, Maryland.

Included species.—*coccymelus* (Dall, 1898); *covepointensis* Ward, 1992b; *jeffersonius* (Say, 1824); *madisonius* (Say, 1824); *middlesexensis* (Mansfield, 1936); *monicae* Ward, 1992b; *nefrens* Ward and Blackwelder, 1975; *nematopleura* (Gardner, 1936), *santamaria* (Tucker, 1934); *sayanus* (Dall, 1898); and *septenarius* (Say, 1824).

Diagnosis.—"This genus is characterized by its generally large size, the extreme reduction of cardinal crura, the scabrous sculpture over the entire exterior of the valves, and the greater convexity of the left valve." (Ward and Blackwelder, 1975:40).

Geographic range.—New Jersey to Florida.

Stratigraphic range.—Kirkwood Formation of New Jersey and Delaware, lower Miocene, Burdigalian (Ward, 1998:80) to upper Yorktown Formation, Zone 2 of Mansfield (1944), upper Pliocene, Piacenzian.

CHESAPECTEN MIDDLESEXENSIS (MANSFIELD, 1936)

Pecten (*Chlamys*) *santamaria middlesexensis* Mansfield, 1936:187, pl.22, figs. 5, 6.

Chlamys (*Lyropecten*) *madisonius richardsi* Tucker-Rowland, 1938:14, pl. 3, figs. 4, 5.

Diagnosis.—"*Chesapecten middlesexensis* is a very large *Chesapecten* with a moderately deep byssal notch, valves of moderate thickness, small gapes between valves, and a highly variable number of ribs." (Ward and Blackwelder, 1975:12).

Type material.—Lectotype, USNM 373074, a right valve designated by Ward and Blackwelder (1975:12).

Type locality.—USGS Locality 3915, Urbanna, Virginia, "riverfront between mouth of creek and Wharf of Weems line of Seamers." (Ward and Blackwelder, 1975:13).

Distribution.—Restricted to the Eastover Formation, upper Miocene, of Virginia and North Carolina (Ward, 1992b:69).

Remarks.—Only one subspecies of *Chesapecten middlesexensis* is currently recognized in addition to *Ch. middlesexensis middlesexensis*: *Ch. middlesexensis ceccae* Ward, 1992b, from the upper half of the Claremont Manor Member of the upper Miocene Eastover Formation in Virginia. An anonymous reviewer suggested that this taxon may be a junior synonym of *Chesapecten richardsi* (Tucker-Rowland, 1938), which Ward (1992b) regarded as a synonym of *Ch. middlesexensis middlesexensis*.

CHESAPECTEN MIDDLESEXENSIS HUNTERAE n. ssp.
Figure 3A–K

Zoobank Nomenclatural Act.—E87793D5-F4B0-4ACF-80D4-415F6153A6CA.

Diagnosis.—*Chesapecten middlesexensis* with 9–12 radial ribs, most commonly 10–11, rarely as many as 14, with coarse radial scabrous costae on ribs and interspaces; byssal notch remaining moderately deep throughout ontogeny; byssal fasciole slightly depressed and either non-costellate or with a few faint costellae appearing in late ontogeny; active ctenolium commonly absent in individuals greater than shell height of 100 mm; hinge dentition weak or absent in mature individuals.

Description.—Shell large, reaching heights of about 145 mm, equilateral or slightly posteriorly extended, with length exceeding height in mid- to late ontogeny; both valves moderately convex, with left valve more convex than right and with narrow anterior and posterior disk gapes; byssal notch moderately deep in late ontogeny, with an active ctenolium commonly absent on right valves greater than 100 mm height; broad byssal fasciole slightly sunken, becoming faintly costellate in late ontogeny; byssal sinus of left valve shallow. Disks with 9–12 interlocking radial ribs, most commonly 10–11, rarely as many as 14, high with rounded crests and steep sides in early ontogeny, becoming lower and rounded or slightly flattened in later ontogeny; ribs, interspaces, and disk flanks covered by coarse scabrous radial costae beginning at shell height of 15–25 mm, costae increasing by intercalation, numbering 3–5 in interspaces in central sector at shell height of 50 mm and 4–7 at shell height of 100 mm. Disk flanks costate, narrow, and steep, curved inward on posterior side. Total hinge length about 60% of shell length, with anterior hinge slightly longer than posterior hinge; anterior margin of right anterior auricle shallowly curved, then curving more sharply on ventral side into deep byssal notch with apex acute in early ontogeny but forming a right angle between edge of fasciole and disk flank in later ontogeny; anterior margin of left anterior auricle shallowly outwardly convex to nearly straight, with byssal sinus decreasing ontogenetically to very shallow in largest shells; margins of posterior auricles nearly straight, forming slightly acute angle with dorsal margin in early ontogeny, becoming slightly obtuse to dorsal margin in late ontogeny; all auricles densely and finely costate, with about 10–15 radial costae at margin of right anterior auricle and 15–20 at margins of other auricles. Hinge teeth weakly developed or absent in late ontogeny. Pallial line inset far from shell margin at about two-thirds height of shell. Umbonal inner foliated calcite layer extending ventrally beneath posteroventral margin of adductor scar.

Etymology.—Named for the late Muriel E. Hunter, who was the first to recognize the stratigraphic significance of marine strata in the Port Charlotte area.

Type material and measurements.—Holotype: USNM 716578, right valve, Ht 74.5 mm, L 77.0 mm, convexity 10.4 mm (Fig. 3A–E). A nonmatching left valve, USNM 716579, of nearly the same size as the holotype is shown in Figure 3F–G to show relative convexity of the valves.

Type locality.—USGS 26913. Cocoplum Waterway at Collingswood Boulevard, North Port, Sarasota County, Florida.

Other material.—About 150 specimens (single valves plus pairs of matching valves) from 27 localities in the Port Charlotte area.

Comparisons.—Within the *Chesapecten middlesexensis* species complex in the Mid- Atlantic Coastal Plain, *Ch. middlesexensis hunterae* most closely resembles *Ch. middlesexensis ceccae* Ward, 1992b, but differs from that subspecies in having a lower rib count (10–13, compared to 15–16). The deep byssal notch and differentiated non-costellate byssal fasciole of *Ch. middlesexensis hunterae* separate it from *Ch. jeffersonius* and *Ch. madisonius sensu lato*. Compared to *Ch. madisonius sarasotensis* n. ssp. of Unit 11 in the Sarasota pits, *Ch. middlesexensis hunterae* has a much deeper byssal notch, ribs that are less squared in profile in late ontogeny, and a hinge length that is more than half the length of the shell (64% in holotype of *Ch. middlesexensis hunterae*, but only 47% in holotype of *Ch. madisonius sarasotensis*).

Occurrence.—Port Charlotte area, west of Murdock: Cocoplum Waterway: USGS 26913, USGS 26937, SO010A, B, SO011, SO058, SO010C; Auburn Waterway: USGS 26907; Flamingo Waterway: USGS 26924, USGS 26914, CH017, CH112; Bayshore Waterway: USGS 26932, USGS 26917, CH030A. Port Charlotte area, east of Murdock: Pellam Waterway: USGS 22911, USGS 22912; Crestview Waterway: CH119, CH118; Lion Heart Waterway: USGS 23118, USGS 26933; Sunset Waterway: USGS 23117, USGS 26912, USGS 26930.

Distribution.—Known only from the Port

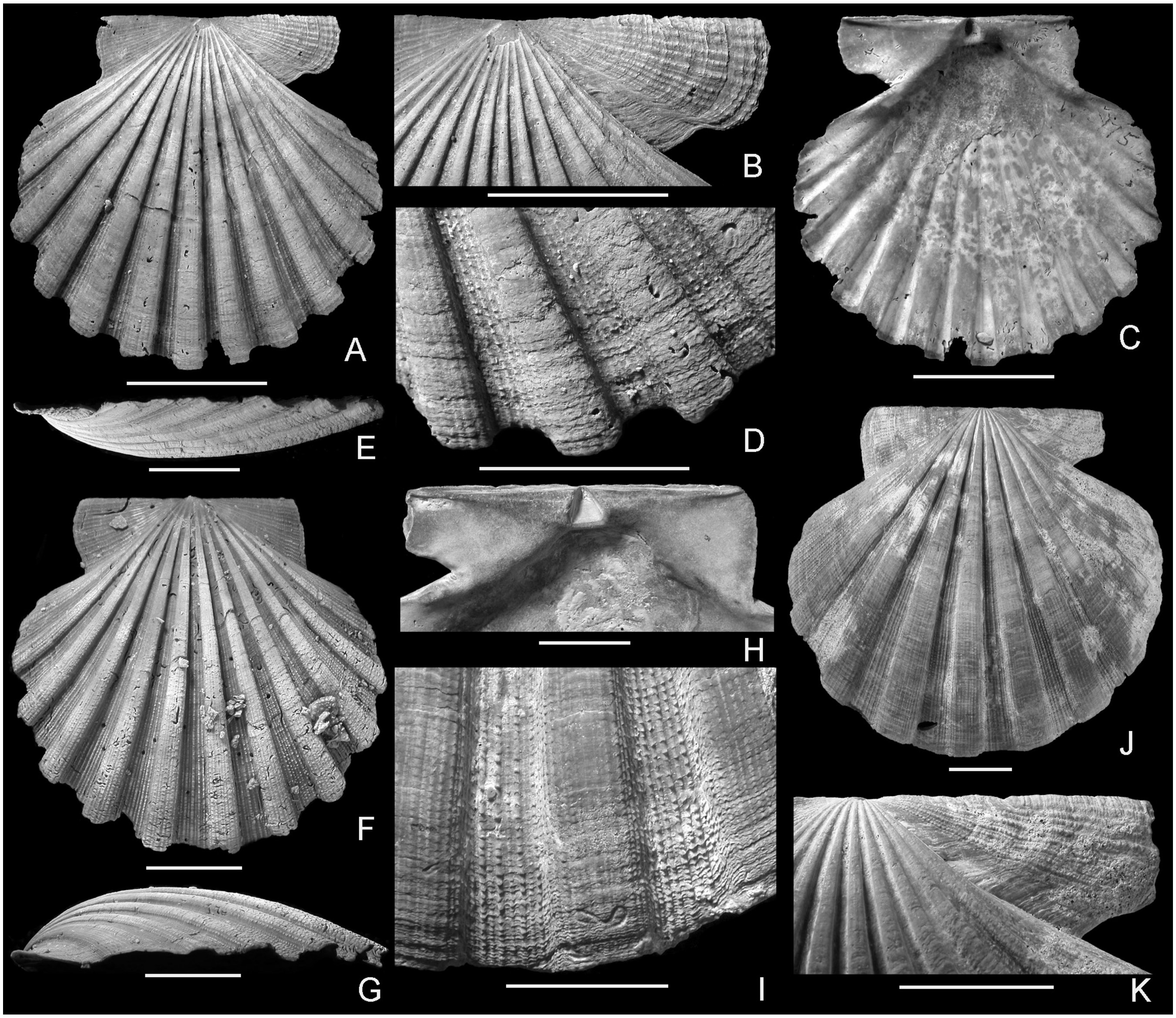


Figure 3. *Chesapecten middlesexensis hunterae* n. ssp. **A–E.** holotype, USNM 716578, USGS 26913, Cocoplum Waterway, right valve. **A.** exterior; **B.** detail of anterior auricle; **C.** interior; **D.** detail of sculpture near margin; **E.** anterior. **F, G.** paratype, USNM 716579, USGS 26913, Cocoplum Waterway, left valve. **F.** exterior; **G.** anterior; **H–K.** thick-shelled paratype, USNM 716580, USGS 23118, Sunset Waterway, right valve. **H.** dorsal interior showing persistent ctenolium and byssal notch; **I.** detail of sculpture near margin; **J.** exterior; **K.** detail of anterior auricle. Scale bars: A, C = 2 cm; B, D–K = 3 cm.

Charlotte area in the southwestern Florida Peninsula, where it occurs in the Bayshore Clay Member of Hunter (1968), now regarded as within the upper Peace River Formation with an estimated age of late Miocene (Tortonian). In the present study, *Ch. middlesexensis hunterae* is assigned to zone PZ2 (see Biostratigraphy section).

Remarks.—*Chesapecten middlesexensis hunterae* displays two intergradational morphologies that may have some stratigraphic significance. Forms that occur mainly along the Cocoplum Waterway, including the holotype (Fig. 3A–E), have somewhat thinner shells, lower convexity, deeper byssal notches, and slightly higher rib counts than forms that occur along the Sunset and Lion Heart Waterways east of Murdock (Fig. 3H–K). The former are commonly associated on the Cocoplum Waterway (USGS 26913, USGS 26937) with a barnacle-hash coquina containing abundant fragments of a broad-ribbed *Ecphora* in the *Ecphora gardnerae* group (*E.* cf. *gardnerae whiteoakensis* Ward and Gilinsky, 1988) (Fig. 4D–F) as well as *Mansfieldostrea compressirostra brucei* (Ward, 1992b) (Fig. 4G, H). Both of these taxa are associated with the lower upper Miocene (Tortonian) Claremont Manor Member of the Eastover Formation in the Mid-Atlantic Coastal Plain (Ward and Gilinsky, 1988; Ward, 1992b). Additional associated calcitic bivalve species include *Carolinapecten murdockensis druidwilsoni* n. sp. and n. ssp., described below, *Euvola smithi* (Olsson, 1914) (Fig. 4A), and a very worn but abundant undescribed species of *Argopecten* Monterosato, 1889 (Fig. 4B–C).

The barnacle fragments that comprise the barnacle-hash coquina are all from a single species, *Fistulobalanus klemmi* Zullo, 1984 (Fig. 4I–J). Although the type material of this species from the Lee Creek Mine in North Carolina has been determined to be from the lower Pliocene Sunken Meadow Member of the Yorktown Formation (Ward, 2008:355), the genus has a long Miocene history in the western Atlantic region (Zullo, 1984), and its Florida occurrence may be late Miocene in age.

The form of *Chesapecten middlesexensis hunterae* present along the Sunset and Lion Heart waterways occurs in a more clay-rich quartz sandy lithology with abundant rounded black phosphate grains and rare brown grains and is associated with *Ca. murdockensis murdockensis* n. sp. and n. ssp. Miocene indicators include non-auriculate members of the *Mansfieldostrea compressirostra* group, *Euvola smithi*, and the barnacles *Chesaconcavus myosulcatus* Zullo, 1992b, and *Arossia* sp. aff. *newmani* Zullo, 1992b. However, certain taxa previously assumed to have stratigraphic ranges beginning in the late Pliocene are also present at Sunset Waterway localities. These include the oysters *Myrakeena sculpturata* (Conrad, 1840), *Undulostrea locklini* (Gardner, 1945), and *Cubitostrea coxi* (Gardner, 1945), and the gastropod *Dicathais handgenae* Portell and Vokes, 1992. It is not clear whether these taxa may have originated in the Miocene or that Pliocene beds may be represented in the spoil-bank collections.

CHESAPECTEN MIDDLESEXENSIS BAYSHORENSIS n. ssp.
Figure 5A–G

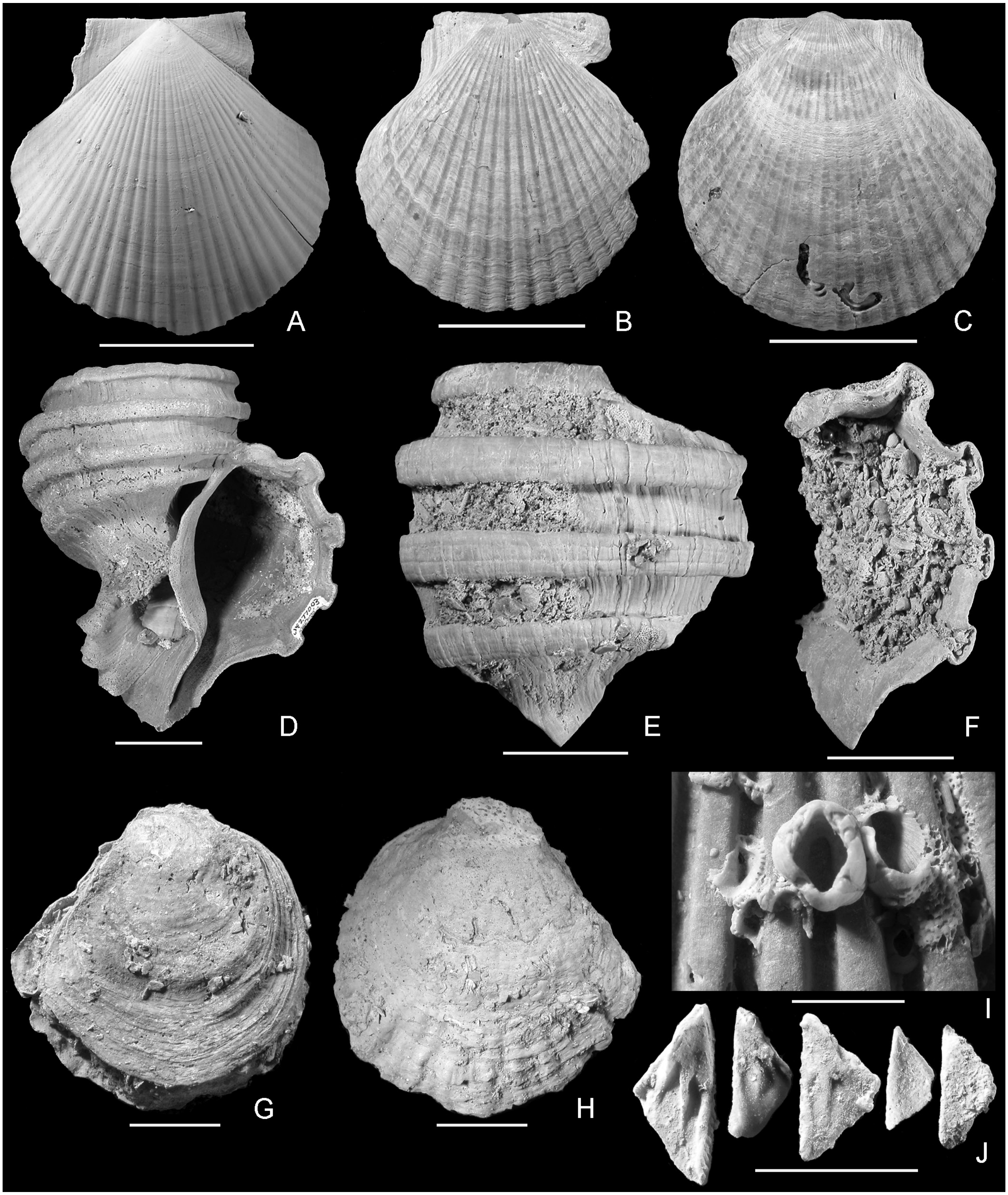
Zoobank Nomenclatural Act.—F8BF0579-FB5C-4DBA-8EFF-9CF149C32E94.

Diagnosis.—Moderately thick-shelled, slightly left-convex *Chesapecten middlesexensis* with 6–8 radial ribs, rarely nine or ten, with coarse radial scabrous costae on ribs and interspaces; byssal notch remaining deep with active ctenolium throughout ontogeny; byssal fasciole slightly sunken, lacking radial costellae; hinge dentition weakly developed.

Description.—Shell of moderate size, reaching heights of about 80–90 mm, equilateral to slightly posteriorly extended, with length and height about equal in early ontogeny but length exceeding height in late ontogeny; both valves moderately convex, with left valve more convex than right and with narrow disk gapes; byssal notch remaining deep with active ctenolium throughout ontogeny; byssal fasciole slightly depressed, lacking radial costellae; byssal sinus of left valve shallow. Disks with 6–8 radial ribs, rarely 9 or 10;

Figure 4. Calcitic fossils associated with *Chesapecten middlesexensis hunterae*. **A.** *Euvola smithi*, USNM 715581, USGS 23117, right valve, Sunset Waterway. **B, C.** *Argopecten* sp., Cocoplum Waterway, USGS 26913, **B.** USNM 716582, right valve; **C.** USNM 716583, non-matching left valve. **D–F.** *Ecphora* cf. *gardnerae whiteoakensis*. **D.** UF 277003, CH108, apertural view; **E, F.** USNM 716584, USGS 26913, abapertual and apertual views to show multiple striae on rib crests and broad ribs along apertural margin. **G, H.** *Mansfieldostrea compressirostra brucei*, USNM 716585, USGS 26913, Cocoplum Waterway, right and left valves of articulated shell. **I, J.** *Fistulobalanus klemmi*, USGS 26913, Cocoplum Waterway, **I.** shells attached to juvenile *Carolinapecten murdockensis druidwilsoni*, USNM 716586; **J.** opercular plates (scuta), USNM 716587. Scale bars: A–H = 2 cm; I = 3 mm; J = 5 mm. →

ribs high, with slightly rounded crests and steep, vertical sides in early ontogeny, becoming lower and broader with sloping sides in late ontogeny; ribs, interspaces, and disk flanks covered by coarse radial costae of uneven strengths beginning in interspaces of central sector at shell heights of 12–15 mm and increasing in number by intercalation, numbering 5–9 in interspaces on right valve



and 8–11 on left valve at shell height of 50 mm. Total hinge length about 60% of shell length, with anterior hinge slightly longer than posterior hinge; byssal notch remaining deep throughout ontogeny, with apex of notch forming an acute angle; active ctenolium continuing to form throughout ontogeny; byssal sinus of left anterior auricle shallow, with overall trend of left anterior auricular margin forming an acute angle with dorsal margin; margins of posterior auricles nearly straight or forming slightly acute angle with dorsal margin in early ontogeny, becoming perpendicular to or forming slightly obtuse angle with dorsal margin in late ontogeny; all auricles densely and finely costate, with number of costae ranging from about 12–18 at margin of right anterior auricle and 16–27 at margin of other auricles. Weak dorsal hinge teeth and resilial teeth present throughout ontogeny. Auricular denticles well developed at distal ends of ridges on shell interior at ventral edge of auricles. Pallial line inset far from shell margin at about two-thirds height of shell. Umbonal inner foliated calcite layer extending ventrally to the mid-adductor-scar level, not extending beneath posteroventral margin of adductor scar.

Etymology.—Named with reference to the type locality on the Bayshore Waterway, Charlotte County, Florida.

Type material and measurements.—Holotype: USNM 716588, right valve, Ht 82.0 mm, L 89.0 mm, convexity 16.4 mm (Fig. 5A–D).

Type locality.—USGS 23858, Charlotte

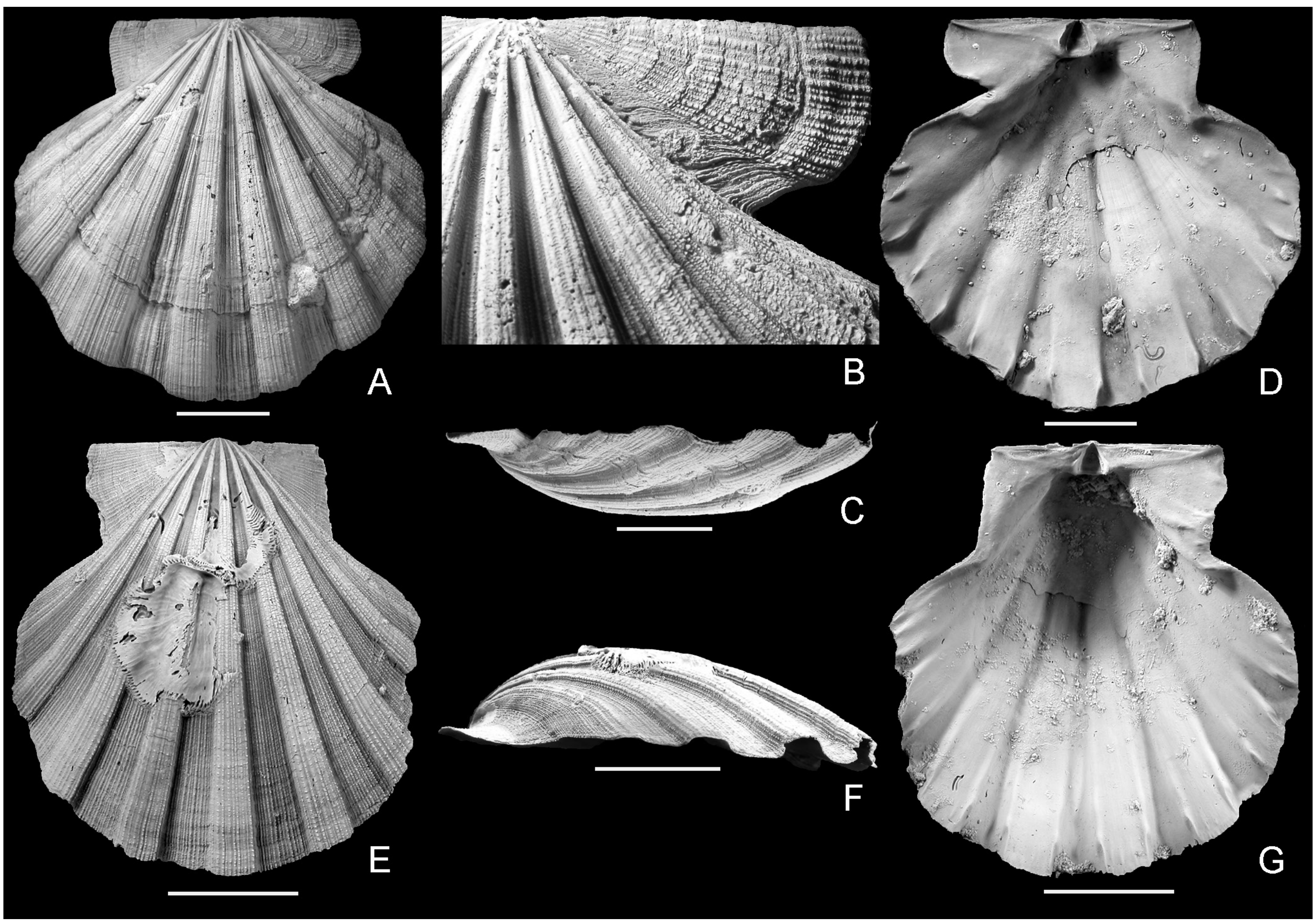


Figure 5. *Chesapecten middlesexensis bayshorensis* n. ssp., USGS 23858, Bayshore Waterway. **A–D.** holotype, USNM 716588, right valve. **A.** exterior; **B.** detail of anterior auricle showing non-striate byssal fasciole; **C.** anterior view; **D.** interior. **E–G.** paratype, USNM 716589, non-matching left valve. **E.** exterior; **F.** anterior; **G.** interior. Scale bars = 2 cm.

County, Florida; spoil banks of Bayshore Waterway on north side of Rte. 41, about 5.1 km (3.2 miles) west of junction of U.S. 41 and Rte. 77. T. R. Waller, July 11, 1962.

Other material.—About 100 specimens (single valves plus one pair of matching valves) from 11 localities in the Port Charlotte area.

Comparisons.—*Chesapecten middlesexensis bayshorensis* differs from *Ch. middlesexensis hunterae* in having fewer ribs (commonly 6–8, compared to 10 or 11), a deeper byssal notch that remains deep throughout ontogeny, and a ctenolium that persists throughout ontogeny. Compared to *Ch. jeffersonius* and *Ch. septenarius*, *Ch. middlesexensis bayshorensis* has a deeper byssal notch, a more differentiated non-costellate byssal fasciole, and rib profiles that are less squared throughout ontogeny. Compared to variants of *Ch. madisonius sarasotensis* n. ssp. that have only seven or eight ribs, *Ch. middlesexensis bayshorensis* differs in having a deeper byssal notch, a more differentiated byssal fasciole throughout ontogeny, and a thinner, less biconvex shell. *Chesapecten quinarius* differs from *Ch. middlesexensis bayshorensis* in having fewer ribs (commonly only five or six) that are more rounded in profile throughout ontogeny.

Occurrence.—Port Charlotte area, west of Murdock: Auburn Waterway: USGS 22256, CH104A; Como Waterway: USGS 22931; Crestwood Waterway: USGS 22916; Bayshore Waterway: USGS 26931, USGS 26932, USGS 23858 (type locality), USGS 26910, USGS 26911. Port Charlotte area, east of Murdock: Sunset Waterway: USGS 26915.

Distribution.—Known only from the Port Charlotte area in the southwestern Florida Peninsula, where it is apparently limited to Hunter's (1968) lower Murdock Station Member, now regarded as within the upper Peace River Formation of late Miocene (Tortonian) age. In the present study, *Ch. middlesexensis bayshorensis* is assigned to pectinid zone PZ3 (see Biostratigraphy section).

Remarks.—*Chesapecten middlesexensis bayshorensis* is present at several localities along the Bayshore Waterway in the Port Charlotte area, where it co-occurs with *Ca. murdockensis parawatsonensis*, n. ssp. as well as with the late Miocene barnacle *Chesaconcavus myosulcatus* (USGS 26931) and non-auriculate oysters of the *Mansfieldostrea compressirostra* complex (USGS 26910).

***CHESAPECTEN QUINARIUS* n. sp.**
Figure 6A–F

Chlamys (*Lyropecten*) *jeffersonius* (Say, 1824). Mansfield, 1932b:59, pl. 11, fig. 1.

Chesapecten palmyrensis (Mansfield, 1936): Petuch, 2004:143, pl. 44C; Petuch and Roberts, 2007:64, fig. 3.11Eb.

Zoobank Nomenclatural Act.—293E9C29-9278-4C72-86E5-A60853E1BDF9.

Diagnosis.—*Chesapecten* with 4–8, most commonly 5 or 6, broad radial ribs that are rounded throughout ontogeny and covered by moderately coarse radial costae; byssal notch shallow, with poorly differentiated byssal fasciole becoming costellate in late ontogeny.

Description.—Shell of moderate size, commonly with height of 60–100 mm but reaching maximum known height of 141 mm, equilateral to slightly posteriorly extended, both valves moderately convex, with left valve more convex than right. Byssal notch shallow, its depth about 14% of length of anterior hinge, with active ctenolium still present on shells 70 mm in height but absent in larger individuals; byssal fasciole not depressed, with fine radial costellae present on dorsal side of fasciole in young individuals and across entire fasciole in adult individuals; byssal sinus of left valve shallow. Disks with 5 or 6, rarely 7, broad moderately high radial ribs, rounded in early to mid-ontogeny, becoming somewhat flattened but not fading out in late ontogeny; ribs and interspaces covered by moderately coarse radial costae of fairly even strengths beginning in interspaces at shell heights of 12–16 mm; all costae with fine scales, costae increasing in number by intercalation. Total hinge length about 50–60% of shell length, with anterior hinge slightly longer than posterior hinge; anterior margin of right anterior auricle shallowly curved, meeting disk flank at about a right angle in larger shells; anterior margin of left anterior auricle outwardly convex, forming moderately shallow byssal sinus; posterior margins of posterior auricles in young growth stages shallowly sigmoidal, becoming outwardly convex in late ontogeny with overall trend about perpendicular to dorsal margin or forming slightly acute angle; all auricles densely and finely costate, 15–19 at margin of right anterior auricle, 18–20 at margins of other auricles. Interior ribs flattened, with carinate edges near margins of valves; interior rib interspaces extending dorsal to adductor scar into umbonal region in early to mid-ontogeny, becoming filled in umbonal region with thick inner foliated calcitic layer in gerontic individuals. Moderately strong dorsal hinge teeth and weak intermediate and resilial teeth present in early to mid-ontogeny, becoming obscured by ventral migration of ligament system in late ontogeny. Pallial line inset far from shell margin at about two-thirds height of shell. Umbonal inner foliated calcite layer extending ventrally beneath ventral margin of adductor scar in gerontic individuals with greatly thickened shells.

Etymology.—From the Latin *quinarius*, meaning “of five”, with reference to the common presence of only five radial ribs.

Type material and measurements.—Holotype: USNM 716590, pair of matching valves, Ht 69.0 mm, L 70.5 mm, convexity of articulated shell 28.9 mm.

Type locality.—USGS 26936. Sarasota County, Florida. Warren Brothers Pit, E½ sec. 12,

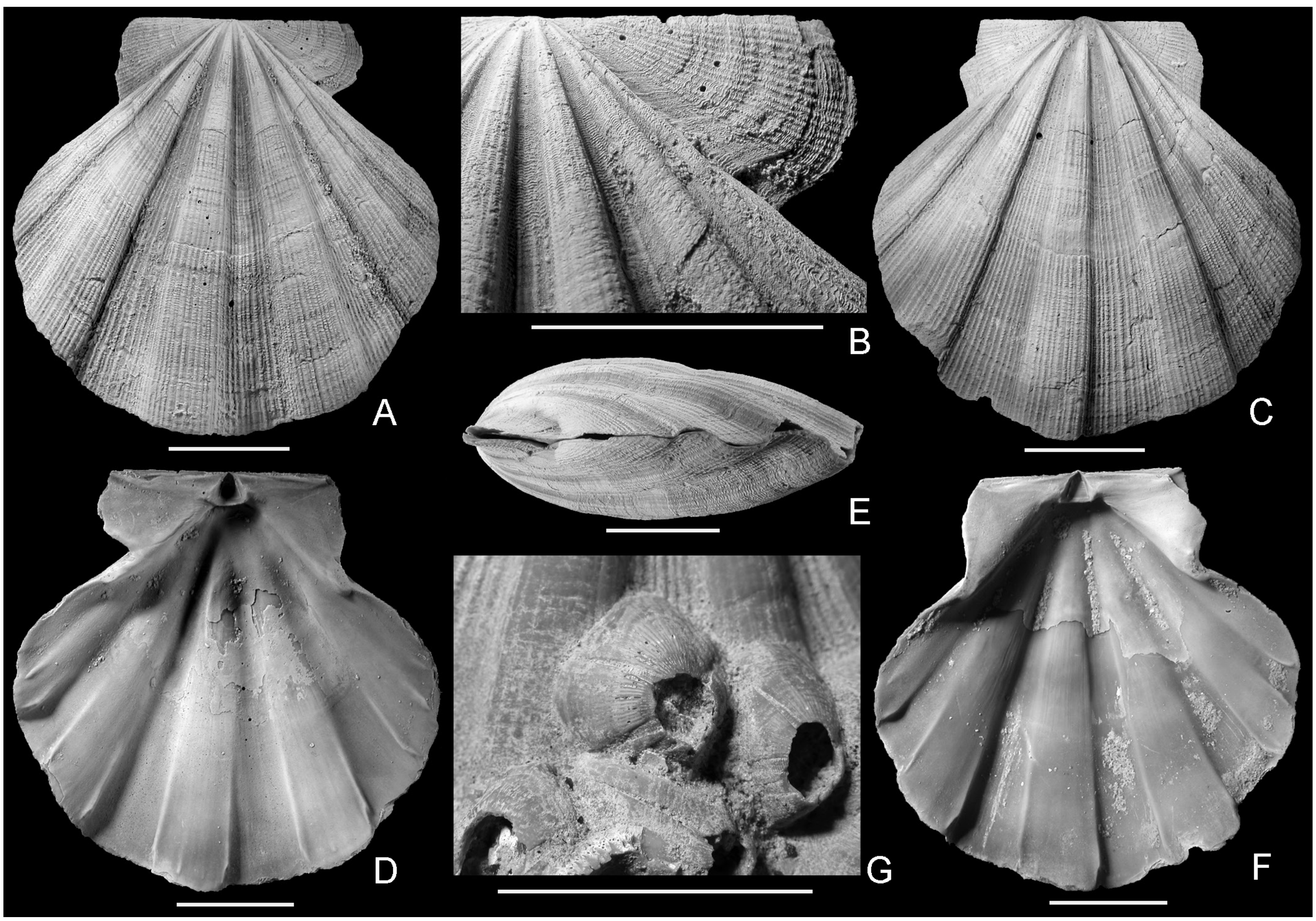


Figure 6. A–F. *Chesapecten quinarius* n. sp., holotype, matching valves, USNM 716590, USGS 26935, Warren Brothers Pit, Sarasota. **A.** right valve exterior; **B.** right anterior auricle showing partially costate byssal fasciole; **C.** left valve exterior; **D.** right valve interior; **E.** anterior view of paired valves; **F.** left valve interior. **G.** *Arossia aurae* Zullo, 1992b, in cluster of barnacles attached to exterior of right valve of *Chesapecten quinarius*, USNM 716591, USGS 25174, Warren Brothers Pit, Sarasota. Scale bars = 2 cm.

T36S, R18E, from base of section on east wall of pit. Evelyn Bradley, May 1978.

Other material.—About 80 specimens from localities in Sarasota, Pinellas, and Calhoun counties, Florida.

Comparisons.—*Chesapecten quinarius* resembles *Ch. jeffersonius* and has been confused with that species in the past. *Chesapecten quinarius* differs from *Ch. jeffersonius* in lacking sharply squared ribs throughout ontogeny and in having fewer ribs, commonly only five or six compared to eight to twelve in *Ch. jeffersonius. Chesapecten quinarius* differs from *Ch. middlesexensis bayshorensis* in having fewer, more rounded ribs, finer secondary costation, a shallower byssal notch, and a poorly differentiated byssal fasciole that becomes costellate in late ontogeny. Compared to *Ch. septenarius*, *Ch. quinarius* lacks sharply squared, flattened ribs throughout ontogeny. Sharply squared ribs are also present in the early ontogeny of *Ch. palmyrensis* (Mansfield, 1936), a species synonymized with *Ch. septenarius* by Ward and Blackwelder (1975:15).

Occurrence.—Sarasota County: Sarasota pits (Warren Brothers, APAC, Quality Aggregates, Richardson Road pits), USGS 25174, USGS 25183, USGS 26934, USGS 26935, USGS 26936, SO001A, SO001C; other localities in Sarasota County: USGS 26921, USGS 24527; Pinellas County: USGS 21900; Calhoun County: USNM 371776 (specimen figured by Mansfield, 1932b:pl. 11, fig. 1).

Distribution.—Units 11 and 12 in the Sarasota pits and correlative strata in the southwestern Florida Peninsula. In the present study *Ch. quinarius* is assigned to pectinid zone PZ4, early Pliocene (late Zanclean) in the absence of *Ch. madisonius sarasotensis*. It co-occurs with *Ch. madisonius sarasotensis* in pectinid zone PZ5, late Pliocene (Piacenzian).

Remarks.—Petuch and Roberts (2007:63) listed *Ch. palmyrensis* (Mansfield, 1936) as an index fossil for their newly named Jupiter Waterway Member of the Murdock Station Formation (= *Pecten* biostrome or lower bed of Murdock Station Member of Hunter, 1968), but the specimen that they illustrated (their figure 3.11E) is not that species and was not found in the present study to be present in the Murdock Station Member. Rather it is *Ch. quinarius* and probably came from either Unit 12 or Unit 11 in the Sarasota pits.

The specimen of *Chlamys* (*Lyropecten*) *jeffersonius* illustrated by Mansfield (1932b:59, pl. 11, fig. 1, USNM 371776) is a large right valve (Ht 141 mm) with only six major ribs and a minor rib on each side. This low rib count and lack of rib squareness in early ontogeny allow a tentative assignment to *Ch. quinarius.* Mansfield's specimen is from the *Ecphora* zone of the Jackson Bluff Formation "at a dripping spring about three-fourths of a mile north of Clarksville, Calhoun County, Florida." It is the only specimen of *Ch. quinarius* thus far known from outside the Florida Peninsula and is also a size record for the new species. The age of the *Ecphora* zone is well established as late Pliocene (Piacenzian) (Akers, 1974; Ward and Huddlestun, 1988; Jones et al., 1991; Allmon, 1993).

A specimen of *Chesapecten quinarius* collected from low in the section at the Warren Brothers Pit in the Sarasota area (USGS 25174) has attached barnacles identified by the author as *Arossia aurae* Zullo, 1992b (Fig. 6G). This species has previously been reported only from its type locality in the lower Yorktown Formation of Zanclean age at the Lee Creek Mine in Aurora County, North Carolina (Zullo, 1992b:30). In Unit 11 of the Sarasota pits, however, *Ch. quinarius* is associated with a molluscan fauna that indicates an early late Pliocene age correlated with the Rushmere Member of the upper Yorktown Formation (Ward, 1993:163).

***CHESAPECTEN MADISONIUS MADISONIUS* (SAY, 1824)**

Pecten madisonius Say, 1824:134.
Pecten edgecombensis Conrad, 1862:291.
Lyropecten carolinensis Conrad, 1873:18.
Chesapecten madisonius (Say): Ward and Blackwelder, 1975:16, pl. 6, figs. 1–4; pl. 7, figs. 1, 7, 8; Gibson, 1987:73, pl. 22, fig. 1; pl. 24, figs. 3–5; pl. 25, figs. 1–4, 6; pl. 26, figs. 1, 3–5; Campbell, 1993:25, pl. 5, fig. 47.
Chesapecten madisonius carolinensis (Conrad). Campbell, 1993:25.

Diagnosis.—Ward and Blackwelder (1975:17) provided the original description and a lengthy new description but did not provide a diagnosis.

Type material.—Lectotype, ANSP 31787, "left valve from Virginia (probable locality)." (Ward and Blackwelder, 1975:17).

Type locality.—"The type locality is unknown but probably Virginia or North Carolina." (Ward and Blackwelder, 1975:17).

Distribution.—Restricted to Mansfield's (1944) Zone 2 of the Yorktown Formation and equivalent units from the York River in Virginia southward to South Carolina (Ward and Blackwelder, 1975: Gibson, 1987; Ward and Huddlestun, 1988).

Remarks.—Campbell (1993:25) and Campbell and Campbell (1995:78) suggested that the name *Chesapecten madisonius carolinensis* (Conrad, 1873) may be applied to the early form of *Ch. madisonius* in the Carolinas having low rib counts. Although the type of *Liropecten carolinensis* Conrad, 1873 at the Academy of Natural Sciences of Philadelphia was said to be missing by Moore (1962:46), in fact a right valve labeled as *Liropecten carolinensis* is present (Fig. 7A–C). Furthermore, the handwriting on its label (Fig. 7B), which is glued to the interior of the shell, looks very much like Conrad's based on comparison to a sample of Conrad's handwriting shown by Moore (1962:pls. 1 and 2). This specimen was apparently the only specimen that Conrad had on hand as evidenced by his original description, which refers only to the lower (right) valve. The specimen is therefore assumed to be the holotype by monotypy and is illustrated herein for the first time. Although the surface of the specimen is in very poor condition because it was apparently etched, the specimen clearly has only 12 ribs, and secondary costae comparable to those of *Chesapecten* are present. However, its ribs are much narrower and more rounded than those of the new subspecies from Florida and

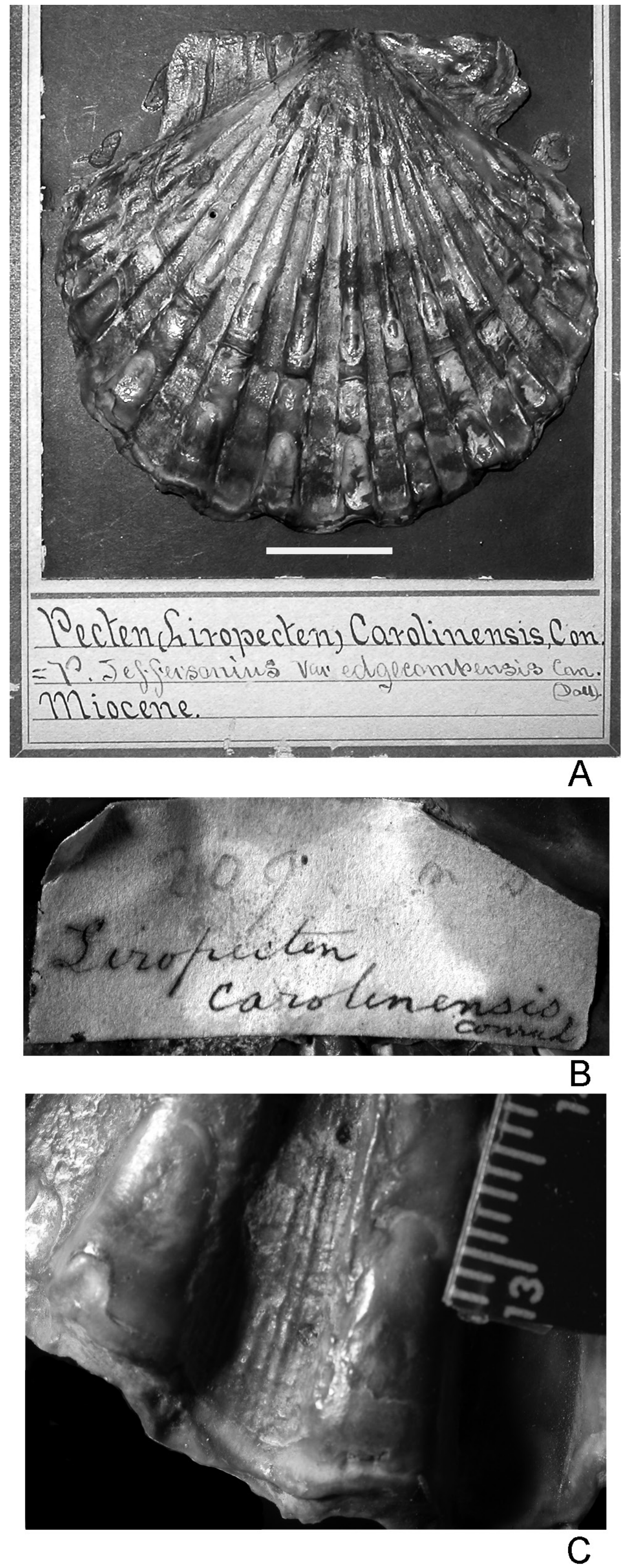


Figure 7. A–C. *Liropecten carolinensis* Conrad, 1873, ANSP, right valve assumed to be the holotype by monotypy. **A.** exterior view of shell resting on labeled board to which it was originally attached; **B.** label pasted on interior of shell with handwriting assumed to be Conrad's; **C.** Detail of exterior showing scabrous costae in interspace between severely etched ribs. Scale bar = 2 cm.

are more comparable to the ribs of more typical *Ch. madisonius* from Edgecombe County, North Carolina. Indeed, Dall (1898:722), who examined Conrad's type, concluded that Conrad's name is a junior synonym of *Pecten edgecombensis* Conrad, 1862, a taxon now regarded as a junior synonym of *Ch. madisonius* (Say, 1824) (Ward and Blackwelder, 1975:16).

CHESAPECTEN MADISONIUS SARASOTENSIS n. ssp.
Figure 8A–D

Chesapecten jeffersonius (Say, 1824): Petuch, 2004:143, pl. 44I; Petuch and Roberts, 2007:64, fig. 3.11D; Portell et al., 2012:9, pl. 8B.

Chesapecten jeffersonius (Say) unnamed subspecies, Petuch and Roberts, 2007:65, fig. 3.12E.

Zoobank Nomenclatural Act.—A7D14827-6294-48E7-BBF6-293BF10DE768.

Diagnosis.—*Chesapecten* with 7–12 ribs, most commonly 10 or 11, with steep, slightly undercut sides and rounded crests in early ontogeny, becoming lower with somewhat flattened crests and sloping sides in later ontogeny; secondary costae on disk coarse, scabrous, and of more than one order; byssal notch shallow and rounded, with byssal fasciole lacking costellae or with costellae limited to dorsal part of fasciole.

Description.—Thick, moderate to large shell known to reach 155 mm height, equilateral to slightly posteriorly extended, both valves moderately convex to well inflated, with left valve consistently more convex than right and with narrow disk gapes between valves. Byssal notch shallow, its depth about 3–12% of length of anterior hinge, averaging 8%, with active ctenolium becoming obsolete or absent in shells greater than about 80 mm height; byssal fasciole slightly arched adjacent to disk, with weak costellae on dorsal part; byssal sinus of left valve shallow, its innermost point anterior to a line perpendicular to hinge and passing through anterior end of dorsal margin. Disks with 7–12, commonly 10 or 11, moderately high ribs, wider than interspaces on right valve, narrower on left valve, crests of ribs rounded with steep sides in early ontogeny, becoming somewhat lower and flattened with sloping sides in late ontogeny; ribs and interspaces covered by rather coarse scabrous costae, with scales small, closely spaced, and erect; costae beginning in interspaces at shell heights from 22–29 mm. Total hinge length about half of shell length, with anterior hinge slightly longer than posterior hinge; all auricles and disk flanks densely and finely costate, about 15 costae on right anterior auricle to at least 20 on other auricles. Ribs on

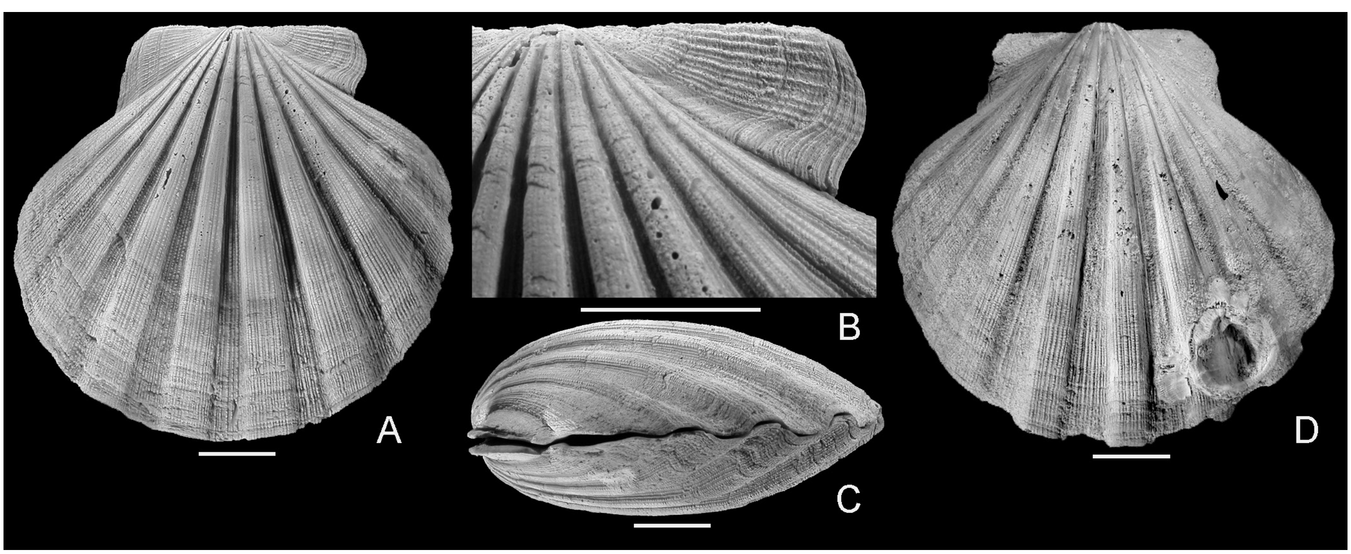


Figure 8. A–D. *Chesapecten madisonius sarasotensis* n. ssp., holotype, USNM 716592, USGS 24968, Warren Brothers Pit, Sarasota, pair of matching valves. **A.** right valve; **B.** detail of right anterior auricle showing shallow byssal notch; **C.** anterior; **D.** left valve. Scale bars = 2 cm.

valve interiors flattened, with carinate edges near margins of valves, the troughs between interior ribs not extending dorsal to adductor scar. Weak dorsal and resilial hinge teeth present in young individuals, becoming obscured by ventrad migration of ligament system in larger individuals. Pallial line inset far from valve margin at about two-thirds height of shell. Thick umbonal inner foliated calcite layer extending ventrally to below ventral margin of adductor scar.

Etymology.—Name refers to the Sarasota pits, Sarasota County, Florida.

Type material and measurements.—Holotype: USNM 716592, a pair of matching valves, Ht 108 mm, L 114 mm, convexity of articulated shell, 52 mm (Fig. 8A–D).

Type locality.—USGS 24968,Warren Brothers Shell Pit, Sarasota County, Florida, 6.5 km (4.05 miles) east of Highway 301 on 17th Street, then left (north) at T-intersection and 0.8 km (0.5 mile) to pit. Collector: Mrs. Evelyn Bradley, 1970 and 1971.

Other material.—About 90 specimens from 17 localities in Sarasota and Pinellas counties, Florida.

Comparisons.—*Chesapecten madisonius sarasotensis* most closely resembles specimens of *Ch. madisonius madisonius* that have fewer than 12 ribs (exemplified by a specimen from the Yorktown Formation at the Lee Creek Mine, Beaufort County, North Carolina, illustrated by Gibson, 1987:pl. 25, fig 1). As observed by Gibson (1987:73-74) these variants occur low in the upper Yorktown Formation and appear to represent an earlier stage of evolution compared to populations with higher rib numbers occurring higher in the formation. Compared to the Lee Creek specimens with lower rib counts, *Ch. madisonius sarasotensis* has a more convex right valve, coarser disk costae, and a byssal fasciole that is more differentiated from the remainder of the right anterior auricle in elevation and in lacking radial costellae across the entire fasciole in most specimens. The specimen of "*Chesapecten madisonius* subspecies ? *carolinensis*" illustrated by Campbell and Campbell (1995:pl. 1, fig. 2) from the lower Goose Creek Limestone of South Carolina is similar to Gibson's (1987:pl. 25, fig. 1). It differs from *Ch. madisonius sarasotensis* in having a right valve of lower convexity and a less differentiated byssal fasciole.

The stratigraphically highest *Chesapecten* in the Florida Peninsula occurs rarely in the Ochopee Limestone (Pliocene, Piacenzian) in Monroe and Collier counties. Based on the few specimens available, the Ochopee form differs from *Ch. madisonius sarasotensis* in having a less differentiated byssal fasciole, a higher mean rib number (commonly 12 or 13), narrower and more rounded ribs, and on average a narrower umbonal angle. Except for its thicker shell, the Ochopee form appears to be within the range of variation of more advanced *Ch. madisonius madisonius* and is tentatively identified as that subspecies.

Chesapecten madisonius sarasotensis differs from *Ch. jeffersonius* in having coarser secondary costae and scales, ribs that remain prominent even at the ventral margin of large individuals, and internal grooves that do not extend into the umbonal region dorsal to the adductor scar. Compared to *Ch. septenarius*, *Ch. madisonius sarasotensis* commonly has more ribs (10 or 11 compared to 6–8), coarser secondary costae, less flattened rib crests with the edges of the crests not as sharp and the sides of the ribs less steep.

Chesapecten madisonius sarasotensis differs from *Ch. quinarius* in having more ribs (commonly 10 or 11 compared to 5 or 6), a slight flattening of rib crests rather than rounded ribs, and lacking internal grooves dorsal to the adductor scar.

Occurrence.—Sarasota pits (Warren Brothers, APAC, Macasphalt, Quality Aggregates, Richardson Road pits): USGS 24968, 25174, USGS 25183, USGS 26927, USGS 26934, USGS 26935, SO001A-C, SO021, SO026, SO017; other localities in Sarasota County: USGS 26919, USGS 22584, SO060, SO061; Pinellas County: USGS 21900, USGS 26926.

Distribution.—Unit 11 in the Sarasota pits and correlative strata in the southwestern Florida Peninsula in pectinid zone PZ5 (see Biostratigraphy section). Reports that *Chesapecten* occurs in the Buckingham Limestone (Waldrop and Wilson,

1990) could not be verified.

Remarks.—The idea that the *Chesapecten* in Unit 11 of the Sarasota pits may be a hybrid of *Ch. madisonius* and *Ch. septenarius* (Ward, 2008:416) is not supported by the present study, because *Ch. septenarius* and *Ch. madisonius madisonius* are both apparently absent from this unit. The so-called *Ch. septenarius* is the taxon described herein as a new species, *Ch. quinarius*, and the so-called *Ch. madisonius* is the new subspecies *Ch. madisonius sarasotensis*.

In Units 11 and 12 of the Sarasota pits, *Chesapecten madisonius sarasotensis* is associated with a molluscan fauna that indicates a Pliocene age correlated with the Rushmere Member of the upper Yorktown Formation (Ward, 1992a:163). In Unit 11 it is associated with the pectinids *Chesapecten quinarius*, *Carolinapecten eboreus watsonensis*, and *Argopecten comparilis* (Tuomey and Holmes, 1855). Other common calcitic associates include auriculate oysters of the *Mansfieldostrea compressirostra* group and the gastropod *Ecphora quadricostata*.

GENUS *CAROLINAPECTEN* WARD AND BLACKWELDER, 1987

Carolinapecten Ward and Blackwelder, 1987:141.

Type species.—*Pecten eboreus* Conrad, 1833, by original designation; Pliocene, upper Yorktown Formation at Suffolk, Virginia, on the Nansemond River (Ward and Blackwelder, 1987: 141).

Included species.—*Carolinapecten* includes a large number of nominal species and subspecies that are still being reviewed. The most commonly accepted species-group names, as evidenced by taxonomic treatments by Gibson (1987), Ward and Blackwelder (1987), Campbell (1993), Campbell and Campbell (1995), and Petuch (2004), include the following: *bertiensis* (Mansfield, 1937), *darlingtonensis* (Dall, 1898), *eboreus* (Conrad, 1833), *gladensis* (Mansfield, 1936), *jamieae* Petuch, 2004, *senescens* (Dall, 1898), *solarioides* (Heilprin, 1887), *urbannaensis* (Mansfield, 1929), *walkerensis* (Tucker, 1934), and *watsonensis* (Mansfield, 1936).

Revised diagnosis.—Aequipectinoid Pectinidae of large size (80–150 mm height), thin valves of low convexity, ranging from left-convex to strongly right convex, about 15–25 low radial ribs, secondary costae, if present, without scales, cardinal crura (hinge teeth herein) low, byssal notch shallow, active ctenolium absent in adults, disk flanks low and poorly demarcated, posterior margins of posterior auricles convex in plane of commissure, posterior sinus obscure or absent. (Modified from Ward and Blackwelder (1987:141.)

Geographic range.—Atlantic and Gulf of Mexico coastal plains from Virginia to Florida and eastern Mexico. See Gardner (1944:37) for Mexican occurrences.

Stratigraphic range.—Upper Miocene (Cobham Bay Member of Eastover Formation in Virginia; Bayshore Clay Member of lower Tamiami Formation) to Pleistocene Bermont Formation in Florida.

Remarks.—The new species of *Carolinapecten* described herein substantially enlarge the original concept of the genus. Both valves of the oldest species, *Carolinapecten corpulentus* n. sp., are strongly convex, and this species as well as its successor, *Ca. murdockensis druidwilsoni* n. sp. and n. ssp., are distinctly right-convex. These taxa, as well as two additional subspecies of *Ca. murdockensis* described herein, also differ from the original diagnosis of *Carolinapecten* in having fewer ribs (15–19).

CAROLINAPECTEN CORPULENTUS n. sp.
Figure 9A–D

Zoobank Nomenclatural Act.—81615907-5C80-4779-A0C7-80973FA14465.

Diagnosis.—Gibbous, right-convex *Carolinapecten* with right umbo projecting well above hinge and left valve nearly as well inflated as right; disk with 15–18, most commonly 16, rounded to slightly flattened ribs that are about twice as wide as interspaces on right valve and about equal in width to interspaces on left valve. Secondary costae absent on disk and disk flanks; right anterior auricle commonly with only three radial costae.

Description.—Shell large, maximum observed height 108 mm, moderately thick shelled, with moderately large anterior and posterior disk gapes; height about 90% of length, both valves well inflated but with right valve more convex than left; maximum convexity of right valve ranging from 25 to 30% of valve height, that of left valve commonly about 20%; convexity of articulated shell about 50% of shell height with maximum convexity occurring dorsal to midpoint of shell; byssal notch of right valve deep in small shells, becoming shallower in late ontogeny, its depth at maturity about 25% of length of anterior hinge, with active ctenolium commonly disappearing at valve heights greater than about 70 mm; byssal fasciole moderately broad and slightly arched, crossed by commarginal growth lines and rarely by one or two radial costellae. Disks with 15–18 low, rounded to slightly flattened radial ribs, most commonly 16 on right valve and 17 on left, with lateralmost ribs on each valve tending to fade out distally or to break up into low costellae; commarginal growth lines arched dorsally on ribs and ventrally in rib interspaces; disk flanks rounded, not steep, without radial costae but with fine costellae adjacent to lateralmost faded ribs. Total hinge length 65–70% of shell length, with anterior hinge slightly shorter than posterior hinge; dorsal folds of auricles weakly developed, with anterior dorsal fold of greater amplitude than posterior fold; anterior margin of right anterior auricle curving into rounded apex of byssal notch; anterior mar-

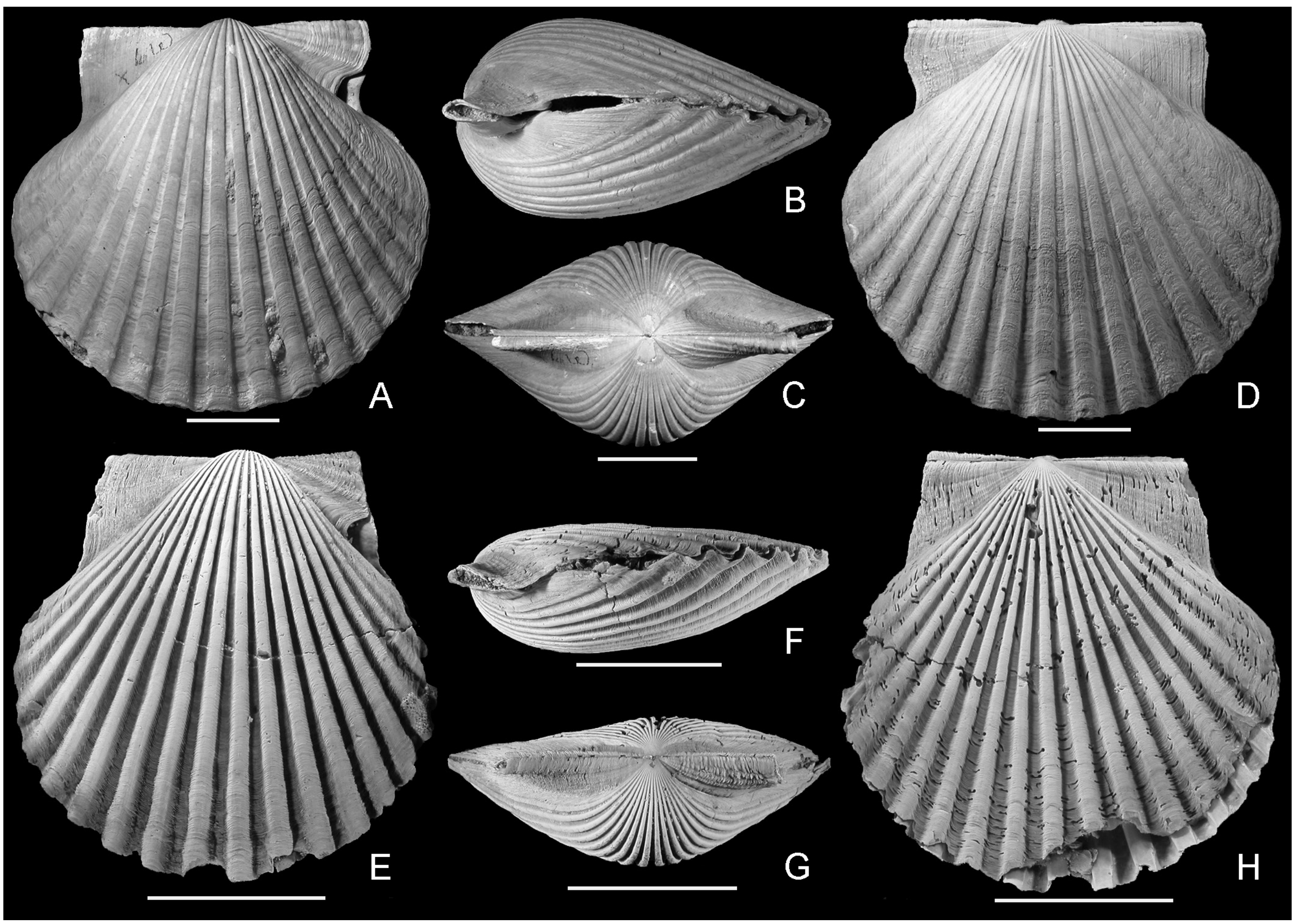


Figure 9. A–D. *Carolinapecten corpulentus* n. sp., holotype, USNM 716593, USGS 26939, Jupiter Waterway, articulated shell. **A.** exterior of right valve; **B.** anterior; **C.** dorsal view; **D.** exterior of left valve. **E–H.** *Carolinapecten murdockensis druidwilsoni* n. ssp., holotype, USNM 716594, USGS 26913, Cocoplum Waterway, articulated shell. **E.** exterior or right valve; **F.** anterior view; **G.** dorsal view; **H.** exterior of left valve. Scale bars = 2 cm.

gin of left anterior auricle rather sharply rounded dorsally, then recurving into broad, shallow byssal sinus; margins of posterior auricles very shallowly outwardly convex, with overall trend forming an angle that is commonly perpendicular to dorsal margin, rarely slightly acute; right anterior auricle commonly with three broad radial costae (63% of specimens, n=32), these costae sometimes faintly striate near margin, less commonly with four costae, the ventralmost narrower than others; left anterior auricle with five to eight radial costae, most commonly six or seven, costae on posterior auricles very weak and difficult to count, not known to exceed eight. Hinge dentition of right valve consisting of strong resilial teeth extending laterally nearly parallel to hinge line, dentition of left valve consisting of strong infradorsal and infraresilial teeth. Umbonal cavity extending beneath resilifers of both valves; auricular denticles well developed at distal ends of ridges on shell interior at ventral edge of auricles. Pallial line well inset from ventral margin at about one-third height of valve. Umbonal inner foliated calcite layer extending ventrally to about mid-adductor level.

Etymology.—Name based on the Latin adjective meaning fat or stout.

Type material and measurements.—Holotype: USNM 716593, closed pair of valves, Ht 83.0 mm, L 90.5 mm, convexity of articulated shell 45.4 mm (Fig. 9A–D).

Type locality.—USGS 26939, Charlotte County, Florida. Sixth canal west of Murdock [Jupiter Waterway], lower zone, possibly equal to "mold bed" at North Port Charlotte. M. E. Hunter, probably collected in early 1960s.

Other material.—About 50 specimens (single valves plus pairs of matching valves) from four localities in the Port Charlotte area.

Comparisons.—*Carolinapecten corpulentus* differs from all other species of the genus in having both valves well inflated, with the umbo of the right valve extending well above the dorsal margin. It is closest to *Ca. murdockensis druidwilsoni* n. sp. and n. ssp. (Fig. 9E–H), but that taxon is strongly inequivalve, with its left valve much less convex than that of *Ca. corpulentus*. Although some right valves of *Ca. corpulentus* and *Ca. murdockensis druidwilsoni* may be difficult to distinguish, the latter more commonly has four radial costae on its right anterior auricle, its ribs tend to be squared rather than rounded, and it does not attain the large size of *Ca. corpulentus*.

Occurrence.—Port Charlotte area, west of Murdock: Como Waterway: USGS 26922; Jupiter Waterway: USGS 26925, CH108; Apollo Waterway: CH022.

Distribution.—Known only from the Port Charlotte area in the southwestern Florida Peninsula in the lower Bayshore Clay Member of the lower Tamiami Formation of Hunter (1968), now regarded as within the upper Peace River Formation of late Miocene (Tortonian) age. The new species is assigned to pectinid zone PZ1 (see Biostratigraphy section).

Remarks.—The determination that *Carolinapecten corpulentus* belongs in the genus *Carolinapecten* is surprising considering the highly gibbous shape of this species. The generic placement is supported, however, by the folded dorsal hinge margin of the right valve, the arcuate rather than strongly sigmoidal shape of the posterior margins of the posterior auricles, the fairly prominent disk gapes, and the rather shallow byssal notch in mature specimens. The generic placement is further supported by the inferred succession of *Carolinapecten* species in the Port Charlotte area, with *Ca. murdockensis druidwilsoni* n. sp. and ssp. forming an intermediate step (gibbous right valve, but low-convexity left valve) between *Ca. corpulentus* and the more equiconvex *Ca. murdockensis murdockensis* and *Ca. murdockensis parawatsonensis*.

At its type locality on the Jupiter Waterway and at a second locality on the Apollo Waterway, *Carolinapecten corpulentus* is represented by abundant paired valves greater than 70 mm in size. Small juvenile shells are apparently absent, and there are few associated calcitic fossils. One of these associates is a large specimen (Fig. 4D) of *Ecphora* cf. *gardnerae whiteoakensis* Ward and Gilinsky, 1988, a taxon previously known only from the Claremont Manor Member of the Eastover Formation of early Tortonian Miocene age in Virginia (Ward, 1992b: 124). A second calcitic associate at the type locality of the new species (USGS 26925) is a large pycnodonteine oyster that Wilson (1987:15) identified as *Pycnodonte* (*Gigantostrea*) aff. *leeana* Wilson, 1987. He regarded this taxon as being very close to *P.* (*G.*) *leeana* from the early to middle Miocene Pungo River Formation of North Carolina and to be "the last known *Gigantostrea* Sacco, 1897, in the Coastal Plain." Wilson noted that the specimen from Charlotte County was probably from Hunter's (1968) Bayshore Clay Member, an assessment that is reinforced by the stark white color of the specimens, a feature that Hunter (1968) observed in the Bayshore Clay.

CAROLINAPECTEN MURDOCKENSIS MURDOCKENSIS, n. sp. and ssp.
Figure 10A–D

Zoobank Nomenclatural Act.—10C8F80C-454A-4122-86C6-B28F5E6E2733.

Diagnosis.—Moderately inflated, equiconvex to slightly right-convex *Carolinapecten* with right umbo not projecting far above dorsal margin and dorsal margins on auricles of right valve not strongly folded; disks with 15–18 ribs, most commonly 17, with variable rib profiles ranging from distinctly squared to rounded; commarginal lamellae closely spaced in rib interspaces and on rib crests, secondary radial costae absent on disk and disk flanks; right anterior auricle commonly with four radial costae.

Description.—Shell moderately large, equilateral or with slightly extended posterior, maximum observed height 108 mm but most specimens less than 80 mm, moderately thick shelled, disk gapes absent or very narrow; height about 90% of length, both valves moderately inflated, either equiconvex or with right valve slightly more convex than left; maximum convexity of right valve less than 25% of valve height, that of left valve commonly less than 20%; convexity of articulated shell commonly less than 40% of shell height; byssal notch of right valve deep in small shells, becoming shallower in late ontogeny, its depth at maturity about 25% of length of anterior hinge, with active ctenolium commonly disappearing at valve heights greater than about 80 mm, rarely minimally present at shell heights up to 90 mm; byssal fasciole narrow, either flat or slightly depressed, becoming narrowly raised along suture and crossed by commarginal growth lines. Disks with 15–18, most commonly 17, high ribs having profiles that vary among populations, squared at least in early ontogeny and commonly throughout ontogeny in some,

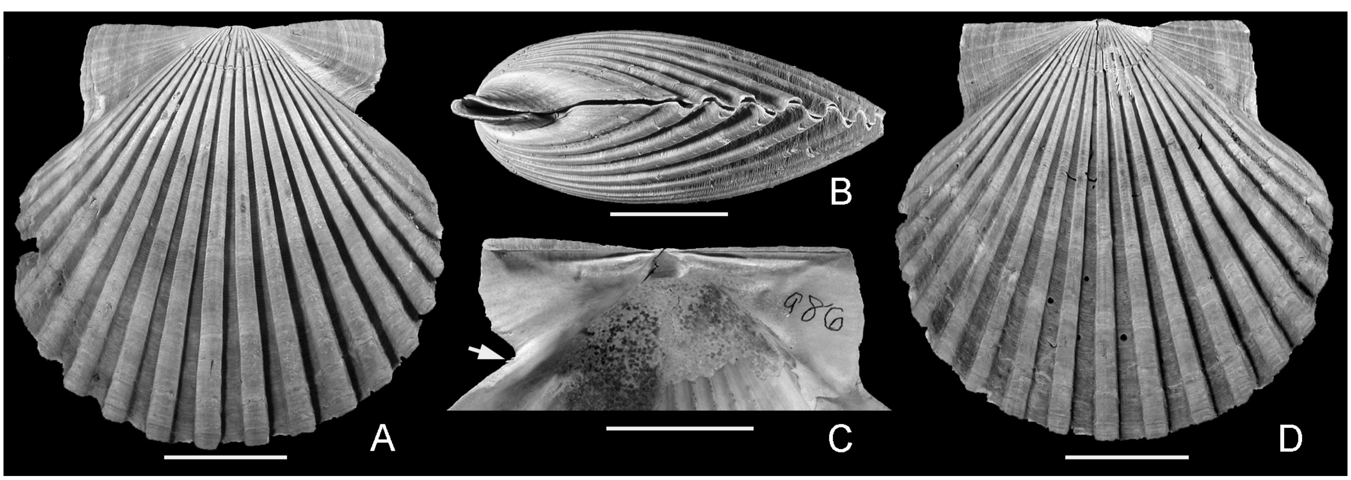


Figure 10. A–D. *Carolinapecten murdockensis murdockensis* n. sp., holotype, matching valves, USNM 716595, USGS 26933, Lion Heart Waterway, pair of matching valves. **A.** exterior of right valve; **B.** anterior view; **C.** dorsal interior of right valve showing persistent active ctenolium (arrow); **D.** exterior of left valve. Scale bars = 2 cm.

but high and rounded in others, consistently wider than interspaces on right valve and about equal to interspaces on left, with lateralmost ribs on each valve tending to persist to margin; commarginal growth lines closely spaced in rib interspaces, tending to disappear on rib crests; disk flanks lacking radial striae, narrow, flat, and steep in square-ribbed forms, broader and more sloping in rounder ribbed forms. Total hinge length variable, 55–75% of shell length, with anterior hinge slightly shorter than posterior hinge; dorsal folds of auricles of right valve weakly developed, with anterior dorsal fold of greater amplitude than posterior fold; anterior margin of right anterior auricle curving into apex of byssal notch; anterior margin of left anterior auricle evenly rounded to shallowly sigmoidal, producing a shallow byssal sinus; margins of posterior auricles very shallowly outwardly convex, with overall trend variable, forming distinctly acute angle with dorsal margin in some populations but perpendicular in others; right anterior auricle commonly with four radial costae, rarely with three; left anterior auricle with five to eight radial costae, most commonly six or seven, costae on posterior auricles very weak and difficult to count, not known to exceed eight. Hinge dentition of right valve consisting of strong resilial teeth extending laterally nearly parallel to hinge line, dentition of left valve consisting of strong infradorsal and infraresilial teeth. Umbonal cavity extending beneath resilifers of both valves; auricular denticles well developed at distal ends of ridges on shell interior at ventral edge of auricles. Pallial line well inset from ventral margin at about one-third height of valve. Umbonal inner foliated calcite layer extending ventrally to about mid-adductor level.

Etymology.—Named for the Murdock area of northwestern Port Charlotte, Charlotte County, Florida.

Type material and measurements.—Holotype: USNM 716595, pair of matching valves, Ht 69 mm, L 71 mm, convexity of articulated shell 29.6 mm (Fig. 10A–D).

Type locality.—USGS 26933, Charlotte County, Florida, spoil banks of canal [Lion Heart Waterway] at north edge of Port Charlotte Information Center, northwest edge of Port Charlotte, US 41 (Sec. 17, T40S, R22E). Collectors: H. E. and E. H. Vokes, 1969.

Other material.—185 specimens (single valves plus pairs of matching valves) from 32 localities mainly in the Port Charlotte area.

Comparisons.—*Carolinapecten murdockensis murdockensis* differs from *Ca. murdockensis druidwilsoni* n. ssp. in being nearly equiconvex rather than strongly right convex, having a more inflated left valve, and having a much greater percentage of specimens with four costae on the right anterior auricle. *Carolinapecten murdockensis murdockensis* differs from *Ca. murdockensis parawatsonensis* n. ssp. in having more squared ribs, a less equilateral shell with its posterior side slightly extended, much narrower or absent disk gapes, and in lacking lateralmost ribs that fade out and/or subdivide before reaching the shell margin in mature specimens.

Occurrence.—Port Charlotte area, west of Murdock: Cocoplum Waterway: SO010C; Auburn Waterway: USGS 22256, USGS 26906, CH104B, CH018; Como Waterway: USGS 22926, USGS 23202, USGS 26922, CH106, CH120; Bayshore Waterway: USGS 26932, USGS 26910, USGS 26917, USGS 26923, USGS 26938, CH030B; Jupiter Waterway: USGS 26916, CH113. Port Charlotte area, east of Murdock: Pellam Waterway: USGS 22911, USGS 22912, USGS22913; Lion Heart Waterway: USGS 26928, USGS 26933; Sunset Waterway: USGS 23118, USGS 26912. Other localities: Charlotte County: CH026; DeSoto County: USGS 21258, USGS 26920, USGS DE006.

Distribution.—Known mainly from the Port Charlotte area in the southwestern Florida Peninsula in pectinid zone PZ2 in the upper Bayshore Clay Member and lower Murdock Station Member of the lower Tamiami Formation of Hunter (1968), now regarded as within the upper Peace River Formation of late Miocene (Tortonian) age.

Remarks.—*Carolinapecten murdockensis murdockensis* is highly variable in rib profiles. These range from squared throughout ontogeny as in the holotype (Fig 4A–D) and in specimens in CH113 marked by Hunter as "type *Pecten* biostrome," to forms that have squared ribs limited to early ontogeny. Abundant specimens at Locality CH026 have rib profiles that vary from rounded to squared and differ from other populations of *Ca. murdockensis murdockensis* in having a higher percentage of right valves with three rather than four costae on the right anterior auricle (54% with three, 46% with four in a measured sample of 13 right valves).

Calcitic associates of *Carolinapecten murdockensis murdockensis* include *Chesapecten middlesexensis hunterae*, broad-ribbed *Ecphora* in the *E. gardnerae complex*, the non-auriculate oyster, *Mansfieldostrea compressirostra brucei*, and the pectinid *Euvola smithi*, all regarded as indicators of late Miocene (Tortonian) age.

CAROLINAPECTEN MURDOCKENSIS DRUIDWILSONI n. ssp.
Figure 9E–H

Zoobank Nomenclatural Act.—E4BBCA70-540D-4590-883B-C993170047C0.

Diagnosis.—Strongly right-convex *Carolinapecten* with right umbo projecting above dorsal margin and left valve much less convex than right; dorsal margins of auricles of right valve with shallow folds barely projecting above outer-ligament grooves; disks with 16–18 ribs squared in early ontogeny, high and rounded later, without secondary costellae; right anterior auricle with three or four radial costae, most commonly three, and moderately deep byssal notch with active ctenolium persisting throughout ontogeny.

Description.—Shell of medium size, with maximum observed height of 80 mm but most specimens no higher than 65 mm, strongly right convex with right valve moderately inflated and commonly over twice the convexity of left valve; disk gapes absent or narrow; height and length about equal or with length slightly the greater; convexity of articulated shell about 35% of shell height. Total hinge length 55–70% of shell length, with anterior and posterior hinge lengths about equal; dorsal folds of right auricles weakly developed, not projecting far above outer-ligament grooves. Disks with 16–18 ribs, most commonly 17, ribs high with deeply incised interspaces on both valves, wider than interspaces on right valve, narrower on left; rib profiles rectangular to subrectangular on right valve, becoming more rounded but remaining high in late ontogeny; ribs of left valve more distinctly rectangular in profile with more flattened crests in early ontogeny; lateralmost ribs of each valve weaker than others but persisting without subdivision throughout ontogeny. Commarginal growth lines closely spaced in rib interspaces, disappearing or weakly developed on rib crests; disk flanks sloping and rounded on right valve, narrower and steeper on left, lacking radial striae but crossed by commarginal growth lines. Byssal notch of right valve remaining moderately deep with rounded apex throughout ontogeny; active ctenolium persisting into late ontogeny, with byssal fasciole slightly depressed but narrowly raised along suture and crossed by commarginal growth lines; byssal sinus of left anterior auricle very shallow; margins of posterior auricles shallowly outwardly convex, with overall trend varying from perpendicular to dorsal margin to forming an acute angle; right anterior auricle with three or four radial costae, most commonly three; left anterior auricle with six to nine radial costae, posterior auricles with very weak costae, about five or six. Hinge dentition of right valve consisting of strong resilial teeth extending laterally nearly parallel to hinge line; dentition of left valve consisting of strong infradorsal and infraresilial teeth. Umbonal cavity extending beneath resilifers of both valves, more so on right valve than on left; auricular denticles well developed at distal ends of ridges on shell interior at ventral edge of auricles. Pallial line well inset from ventral margin at about one-third height of valve. Umbonal inner foliated calcite layer extending ventrally to about mid-adductor level.

Etymology.—Named for the late Druid Wilson, paleontologist of the U.S. Geological Survey, whose extensive collections from the southwestern Florida Peninsula have been the primary source of data for the present study.

Type material and measurements.—Holotype: USNM 716594, closed articulated shell, Ht 48.1 mm, L 49.0 mm, convexity of articulated shell

17.9 mm (Fig. 9E–H).

Type locality.—USGS 26913, Sarasota County, Florida. "Cocoplum Waterway, Port Charlotte-Collingswood. D. Wilson, M. Hunter, J. Banks, T. Waller, and W. Blow, Feb. 26, 1968."

Other material.—About 100 specimens (single valves plus pairs of matching valves) from six localities in the Port Charlotte area.

Comparisons.—*Carolinapecten murdockensis druidwilsoni* resembles *Ca. corpulentus* in being right-convex and having a majority of specimens with only three costae on the right anterior auricle, but differs in having a much less inflated left valve and subrounded ribs. *Carolinapecten murdockensis murdockensis*, in contrast to *Ca. murdockensis druidwilsoni*, is nearly equiconvex and has more sharply squared rib profiles and commonly four costae on the right anterior auricle. *Carolinapecten murdockensis parawatsonensis* differs from other subspecies of *Ca. murdockensis* in having fairly broad disk gapes and lateralmost ribs that subdivide near the distal margin. All of the subspecies of *Ca. murdockensis* differ from *Ca. eboreus watsonensis* in having less deeply folded dorsal margins of the right-valve auricles, a deeper byssal notch, a more ontogenetically persistent active ctenolium, and higher ribs.

Occurrence.—Port Charlotte area, west of Murdock: Cocoplum Waterway: USGS 26913; Auburn Waterway: USGS 22256, USGS 269061, USGS 26908; Jupiter Waterway: USGS 26916.

Distribution.—*Carolinapecten murdockensis druidwilsoni* occurs in biozone PZ2 (see Biostratigraphy section) in beds interpreted as being in the lower part of the Bayshore Clay Member of the lower Tamiami Formation of Hunter (1968).

Remarks.—*Carolinapecten murdockensis druidwilsoni* is associated with broad-ribbed *Ecphora* in the *Ecphora gardnerae* complex (Fig. 4D–F), non-auriculate oysters in the *Mansfieldostrea compressirostra* complex (Fig. 4G–H), and *Chesapecten middlesexensis hunterae* (Fig. 3A–K). At its type locality on the Cocoplum Waterway, *Ca. murdockensis druidwilsoni* occurs in a barnacle-hash coquina consisting mainly of fragmented *Fistulobalanus klemmi* Zullo, 1984 (Fig. 4I–J), a barnacle heretofore known only from the lower Yorktown Formation in North Carolina, but inferred herein to be present also in the upper Miocene (see Biostratigraphy section). Also abundant is an undescribed species of *Argopecten*, with all valves having very worn surfaces (Fig. 4B–C).

CAROLINAPECTEN MURDOCKENSIS PARAWATSONENSIS n. ssp.
Figure 11A–F

Zoobank Nomenclatural Act.—E5F6ACA3-C651-4C3B-9279-C672F9A0CC97.

Diagnosis.—Equilateral *Carolinapecten* with 15–19 subrounded ribs with low, steep sides, with lateralmost rib on each side subdividing and becoming lower near margin; secondary radial costellae or striae absent from ribs and interspaces; close-set commarginal lamellae commonly limited to rib interspaces or forming a fringe along sides of rib crests; byssal notch remaining moderately deep throughout ontogeny.

Description.—Shell moderately large, maximum observed height 104 mm, moderately thick shelled, equilateral or with slightly extended posterior, disk gapes moderately broad; height and length nearly equal or with length slightly longer than height, hinge length about 60–70% of shell length, with anterior hinge length nearly equal to posterior hinge length or slightly shorter; valves about equally convex or slightly right-convex, with convexity of each valve not exceeding 20% of valve height, convexity of articulated shell about 40% of shell height. Disks with 15–19 ribs, most commonly 17 or 18, with shallowly rounded crests and low, steep sides, broader than interspaces on both valves or equal in width to interspaces on left valve; lateralmost ribs commonly becoming lower and subdividing near margin; commarginal lamellae closely spaced in rib interspaces and on edges of rib crests, with smooth centers of rib crests slightly elevated above lamellae on sides of crests (Fig. 11E–F), secondary radial costae absent on disk and disk flanks. Disk flanks narrow and steep, crossed by commarginal growth lines. Right anterior auricle commonly with four radial costae, rarely three or five; byssal notch remaining moderately deep with angular apex in late ontogeny, its

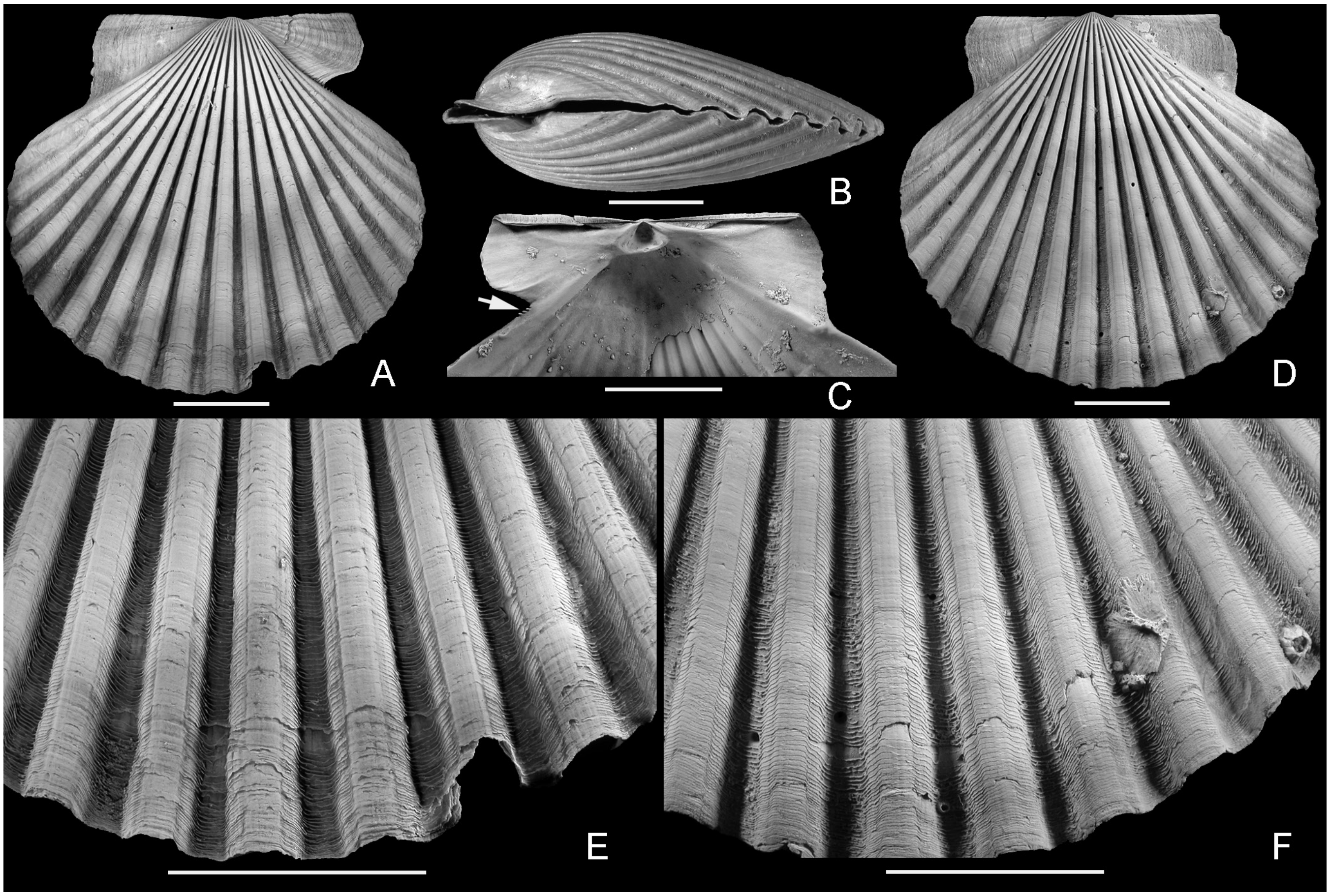


Figure 11. *Carolinapecten murdockensis parawatsonensis* n. ssp. Holotype, USNM 716596, USGS 26931, Bayshore Waterway, matching valves. **A.** exterior of right valve; **B.** anterior view; **C.** dorsal interior of right valve showing persistent active ctenolium (arrow); **D.** exterior of left valve; **E, F.** details of exterior sculpture showing rib crests with lateral fringes. **E.** right valve; **F.** left valve. Scale bars = 2 cm.

depth at maturity about 20% of length of anterior hinge, with active ctenolium commonly weakly developed at valve heights greater than about 80 mm, rarely present with only one or two teeth at shell heights up to 100 mm; byssal fasciole broad, slightly raised and crossed by commarginal growth lines; radial costae on posterior auricles and left anterior auricle weakly developed and difficult to count, about six or seven, commonly stronger on dorsal part of these auricles; dorsal folds of auricles of right valve moderately developed, with anterior dorsal fold of greater amplitude than posterior fold. Hinge dentition of right valve consisting of strong resilial teeth extending laterally nearly parallel to hinge line, dentition of left valve consisting of strong infradorsal and infraresilial teeth. Umbonal cavity extending beneath resilifers of both valves; auricular denticles well developed at distal ends of ridges on shell interior at ventral edge of auricles. Pallial line well inset from ventral margin at about one-third height of valve. Umbonal inner foliated calcite layer extending ventrally to about mid-adductor level.

Etymology.—Named for its close morphological resemblance to *Carolinapecten eboreus watsonensis*.

Type material and measurements.—Holotype (Fig. 11A–F): USNM 716596, pair of matching valves, Ht 79 mm, L 88.5 mm, convexity of articulated shell 31.2 mm.

Type locality.—USGS 26931, Charlotte County, Florida, Port Charlotte development, spoil banks, canal [Bayshore Waterway] north side of US 41, 5.3 km (3.3 miles) west of SR 776 at old Murdock junction, sec. 3, T40S, R21E. H. E. and E. H. Vokes, 1969.

Other material.—About 250 specimens (single valves plus pairs of matching valves) from 13 localities in the Port Charlotte area.

Comparisons.—*Carolinapecten murdockensis parawatsonensis* resembles other subspecies of *Ca. murdockensis* in having closely spaced commarginal lamellae in rib interspaces, a moderately deep byssal notch, an active ctenolium that tends to persist into late ontogeny, and low dorsal folds on its right anterior auricles. It differs from the other subspecies in having moderately wide disk gapes (Fig. 11B), subrounded ribs with low, steep sides, and in many specimens rib crests that have a smooth center slightly raised above flanking lamellate fringes (Fig. 11–F). *Carolinapecten murdockensis parawatsonensis* differs from *Ca. eboreus watsonensis* in having higher, more steeply sided ribs, more closely spaced commarginal lamellae throughout ontogeny, a deeper byssal notch, a more persistent active ctenolium, and less deeply folded dorsal margins of right-valve auricles.

Occurrence.—Port Charlotte area, west of Murdock: Como Waterway: USGS 22931; Crestwood Waterway: USGS 22916; Eastwind Waterway: USGS 26909; Bayshore Waterway: USGS 23858, USGS 26910, USGS 26911, USGS 26923, USGS 26931, CH029. Port Charlotte area, east of Murdock: Crestview Waterway: CH119; Sunset Waterway: USGS 23117, USGS 26915; Morningstar Waterway: USGS 26929. Generalized Murdock localities: USGS 26938.

Distribution.—*Carolinapecten murdockensis parawatsonensis* is known only from the Port Charlotte area, where it occurs in biozone PZ3 (see Biostratigraphy section) associated with *Ch. middlesexensis bayshorensis*.

Remarks.—C*arolinapecten murdockensis parawatsonensis* is regarded as the youngest and most derived member of the *Ca. murdockensis* lineage in the Port Charlotte area. It co-occurs at most localities with *Ch. middlesexensis bayshorensis*, regarded as the latest member of the *Ch. middlesexensis* lineage in Florida. Other co-occurring calcitic fossils corroborate a position near the Miocene-Pliocene boundary. At locality USGS 23117 on the Sunset Waterway east of Murdock, associated barnacles include *Arossia glyptopoma* (Pilsbry, 1916) and *Tamiosoma advena* Zullo, 1992b, both previously regarded as Pliocene species (Zullo, 1992b), but *Chesaconcavus myosulcatus* Zullo, 1992b, a Miocene species, is also present at the same locality as well as the non-auriculate oyster *Mansfieldostrea compressirostra geraldjohnsoni* (Ward, 1992b) and the pectinid *Euvola smithi*.

BIOSTRATIGRAPHY—NEW FINDINGS

The new species and subspecies of *Chesapecten* and *Carolinapecten* from the Port Charlotte area differ from those in the Sarasota pits and from the Eastover and Yorktown formations of the Mid-Atlantic Coastal Plain. In the Port Charlotte area, *Ch. middlesexensis hunterae* and *Ch. middlesexensis bayshorensis* both retain deep byssal notches and non-costellate byssal fascioles throughout ontogeny, indicating a grade of evolution comparable to that of Miocene *Ch. middlesexensis s.l.*. in the Mid-Atlantic Coastal Plain. In contrast, *Ch. quinarius* and *Ch. madisonius sarasotensis* in the basal beds exposed in the Sarasota pits have byssal notches that become shallow in late ontogeny and byssal fascioles that become partially costellate, indicating a grade of evolution approaching that of Pliocene *Chesapecten* species in the Yorktown Formation of the Mid-Atlantic Coastal Plain.

In both areas there are specimens of *Chesapecten* with reduced rib counts (fewer than 8) that have been mistakenly identified as *Ch. jeffersonius*, and these misidentifications have led to the deeply entrenched idea that the Murdock Station Member in its type area in Port Charlotte correlates with the basal beds (Units 11 and 12) of the Sarasota pits. In the Port Charlotte area, however, the specimens with low rib counts, described herein as *Ch. middlesexensis bayshorensis*, are part of the *Ch. middlesexensis* lineage, as evidenced by their persistent deep byssal notch, differentiated byssal fasciole, and coarse scaliness. In the Sarasota pits, the “five-ribbed *Chesapecten*” said by Waldrop and

Wilson (1990) to occur in Units 11 and 12, is a new species, *Chesapecten quinarius*. As described in detail in the Systematics section, it is distinct from both *Ch. jeffersonius s.s*. and *Ch. septenarius* in lacking squared rib profiles throughout ontogeny and having fewer ribs, commonly six on right valves and five on left valves. True *Chesapecten septenarius*, distinguished by its sharply squared rib profiles with flat crests, has not been found in the Sarasota pits and is possibly limited in Florida to the Atlantic side of the Ocala arch (e.g., the Kissimmee River beds, unpublished data). In Unit 11, *Ch. quinarius* co-occurs with the *Chesapecten* referred to by Ward (1990, 2008:347) as a possible hybrid of *Ch. madisonius* and *Ch. septenarius*. This "hybrid" *Chesapecten* is determined herein to be a new subspecies, *Chesapecten madisonius sarasotensis*, thus far known only from Florida. It appears to be a reliable indicator of early late Pliocene (Piacenzian) age and possibly also late Zanclean (post-Sunken Meadows Member of the Yorktown Formation).

Carolinapecten in the Port Charlotte area is represented by a succession of species and subspecies beginning with *Ca. corpulentus*, a highly gibbous new species not previously recognized as a *Carolinapecten*. *Ca. corpulentus* is followed in succession by *Ca. murdockensis druidwilsoni*, *Ca. murdockensis murdockensis*, and *Ca. murdocknesis parawatsonensis*. Collectively these taxa form a morphological bridge leading to *Ca. eboreus watsonensis* in the basal units of the Sarasota pits, the latter co-occurring with *Chesapecten quinarius* and *Ch. madisonius sarasotensis*. Morphological evolution of the shell in this sequence involves changes from right-convexity to equiconvexity or slight left-convexity, a shallowing of the byssal notch and disappearance of the active ctenolium in late ontogeny, a deepening of the dorsal folds of the auricles of the right valve, an increase in disk gapes accompanied by thinning of the shell, and lowering and rounding of rib profiles.

These stratigraphic and morphological successions of *Chesapecten* and *Carolinapecten* in Hunter's (1968) "lower Tamiami Formation" allow the construction of interval biozones based on the first appearance datum (FAD) of pectinid taxa (see Ward, 1992b:8; NACSN, 2005:article 50b). The pectinid biozones (abbreviated PZ), beginning with the oldest, are as follows:

PZ1) *Carolinapecten corpulentus* zone: FAD of *Ca. corpulentus* to FAD of *Ch. middlesexensis hunterae*.

PZ2) *Chesapecten middlesexensis hunterae* zone: FAD of *Ch. middlesexensis hunterae* to FAD of *Ch.middlesexensis bayshorensis*.

PZ3) *Chesapecten middlesexensis bayshorensis* zone: FAD of *Ch. middlesexensis bayshorensis* to FAD of *Ch. quinarius*.

PZ4) *Chesapecten quinarius* zone: FAD of *Ch. quinarius* to FAD of *Ch. madisonius sarasotensis*.

PZ5) *Chesapecten madisonius sarasotensis* zone: FAD of *Ch. madisonius sarasotensis* to FAD of *Interchlamys tamiamiensis*.

The Miocene-Pliocene boundary, as interpreted in this report, lies between the Murdock Station Member in the Port Charlotte area and the basal units (Units 11 and 12) of the Sarasota pits or between interval zones PZ3 and PZ4 (Fig. 12). This is because species of *Chesapecten* that resemble Miocene *Ch. middlesexensis s.l.* occur in Florida only in the Port Charlotte area and are unknown in the Sarasota pits. *Ch. madisonius s.l.*, restricted to the Pliocene (Piacenzian) upper Yorktown Formation in the Mid-Atlantic Coastal Plain, occurs in Florida near the base of the section (Unit 11) in the Sarasota pits but is unknown in the Port Charlotte area. *Ch. jeffersonius* is absent in both of these areas in Florida.

Other calcitic fossils support this placement of the Miocene-Pliocene boundary (Fig. 12). Hunter (1968:447–448) emphasized that *Ecphora* in the Bayshore Clay and Murdock Station members is represented by forms that compare closely to specimens from the St. Marys Formation in Virginia. The St. Marys Formation of Virginia is now placed in the Eastover Formation and is regarded as late Miocene (Tortonian) in age (Ward and Blackwelder, 1980:D3). In the present study, the "broad-ribbed *Ecphora"* of Hunter (1968) is present in biozones PZ1 and PZ2. It is identified herein (Fig. 4D–F) as *E.* cf. *gardnerae whiteoakensis* Ward

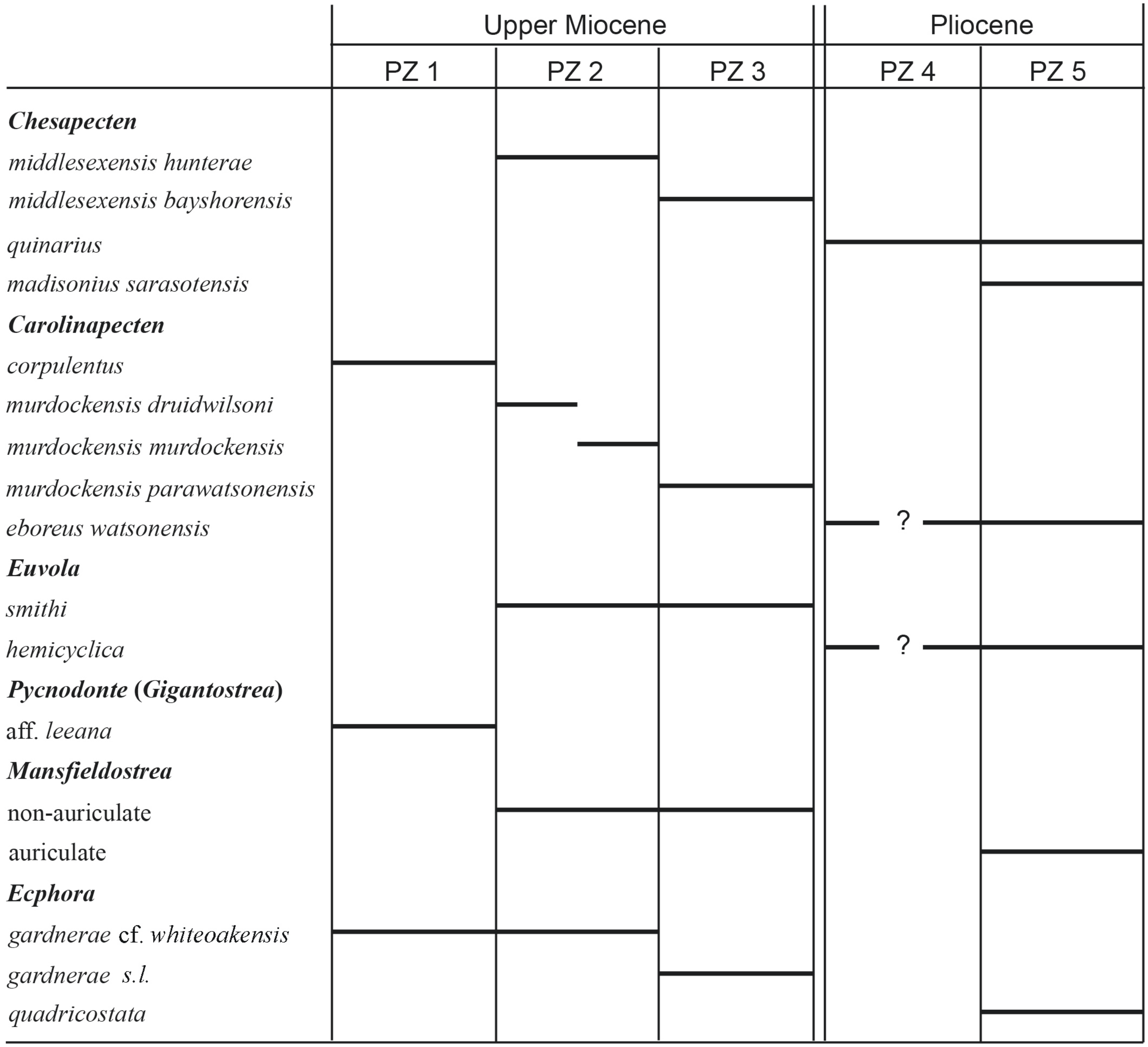


Figure 12. Ranges of age-diagnostic calcitic molluscan species among pectinid interval zones (PZ) in Charlotte and Sarasota counties, Florida. PZ1–PZ3 are in the Bayshore Clay and Murdock Station members of the lower Tamiami Formation of Hunter (1968); PZ4 and PZ5 are in Units 11 and 12 at the base of the section in the Sarasota pits. Question marks indicate uncertain occurrences in Unit 12.

and Gilinsky, 1988 on the basis of its broad, multistriate ribs that remain broad but become low in amplitude in late ontogeny, its variably expressed adapical apertural channel, and its weakly spirally striate columella with a variably expressed weak fifth rib. Its type locality is in the Claremont Manor Member of the Eastover Formation in Virginia of late Miocene (Tortonian) age (Ward, 1992b:fig. 2). This subspecies is rare in PZ1 but is abundantly represented in PZ2, particularly on the Cocoplum Waterway (USGS 26913) in a barnacle-fragment coquina (“barnacle hash”) interpreted to be within the Cocoplum Member of the Bayshore Clay (Petuch, 1982). *Ecphora hopei* Petuch, 1991, is a junior synonym (see Ward, 2008:328, for a detailed account of Petuch's numerous changes in names and localities for this species.). The subspecies is thus far undocumented from higher units. It is apparently absent in the Sarasota pits, where the dominant species of *Ecphora* is *E. quadricostata*, distinguished by its narrow ribs that become narrower and very low to the body whorl in late ontogeny and by its large aperture and widely flaring umbilicus (Ward and Gilinsky, 1988). *Ecphora. quadricostata* is a Pliocene and early Pleistocene (Gelasian) species, ranging through the lower and upper Yorktown and equivalent formations in the Mid-Atlantic Coastal Plain. In Florida, it ranges from Unit 11 up into the Pinecrest beds of the Sarasota pits and the Jackson Bluff Formation of the Florida Panhandle (Ward and Gilinsky, 1988:15).

Certain barnacle species also have biostratigraphic potential across the Miocene-Pliocene boundary. An inherent problem, however, is that pre-late Pliocene barnacles in Florida are poorly known (Zullo, 1992a:129), meaning that the lower limits of the stratigraphic ranges of barnacles that have been described from the Pliocene are also poorly known. A case in point is the small barnacle *Fistulobalanus klemmi* Zullo, 1984, until now known only from its type locality in the Lee Creek Mine in Beaufort County, North Carolina. Although the species was originally said by Zullo (1984:1331) to come from the Middle Miocene Pungo River Formation, Ward (2008:537) noted that the holotype and paratypes (USNM 348788) are attached to a valve of *Chesapecten jeffersonius* (corroborated herein) and must have come from the Sunken Meadow Member of the Yorktown Formation of early Pliocene (late Zanclean) age, a unit that is present in the Lee Creek Mine. In the present study a species that is close to and possibly the same as *F. klemmi* is reported from Florida for the first time (Fig. 4I–J). It is the small barnacle that comprises the barnacle-fragment coquina of the Bayshore Clay (USGS 26913), pectinid biozone PZ2, where it is associated with *Ch. middlesexensis hunterae*, *Ca. murdockensis druidwilsoni,* and the Miocene species *E.* cf. *gardnerae whiteoakensis* and *M. compressirostra brucei* (Ward, 1992b). The weight of evidence in this case indicates that the stratigraphic range of *F. klemmi* possibly begins in the Miocene. This is not surprising in that the genus has a Miocene presence in the tropical western Atlantic region (Zullo, 1984:1331).

The large barnacle *Chesaconcavus* Zullo, 1992b, in contrast to *Fistulobalanus*, undergoes a species change across the Miocene-Pliocene boundary. In the Port Charlotte area, *Chesaconcavus myosulcatus* Zullo, 1992b, originally described from the late Miocene Cobham Bay Member of the Eastover Formation in Virginia, is reported herein for the first time in Florida, in pectinid zones PZ2 (localities USGS 22911, 22913, 26908, 26912) and PZ3 (localities USGS 22256, 22916, 23117, 23202, 26931). *Chesaconcavus myosulcatus* is thus far unknown in the Sarasota pits. Instead, in this area *Chesaconcavus tamiamiensis* (Ross, 1965) occurs in the upper Tamiami Formation (in the *Interchlamys tamiamiensis* zone of Hunter, 1968; Units 10 and 11 according to Zullo and Portell, 1993). In both the Port Charlotte area and the Sarasota pits, *Chesaconcavus* is commonly associated and sometimes intergrown with *Tamiosoma advena* Zullo, 1992b, but, unlike *Chesaconcavus*, *T. advena*, occurs in both areas and appears to transcend the Miocene-Pliocene boundary.

Another biostratigraphically informative calcitic fossil is the pectinid bivalve *Euvola smithi* (Olsson, 1914; Fig. 4A herein). In the Mid-Atlantic Coastal Plain, this species crosses the Miocene-Pliocene boundary, occurring most commonly in the upper Miocene (Tortonian) Cobham Bay Member of the Eastover Formation but also extending with greatly reduced abundance into the lower Pliocene (late Zanclean) Sunken Meadow Member of the Yorktown Formation (Ward, 1992b:67). In the southwestern Florida Peninsula, the stratigraphically lowest occurrence of *E. smithi* is in the Port Charlotte area in pectinid biozones PZ2 and PZ3, associated respectively with *Chesapecten middlesexensis hunterae* and *Chesapecten bayshorensis*. It is not known to occur in the Sarasota pits, where it is replaced by the late Pliocene species *Euvola hemicyclica* (Ravenel in Tuomey and Holmes, 1855) in Unit 11 and higher units in the

Pinecrest beds.

Oysters in the *Mansfieldostrea compressirostra* complex also undergo morphological change in the interval from late Miocene to early Pliocene in the Mid-Atlantic Coastal Plain as documented by Ward (1992b). Miocene species, exemplified by *M. compressirostra brucei* (Ward, 1992b), and *M. compressirostra geraldjohnsoni* (Ward, 1992b), lack projecting posterodorsal margins, referred to by some authors as "auricles." In contrast, Pliocene species, beginning with the Zanclean Sunken Meadow Member of the Yorktown Formation, develop these projections as exemplified by *M. compressirostra compressirostra* (Say, 1824). In the present study, only non-auriculate forms of *M. compressirostra s.l*. were found in the Port Charlotte area in the Bayshore Clay and Murdock Station members, whereas auriculate forms were found in the Sarasota pits beginning with the basal Units 11 and 12. *Undulostrea locklini* (Gardner, 1945) and *Cubitostrea coxi* (Gardner 1945), both commonly regarded as Pliocene indicators because they occur in the Ochopee Limestone and the Pinecrest beds, also occur in the Port Charlotte area and appear to have stratigraphic ranges that extend down into the upper Miocene. This corroborates Hunter's (1968:448) report that *Undulostrea locklini* occurs in both the Bayshore Clay and Murdock Station members of lower Tamiami Formation.

Collectively, these results indicate that the Miocene-Pliocene boundary lies between the Murdock Station Member of the lower Tamiami Formation in the Port Charlotte area and the basal beds (Units 11 and 12) of the Sarasota pits. Furthermore, the results demonstrate that calcitic macrofossils, especially the pectinids, can be useful biostratigraphic indicators in the highly leached upper Miocene and Pliocene deposits in these areas.

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APPENDIX. LOCALITY DATA

Entries for USGS localities through number 25183 are copied from the USGS Station Books for Tertiary Paleontology. These station books were originally maintained by the United States Geological Survey when the Washington office of the Paleontology and Stratigraphy Branch was located in the National Museum of Natural History of the Smithsonian Institution. Since the move of the USGS branch to USGS headquarters in Reston, Virginia, the station books have been maintained by the Department of Paleobiology of NMNH for localities of Cenozoic marine invertebrates collected by USGS and NMNH personnel as well as others who have contributed their collections to NMNH.

Entries beginning with USGS 26906 were copied by the author into the station books from the field notebooks of the late Druid Wilson. Data in parentheses following USGS numbers other than those beginning with “TU” refer to Wilson’s field numbers in these notebooks, which are archived by the Department of Paleobiology. Those beginning with “TU” refer to the Tulane Register of Localities recording collections made by Harold and Emily Vokes, then of Tulane University in New Orleans. Upon their retirement, the Vokes’s collections were reposited at NMNH, FLMNH, and PRI.

In some cases, minor changes in the locality data have been made to reflect updated road numbers or street names. The area centered on the intersection of Florida State Road SR 776 with US 41 (Fig. 2) is indicated by various names in the locality descriptions, including Murdock, Murdock Station, and Port Charlotte Station. M.E. Hunter, on her specimen labels, referred to the waterways west of Murdock by consecutive numbers rather than waterway names beginning with the Auburn Waterway (Fig. 2) as “first canal west of Murdock.” Brackets enclose information added by the present author.

Department of Paleobiology, National Museum of Natural History, Washington, DC.

USGS 21258 (F-7, Z-77) (Nocatee). DeSoto County, Florida. Spoil dumps of marl pits east of

Nocatee. Double and Wilson, Nov. 6, 1957; Wilson, 1961, 1962. [Hunter (1968: fig. 5) correlated the "*Pecten*-barnacle-oyster beds at Nocatee" with her Murdock Station Member. This is Locality 30 of Kier (1963: 10). The marine deposits probably represent the unit discussed by Bergendahl (1956: 73) as "Sand of Late Miocene age." Abundant fragments of large bones are present at this locality, probably representing a lag deposit derived from the Bone Valley Formation disconformably above the marine fossils.]

USGS 21900. Pinellas County, Florida. Snell Island, St. Petersburg, dredged for fill from Tampa Bay. Charles R. Locklin.

USGS 22256 (Z-122). Charlotte County, Florida. Auburn Waterway, Port Charlotte. Spoil bank on east side of waterway which cuts across both US 41 and Florida SR776 at points respectively about 1.0 km (0.6 mile) northwest and about 1.0 km (0.6 mile) southwest of Murdock, apparently on line between R21E and R22E, Murdock Quadrangle. Collection made between US 41 and SR 776 and a short distance south of SR 776. Druid Wilson and Carol Justus, December, 1958.

USGS 22584. Sarasota County, Florida. Osprey. Float from road metal pit some distance east of US 41 just north of North Creek. J. Brookes Knight, Raymond Moore, and Druid Wilson, December, 1953.

USGS 22911 (Y-104, Z-112). Charlotte County, Florida, northern Port Charlotte area. Pellam Waterway (first waterway east of Murdock), El Jobean Quadrangle (1957), SW¼ sec. 20, T40S, R22E. Spoil banks bordering west side of waterway for distance of about 0.2 km (0.1 mile), directly opposite eastward turn of canal, sandy barnacle facies with well-preserved *Encope* sp. Druid Wilson and Doug Smith, Dec. 16, 1961 (Z-112); Druid and Ethel Wilson, January 10, 1964 (Y-104).

USGS 22912 (Z-111). Charlotte County, Florida, northern Port Charlotte area. Pellam Waterway, El Jobean Quadrangle (1957), SW¼ sec. 20, T40S, R22E, directly north of USGS 22911 over distance of about 0.8 km (0.5 mile) to east-west street crossing canal. Druid and Ethel Wilson, Dec. 16, 1961.

USGS 22913 (Z-110). Charlotte County, Florida, northern Port Charlotte area. Pellam Waterway, spoil banks over distance of 0.3 km (0.2 mile) from east-west street crossing canal to northward turn in canal, directly north of USGS 22912 (Z-111). Druid Wilson, December 16, 1961.

USGS 22916 (Z-93, Z-121). Charlotte County, Florida. Crestwood Waterway, Murdock Quadrangle, SW¼ Sec. 2 and NW¼ Sec. 11, T40S, R21E, canal crossing US 41 about 3.9 km (2.4 miles) west of Port Charlotte Station. Float from east side of highway for distance of about 1.0 km (0.6 mile). Porter Kier, John Ayres, Doug Smith, and Druid Wilson, Dec. 7, 1961; Druid Wilson and Doug Smith, December 18, 1961. [Locality published as "Sam Knight Waterway" by Kier (1963:10, Kier's locality 32).]

USGS 22926 (Z-94). Charlotte County, Florida. Como Waterway crossing US 41 about 1.8 km (1.1 miles) west of Port Charlotte Station and running north-south almost through centers of sections 1, 12, 13, 24, and 25, T40S, R21E, Murdock and El Jobean Quadrangles. Float from east side of canal over distance of about 0.3 km (0.2 mile) south of highway. Druid Wilson and Doug Smith, December 8, 1961.

USGS 22931 (Z-100). Charlotte County, Florida. Same as USGS 22926, recollected by Druid Wilson and John Ayres, Nov. 2, 1963.

USGS 23117 (Z-92). Charlotte County, Florida. Float from spoil bank on south side of canal (apparently Sunset Waterway at Peachland Boulevard) about 0.3 km (0.2 mile) north of US 41 at a point about 3.2 km (2.0 miles) east of Port Charlotte (Murdock) station; apparently in NW¼ section 16, T40W, R22E, Punta Gorda Quadrangle. Druid Wilson and others, December 7, 1961.

USGS 23118 (Z-123). Charlotte County, Florida. Port Charlotte east of Murdock, Sunset Waterway, about 1.6 km (1.0 mile) east of US 41 on unpaved road [apparently now Quesada Ave.] which joins US 41 at a point 0.6 km (0.3 mile) east of intersection with Florida SR776, near intersection of Sunset and

Lion Heart Waterways. Float from canal spoil bank north of road, apparently in section 8, T40S, R22E in Murdock or Murdock SE Quadrangle. Druid Wilson and others, December 19 and 21, 1961.

USGS 23202 (C-5). Charlotte County, Florida. Float from small pit on south side of US 41 and west side of canal (Como Waterway) about 1.9 km (1.2 miles) west of Murdock railway station. Druid and Ethel Wilson, December 28, 1960.

USGS 23858. Charlotte County, Florida. Bayshore Waterway, north side of US 41, 5.1 km (3.2 miles) west of junction with SR 776. Thomas Waller, July 11, 1962.

USGS 24527 (Z-202). Sarasota County, Florida. DeSoto Lakes Estates, 4.8 km (3 miles) east of US 301 at its junction with County Route 683. Property of DeSoto Management Corporation. John Ayers and Druid Wilson, May 15, 1962 [= Locality 26 in Waller (1969:94).]

USGS 24968. Sarasota County, Florida. Warren Brothers Pit, Sarasota, 6.5 km (4.05 miles) east of US 301 on 17th Street, then left (north) at T-intersection and 0.8 km (0.5 mile) to pit. Collections from float and spoil banks. Evelyn Bradley, 1970, 1971.

USGS 25174. Sarasota County, Florida. Spoil banks, float, and excavated material, new Warren Brothers Pit, about 1.6 km (1 mile) east of old pit (USGS 24968), east from US 301 on 17th Street, left on Newburn Street to old pit, east on paved road to new pit. Thomas Waller, March 30-31, 1972.

USGS 25183. Warren Brothers Pit (see USGS 25174), in place in bottom three feet of exposed section. Dark gray clayey quartz sand with abundant molds and casts. Thomas Waller, March 30-31, 1972.

USGS 26906 (W-26). Charlotte County, Florida. Auburn Waterway just north of US 41. Druid and Ethel Wilson, January 1, 1966.

USGS 26907 (W-27). Charlotte County, Florida. Auburn Waterway 1.6 km (1.0+) miles north of US 41. Druid and Ethel Wilson and Harold and Emily Vokes, December 28, 1966.

USGS 26908 (W-28). Charlotte County, Florida. Auburn Waterway 0.5 km (0.3 mile) north of US 41. Druid and Ethel Wilson, January 1, 1966.

USGS 26909 (W-83, TU-788). Charlotte County, Florida. U-shaped waterway (Eastwind Waterway) on north side of SR776. Druid Wilson, Harold Vokes, and Emily Vokes, December 28, 1966. [This is probably TU-788 in the Tulane Locality Register, which reads, "at U-shaped canal N. side Fla. Hwy. 771 [now SR 776] - 3.4 mi. SW of US 41 at Murdock Station (now Port Charlotte) - sec. 15, T40S, R21E (El Jobean Quad.)." The Eastwind Waterway is a small waterway in SW¼ NE¼ sec. 15, T40S, R21E, El Jobean Quadrangle USGS 7.5' series (1987). It is near the south end of Crestwood Waterway.]

USGS 26910 (W-84). Charlotte County, Florida. Bayshore Waterway, south of (back of) Beverage Center, which is across highway (US 41) from *jeffersonius* locality. Druid. Wilson, December 28, 1966. [The "*jeffersonius* locality" referred to by Wilson is USGS 26911.]

USGS 26911 (W-85, X-148). Charlotte County, Florida. Entry in Wilson's field book for W-85 dated December 28, 1966, reads "*P. jeffersonius* locality north of US 41 across highway from Trail Beverage Center. (= X-148) [Bayshore Waterway]." His entry for X-148, dated 1965, reads "Trail Beverage Center [Bayshore Waterway] (= W-85). Barnacle facies; *Pecten eboreus* plentiful, *P. jeffersonius* common, indurated highly weathered but not leached bed outcrops in edge of canal; about 0.75 mi. east of Charlotte-Sarasota County line."

USGS 26912 (W-114). Charlotte County, Florida. Port Charlotte. Sunset Waterway. "*P. middlesexensis* locality of Hunter and Banks." Druid Wilson, Muriel Hunter, Joe Banks, Thomas Waller, and Warren Blow, February 26, 1968.

USGS 26913 (W-115). Sarasota County, Florida. North Port [formerly North Port Charlotte], Cocoplum Waterway at Collingswood Boulevard. Druid Wilson, Muriel Hunter, Joe Banks, Thomas Waller, and Warren Blow, February 26, 1968.

USGS 26914 (W-116). Charlotte County, Florida. Port Charlotte, first canal west of McCall Street

[Flamingo Waterway]. Druid Wilson, Muriel Hunter, Joe Banks, Thomas Waller, and Warren Blow, February 26, 1968.

USGS 26915 (X-100). Charlotte County, Florida. Port Charlotte, Sunset Waterway, just north of Peachland Boulevard. Druid Wilson, John Ayres, and J. Reynolds, November 29, 1964.

USGS 26916 (X-149). Charlotte County, Florida. Jupiter Waterway, County-line echinoid locality. Druid Wilson, Feb. 16, 1965.

USGS 26917 (X-157). Charlotte County, Florida. Port Charlotte. East-west segment of Bayshore Waterway south of US 41 which joins "County-line canal" [Jupiter Waterway] from east. Druid Wilson, February 20, 1965.

USGS 26919 (Z-210). Orange County, Florida. Orlando pit. Druid Wilson and L. Root, November 2, 1962.

USGS 26920 (D109). De Soto County, Florida. Borrow pit 1.6 km (1.0 mile) east of Nocatee (NW¼ SE¼ sec. 24, T38S, R24E. M. Bergendahl, 1953. [See Bergendahl (1956: 74) for a discussion of this locality.]

USGS 26921 (Olsson 2027). Charlotte County, Florida. Dredge spoil from finger waterways on south bank of Myakka River on west side of SR776 and railroad bridge, about 12.1 km (7.5 miles) south on SR776 from intersection with US 41. Muriel Hunter, December 2, 1982.

USGS 26922 (Olsson 2028). Charlotte County, Florida. Como Waterway, between US 41 going north almost to an old east-west canal on the [Charlotte-Sarasota] county line. Muriel E. Hunter, December 2, 1982.

USGS 26923 (Olsson 2030). Charlotte County, Florida. Bayshore Waterway near US 41. Muriel E. Hunter, December 2, 1982.

USGS 26924 (Olsson 2031). Charlotte County, Florida. Flamingo Waterway from north of US 41 up to [Charlotte-Sarasota] county line. Muriel Hunter, December 2, 1982.

USGS 26925 (Olsson 2034). Charlotte County, Florida. Doolittle Waterway at SR776, on east side of road about 0.8 km (about a half mile) toward Charlotte Harbor and about 9 km (5.6 miles) south of intersection of SR776 and US 41. Muriel Hunter, December 2, 1982.

USGS 26926 (Olsson 2038). Pinellas County, Florida. St. Petersburg, Vinoy Hotel fill. Collector and date unknown.

USGS 26927 (Olsson 2072). Sarasota County, Florida. Warren Brothers Pit. Axel Olsson.

USGS 26928 (TRW-316). Charlotte County, Florida. Lion Heart Waterway. Spoil banks 2.1 km (1.3 miles) north on Kessler Boulevard (renamed Forest Nelson Blvd.), east side of Kessler, in northwest corner of sec. 4, T40S, R22E. Thomas Waller, Druid Wilson, Warren Blow, Muriel Hunter, and Joe Banks, February 26, 1968.

USGS 26929. Charlotte County, Florida. Port Charlotte. Spoil collection along ditch at Yorkshire Street and Cascade Avenue, near Morningstar Waterway, SW¼ sec. 10, T40S, R22E. Thomas Waller and Joseph Hazel, Oct. 28, 1969.

USGS 26930 (TU-534). Charlotte County, Florida. Spoil bank at Port Charlotte Baptist Church, about 0.8 km (0.5 mile) a half mile north of US 41 on road 2.4 km (1.5 miles) southeast of Murdock, east center sec. 8, R22E, T40S, Murdock SE Quadrangle. Harold and Emily Vokes, 1961.

USGS 26931 (TU-980). Charlotte County, Florida. Port Charlotte. Spoil banks on Bayshore Waterway north of US 41, 5.3 km (3.3 miles) west of junction with SR776, sec. 3, T40S, R21E. Harold and Emily Vokes, 1969.

USGS 26932 (TU-981). Charlotte County, Florida. Port Charlotte. Spoil banks on Bayshore Waterway south of US 41, 5.2 km (3.3 miles) west of junction with SR776, sec. 3, T40S, R21E. Harold and Emily Vokes, 1969.

USGS 26933 (TU-986). Charlotte County, Florida. Spoil banks of canal [Lion Heart Waterway] at north edge of Port Charlotte Information Center, NW edge of Port Charlotte, US 41, sec. 17, T40S, R22E. Harold and Emily Vokes, 1969.

USGS 26934 (TU-1000). Sarasota County, Florida.

Warren Brothers Pit at east end of 17th Street, 5.1 km (3.2 miles) east of Tuttle Road, about 12.8 km (8 miles) east of US 301 in Sarasota, T36S, R19E. Harold and Emily Vokes, 1969.

USGS 26935. Sarasota County, Florida. Warren Brothers Pit, from low in section. Evelyn Bradley, June 6, 1974.

USGS 26936. Sarasota County, Florida. Warren Brothers Shell Pit, E½ sec. 12, T36S, R18E, from base of section on east wall of pit. Evelyn Bradley, May 1978.

USGS 26937. Charlotte County, Florida. Unnumbered collection from Mrs. Thomas through Mike Frazier, Murdock area, labeled "Locality 1." [Locality is inferred to be near 26913 (W-115) on Cocoplum Waterway.]

USGS 26938. Charlotte County, Florida. Collections labeled only as "Murdock". Muriel Hunter, 1966.

USGS 26939 (type locality of *Carolinapecten corpulentus* n. sp.). Charlotte County, Florida. Sixth canal west of Murdock [Jupiter Waterway], lower zone, possibly equal to "mold bed" at North Port Charlotte. Muriel Hunter [collection undated but probably early 1960s].

USNM 371776 (no USGS locality number assigned). Calhoun County, Florida. Dripping spring about 1.2 km (0.75 mile) north of Clarksville, *Ecphora* zone. [Figured specimen identified by Mansfield (1932b:pl. 11, fig. 1) as *Chlamys* (*Lyropecten*) *jeffersonius*, herein placed in *Chesapecten quinarius* n. sp.]

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CH017 (Hunter box 189). Charlotte County, Florida. Third canal west of Murdock (Flamingo Waterway), north of US 41, sec. 1, T40S, R21E, Murdock Quadrangle USGS 7.5' series (1987). Muriel Hunter.

CH018 (FLMNH-IP no number). Charlotte County, Florida. First canal west of Murdock (Auburn Waterway), sec. 1/12, T40S, R21E, Murdock Quadrangle USGS 7.5' series (1987). Muriel Hunter.

CH022 (Hunter locality 6283). Charlotte County, Florida. Port Charlotte. Mold bed on seventh canal west of Murdock (Apollo Waterway), sec. 5, T40S, R21E, Murdock Quadrangle 7.5' series (1987). Muriel Hunter.

CH026. Charlotte County, Florida. Shell pit approximately 1.2 km east of Grove City, NE¼ sec. 16, T41S, R20E, Englewood Quadrangle, USGS 7.5' series (1987). Roger Portell, March 4, 1991.

CH029 (TU 980). Charlotte County, Florida. Murdock, Bayshore Waterway, north side of US 41, 5.3 km (3.3 miles) west of intersection of SR 771/776 at old Murdock Junction, NE ¼ sec. 3, T40S, R21E, Murdock Quadrangle USGS 7.5' series (1987). Harold and Emily Vokes, 1969.

CH030A (Hunter locality 6167). Charlotte County, Florida. Port Charlotte. Fifth canal west of Murdock (Bayshore Waterway), about 0.8 km (0.5 mile) south of US 41, sec. 3, T40S, R21E, Murdock Quadrangle USGS 7.5' series (1987). Type locality of Bayshore Clay Member. Muriel Hunter.

CH030B (FLMNH-IP no number). Charlotte County, Florida. Fifth canal west of Murdock Station (Bayshore Waterway), behind pub, about 0.8 km (0.5 mile) south of US 41, sec. 3, T40S, R21E, Murdock Quadrangle USGS 7.5' series (1987). Type locality of Bayshore Clay Member. Gray shells are barnacle zone; white shells are Bayshore Clay Member. Muriel Hunter.

CH104A (Hunter locality 6126). Charlotte County, Florida. First canal west of Murdock (Auburn Waterway) from US 41 to about 0.8 km (0.5 mile) south of highway, sec.7/12, T40S, R21/22E, Murdock Quadrangle 7.5' series (1987). Muriel Hunter.

CH104B (Hunter locality 6280). Charlotte County, Florida. Port Charlotte. First canal west of Murdock (Auburn Waterway), about half way between US 41 and SR 771 (south of US 41), sec.7/12, T40S, R21/22E, Murdock Quadrangle 7.5' series (1987). Muriel Hunter.

CH106 (Hunter locality 6266, Hunter box 193). Charlotte County, Florida. Second canal west of Murdock (Como Waterway), north of US 41 (Como Waterway), sec. 1, T40S, R21, Murdock Quadrangle USGS 7.5' series (1987). Bayshore Clay Member. Muriel Hunter.

CH107 (Hunter box 190). Charlotte County, Florida. Seventh canal west of Murdock (Apollo Waterway), sec. 4/5/8, T40S, R21E, Murdock Quadrangle USGS 7.5' series (1987). Mold Zone. Muriel Hunter.

CH108. Charlotte County, Florida. Jupiter Waterway, sec. 4/9, T40S, R21E, Murdock Quadrangle USGS 7.5' series (1987). Muriel Hunter.

CH112 (Hunter, no box number). Charlotte County, Florida. Third canal west (Flamingo Waterway), sec. 12, T40S, R21E, Murdock Quadrangle USGS 7.5' series (1987). Muriel Hunter.

CH113 (Florida State University Geology Department box 190). Charlotte County, Florida. Label for entire drawer reads, "*Pecten* biostrome from type section in Hunter (1968)." Hunter (1968:443) gave the locality of her "Type lower bed of Murdock Station Member" as Sec. 4, T40S, R21E, Murdock Quadrangle USGS 7.5' series (1987), on Jupiter Waterway. Muriel Hunter.

CH118 (Hunter locality 6503). Charlotte County, Florida. Second canal east of Murdock (Crestview Waterway), north of US 41 at intersection with Frederick Waterway, sec. 5, T40S, R22E, Murdock Quadrangle USGS 7.5' series (1987). Muriel Hunter.

CH119 (Hunter box 195). Charlotte County, Florida. Second canal east of Murdock (Crestview Waterway), north of US 41, T40S, R22E, Murdock Quadrangle USGS 7.5' series (1987). Muriel Hunter.

CH120 (Hunter locality 6168). Charlotte County, Florida. Second canal west of Murdock (Como Waterway) at intersection with Myakka River, sec. 25, T40S, R21E, El Jobean Quadrangle USGS 7.5' series (1987). Muriel Hunter.

DE006 (Hunter locality 6504). DeSoto County, Florida. (E of Nocatee). DeSoto County, Florida. Old pit about 0.8 km (0.5 mile) east of Nocatee, sec. 24, T38S, R24E, Arcadia Quadrangle USGS 7.5' series (1988). Muriel Hunter.

SO001A (UF 18027 and UF 18039). Sarasota County, Florida. Spoil banks, Macasphalt Shell Pit, E½ sec. 12, T36S, R18E, Bee Ridge Quadrangle USGS 7.5' series (1987). Evelyn and Ernest Bradley, 1986.

SO001B (Hunter locality 6063A). Sarasota County, Florida. New Warren Brothers Pit (about 1971), E½ sec. 12, T36S, Rl8E, Bee Ridge Quadrangle USGS 7.5' series (1987), from lowest bed in dewatered section. Muriel Hunter.

SO001C (UF 31888). Sarasota County, Florida. Macasphalt Shell Pit, E½ sec. 12, T36S, R18E, Bee Ridge Quadrangle USGS 7.5' series (1987), ex-situ. Ernest and Evelyn Bradley, 1969.

SO010A (UF 22280, UF 277006, Hunter locality 6260). Sarasota County, Florida. Cocoplum Waterway, sec. 31/32, T39S, R21E, Murdock quadrangle USGS 7.5' series (1987). Muriel Hunter.

SO010B (Hunter locality 6260). Sarasota County, Florida. North Port Charlotte, on east-west canal (Cocoplum Waterway) about due north of Apollo Waterway, sec. 31/32, T39S, R21E, Murdock Quadrangle USGS 7.5' series (1987). Muriel Hunter.

SO010C (Hunter box 206). Sarasota County, Florida. North Port Charlotte. Cocoplum Waterway, west of seventh canal (Apollo Waterway), sec. 31/32, T39S, R21E, Murdock Quadrangle USGS 7.5' series (1987). Barnacle zone, above mold bed. Muriel Hunter.

SO011 (UF 276997). Sarasota County, Florida. Cocoplum Waterway, sec. 32/33, T39S, R21E, Murdock quadrangle 7.5' series (1987). William and Lelia Brayfield.

SO017 (UF 200672). Sarasota County, Florida. Macasphalt Shell Pit B, sec. 12, T36S, R18E, Bee Ridge quadrangle 7.5' series (1987). = TU-1000. Robert Hoerle, 1971.

SO018 (TU 1000). Sarasota County, Florida. Macasphalt Shell Pit C, sec. 12, T36S, Rl8E, Bee

Ridge Quadrangle USGS 7.5’ series (1987). Robert Hoerle, 1971.

SO021 (UF 45841, UF 158248, TU 1524). Sarasota County, Florida. Richardson Road Shell Pit 01C, sec. 7/8, T36S, R19E, Bee Ridge Quadrangle USGS 7.5’ series (1987). Kevin Schindler, 17 January, 1991, and Emily H. and Harold Vokes, 1990, respectively.

SO024 (UF 129604). Sarasota County, Florida. Quality Aggregates Phase 07A-1, sec. 4/9/10, T36S, R19E, Bee Ridge quadrangle USGS 7.5’ series (1987). Bed 11. Roger Portell, 22 January, 2004.

SO026 (UF 164484). Sarasota County, Florida. Quality Aggregates Quarry, Phase 8-1, SE¼ sec. 3, T36S, R19E, Bee Ridge Quadrangle USGS 7.5’ series (1987). Bed 11. Roger Portell and Alex Kittle, 14 March 2009.

SO058 (Hunter locality 6276). Sarasota County, Florida. Port Charlotte. East-west canal along Hillsborough Blvd. (Cocoplum Waterway) near end of fifth canal west of Murdock (Bayshore Waterway), sec. 34, T39S, R21E, Murdock Quadrangle 7.5’ series (1987). Muriel Hunter.

SO060 (Hunter locality 6169). Sarasota County, Florida. Laurel Canal (Cowpen Slough) at Rte. 72, NE¼ sec. 22, T37S, R19E, Laurel Quadrangle. Muriel Hunter.

SO061. Sarasota County, Florida. Sommer’s Shell Pit, approximately 8.3 km (5.17 miles) east northeast of Fruitville and 0.3 km (0.18 mile) north of Fruitville Road, NE¼ sec. 23, T36S, R19E, Old Myakka Quadrangle, USGS 7.5’ series (1987). John Waldrop.