A MIDDLE PLEISTOCENE BIRD COMMUNITY
FROM SAINT LUCIE COUNTY, FLORIDA

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ABSTRACT

Dickerson Coquina Pit (DCP) is a sand and coquina mine located in Saint Lucie County, Florida, 16 km inland from the Atlantic Ocean. Collections were made from a middle Pleistocene (late Irvingtonian Land Mammal Age) vertebrate fossil bed in the Okeechobee Formation at DCP from 2002 until the pit was flooded in 2008. Vertebrate fossils from DCP also were discovered in fill material used in beach replenishment on North Hutchinson Island, St. Lucie County. The avifauna of DCP is based on 65 fossil elements representing 12 orders, 16 families, and 26 species, with habitat preferences ranging from woodlands and prairies to fresh water and estuarine wetlands to the open ocean. Extinct or extralocal species include a transitional Wild Turkey *Meleagris* cf. *M. gallopavo*, transitional Short-tailed Albatross *Phoebastria* cf. *P. albatrus*, a large stork *Ciconia maltha*, a large crane *Grus* sp., Great Auk *Pinguinus impennis*, and Carolina Parakeet *Conuropsis carolinensis*.

The taphonomy and paleoecology of the Dickerson Coquina Pit generally resemble those of other shell beds in Central and South Florida, such as the Irvingtonian Leisey Shell Pit of Hillsborough County. The avifauna from DCP is distinctive, however, in featuring Florida's first Pleistocene records of four marine species (Short-tailed Albatross, Northern Gannet *Morus bassanus*, Great Cormorant *Phalacrocorax carbo*, and Great Auk) and the Carolina Parakeet.

Key words: biogeography, birds, Dickerson Coquina Pit, extinction, Florida, fossils, Irvingtonian Land Mammal Age, North Hutchinson Island, paleoecology, Pleistocene.

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INTRODUCTION

Peninsular Florida is well known for its fossil avifaunas, ranging in age from the early Miocene Thomas Farm (Steadman, 2008) to late Pleistocene sites such as the Ichetucknee River (Campbell, 1980). Late Pleistocene sites of the Rancholabrean North American Land Mammal Age (NALMA; ~0.15 to 0.01 Ma; Bell et al., 2004) are especially common and well documented in Florida (Lundelius et al., 1983; Emslie, 1998; Webb et al., 2004). Fossil birds from the Irvingtonian NALMA (early to middle Pleistocene; ~1.9/1.72 to 0.15 Ma; Bell et al., 2004) are less common, although the Irvingtonian record of birds is better in Florida than anywhere else in North America (Emslie, 1998; Hulbert, 2001).

The first major vertebrate fossil locality in Saint Lucie County, the Dickerson Coquina Pit (DCP), is unique in being one of the few Irvingtonian vertebrate fossil localities from Florida's Atlantic Coast. While only 65 identifiable bird fossils were recovered from DCP, they represent a wide taxonomic assortment of terrestrial, aquatic, and marine birds. Here we describe the geology and biochronology of the DCP, present the systematic paleontology of its avifauna, and interpret the paleoecology of the area at the time of fossil deposition.

GEOLOGY OF THE DICKERSON COQUINA PIT

The Florida Museum of Natural History, University of Florida (UF) was first alerted to fossils being found in St. Lucie County by George H. Means of the Florida Geological Survey in 2002. Dickerson Aggregates operators were extracting sand and coquina from two large, contiguous borrow pits (27°31′32″ N, 80°28′12″ W) near Indrio, known as Dickerson Coquina Pits 1 and 2 (Figs. 1–2). A vertebrate fossil layer was discovered in the bottommost reaches of the pits, consisting of fishes, reptiles, birds, and mammals. Dickerson Coquina Pit 1 was flooded in 2004, shortly after fossil collections had been made. Mining in Dickerson Coquina Pit 2 was active until 2008. This second pit was allowed to fill with groundwater in 2008, and was joined with the first pit in 2009. Dickerson Coquina Pits 1 and 2 are hereafter referred to jointly as DCP.

The complex geology of DCP consists of interbedded sand and coquina limestone (Fig. 3). Located in the Florida Peninsula sedimentary province (Perkins, 1977), the DCP is ca. 16 km inland in an area that had been subjected to marine transgressions and regressions during the Pleistocene. The modern elevation of the land surface surrounding the site is 7.0 to 8.8 m above sea level. The two borrow pits at DCP

Figure 1. View of Dickerson Coquina Pit 2 (DCP) in 2006. Photo by Roger Portell.
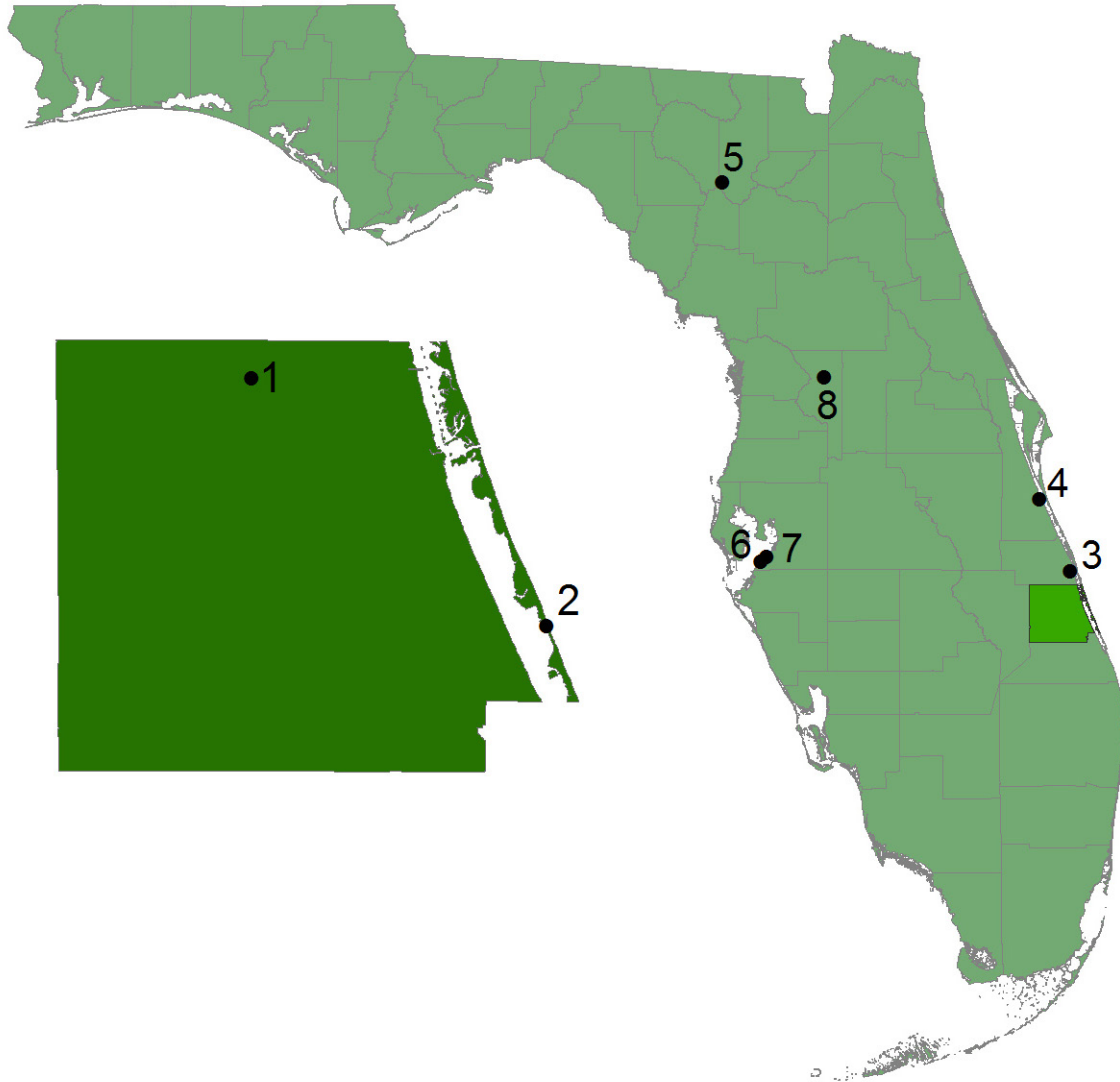
Figure 2. Map of Florida and St. Lucie County (inset) showing the locations of Pleistocene sites discussed in the text. 1. Dickerson Coquina Pit (late Irvingtonian). 2. North Hutchinson Island. 3. Vero Beach (late Rancholabrean). 4. Melbourne (late Rancholabrean). 5. Ichetucknee River (late Rancholabrean). 6. Shell Material Pit (early Irvingtonian). 7. Leisey Shell Pit (early Irvingtonian). 8. Coleman 2A (late Irvingtonian).

were excavated into the Pleistocene Anastasia and Okeechobee formations, which underlie a large stretch of Florida's Atlantic Coast (Scott et al., 2001). Most facies at the site were formed by accreted beach-dune complexes in high-energy environments (Perkins, 1977; Herrera et al., 2006). Lateral correlation of the beds at DCP with those at other locations is difficult at best. Several authors have proposed nomenclature for the strata in the area (Fig. 4) based on lithology (Sellards, 1912;

Scott et al., 2001), invertebrate biostratigraphic units (Petuch and Roberts, 2007), or eustatic sea levels (Perkins, 1977).

The undifferentiated, organic-rich eolian quartz sand that comprises the upper 5 m of sediment at DCP may be Holocene in origin (Herrera et al., 2006; Oleinik and Comas, 2012). The underlying Anastasia Formation was mapped at or near the surface at DCP by Scott et al. (2001). This formation was first described by Sellards
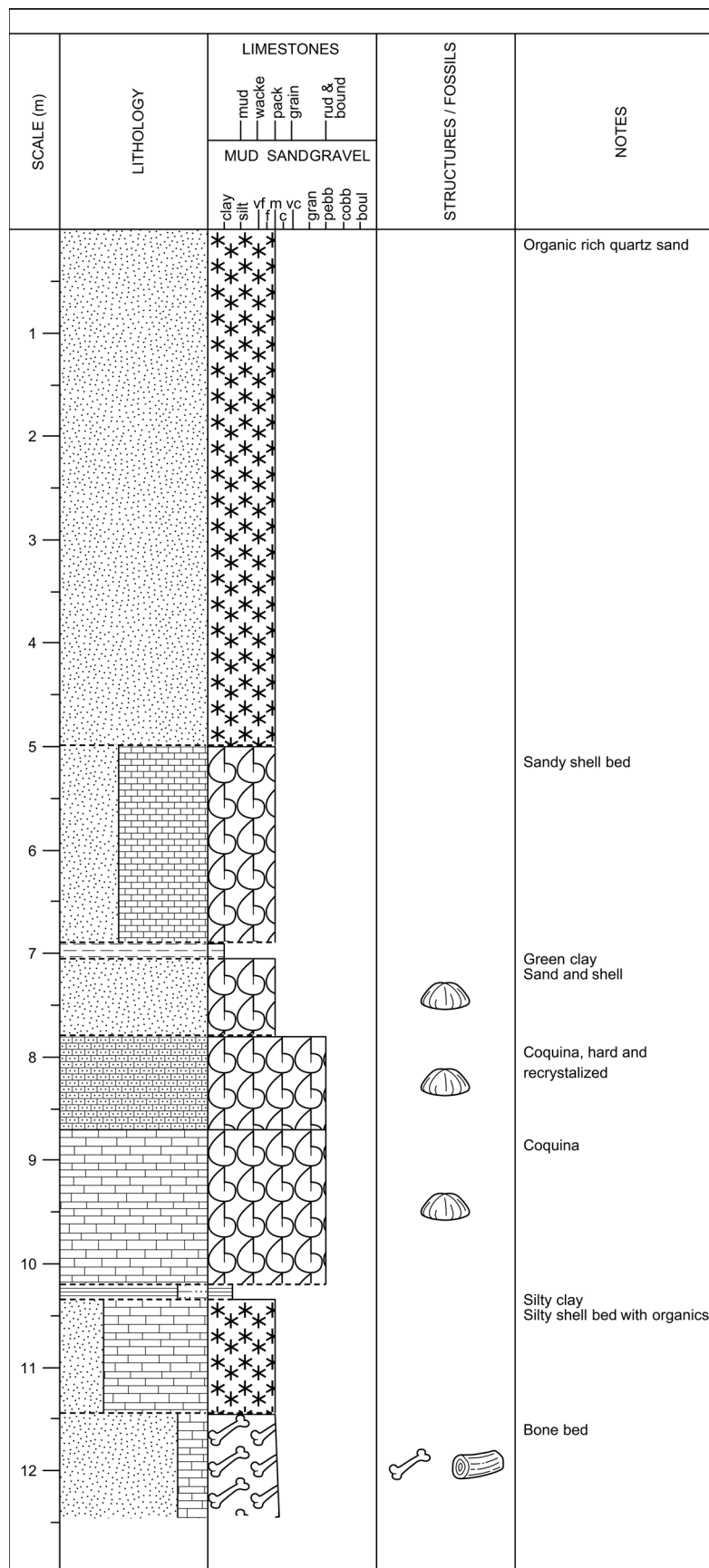
Figure 3. Stratigraphic section of Dickerson Coquina Pit 2 (DCP), St. Lucie County, Florida. Adapted from Herrera et al. (2006). Scale is in meters.

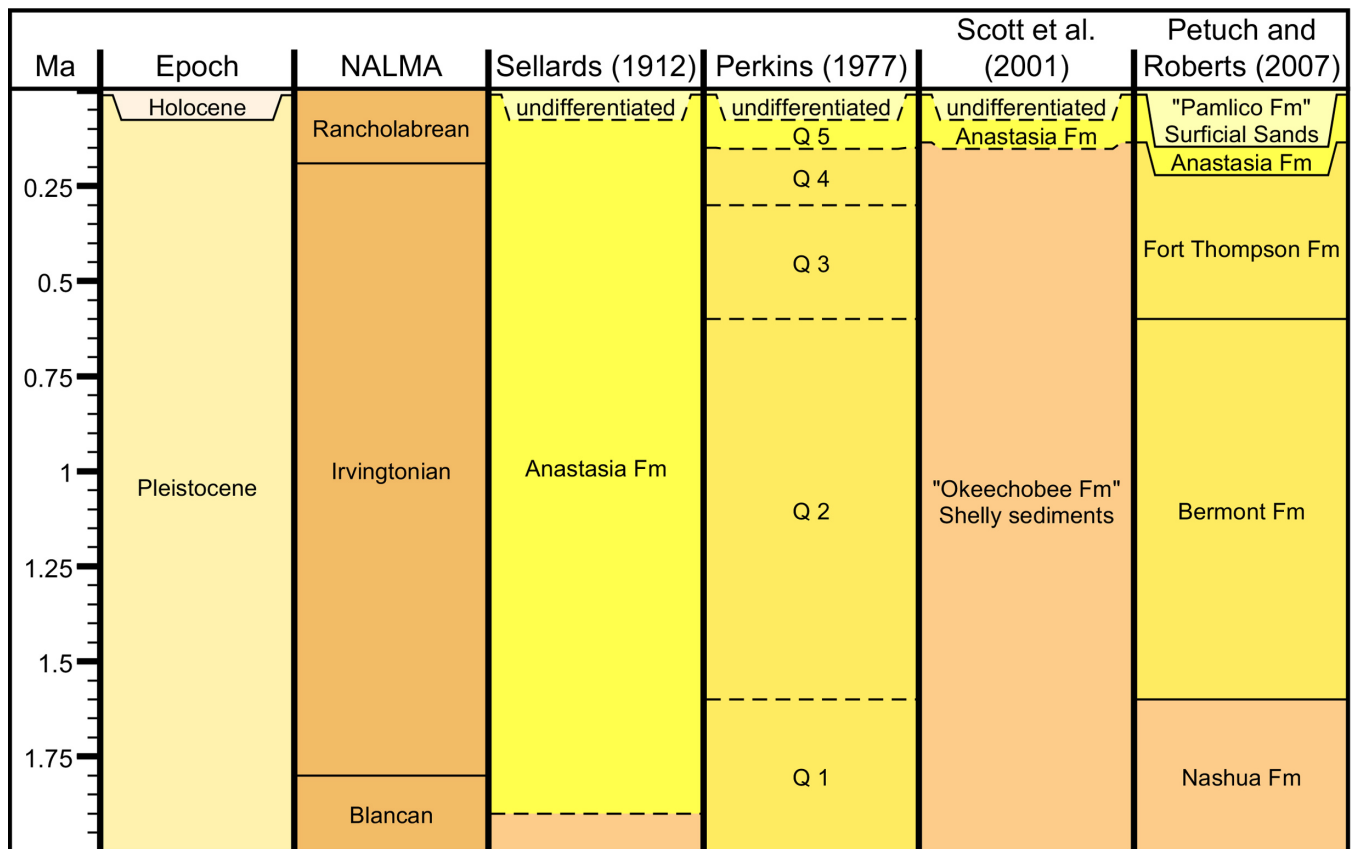| Ma	Epoch	NALMA	Sellards (1912)	Perkins (1977)	Scott et al. (2001)	Petuch and Roberts (2007)
	Holocene		undifferentiated	undifferentiated	undifferentiated	"Pamlico Fm" Surficial Sands
		Rancholabrean		Q 5	Anastasia Fm	Anastasia Fm
0.25				Q 4		
0.5				Q 3		Fort Thompson Fm
0.75						
1	Pleistocene	Irvingtonian	Anastasia Fm	Q 2	"Okeechobee Fm" Shelly sediments	Bermont Fm
1.25						
1.5						
1.75				Q 1		Nashua Fm
		Blancan				

Figure 4. Overview of stratigraphic nomenclature of the Pleistocene deposits of St. Lucie County. Time is in millions of years (Ma). Based on the four publications cited in the column headings.

(1912) as a Pleistocene "deposit of coquinoid rock" along the Atlantic Coast of Florida, but has come to refer to a layer of late Quaternary sands and limestones underlying the Atlantic Coastal Ridge from St. Johns County southward to Palm Beach County and extending as much as 30 km inland in St. Lucie and Martin counties (Scott et al., 2001). Believed to be the youngest lithified marine deposit in Florida (Perkins, 1977), an age range for this unit has been difficult to determine (Portell et al., 2003).

Radiometric (^{234}U/^{230}Th) and amino acid racemization dating of shells and limestone from upper portions of the Anastasia Formation place its age from 136,500 to 8000 years old (136.5-8 ka; Osmond et al., 1970; Murphy, 1973; Mitterer, 1974); no age estimates exist for the lower portions or for many minor facies attributed to the Anastasia Formation. Major facies of the Anastasia probably were deposited during the last interglacial (Marine Isotope Stage 5e) from 130 to 120 ka (Osmond

et al., 1970; Oleinik and Comas, 2012) when sea levels rose to ca. 5 m above current levels (Harmon et al., 1983; Hearty et al., 1998).

Most indurated sand and shell facies at DCP are attributable to the Anastasia Formation (Herrera et al., 2006). The mollusks collected from all depths represent living species, which supports the relative youthfulness of these facies (Fig. 3), although Herrera et al. (2006) cautioned that the lower facies at DCP may be older than typical Anastasia sediments. Electron spin resonance optical dating has confirmed these suspicions; a sample of siliciclastic sediments from just above the vertebrate fossil layer, at a depth of 11.5 m, was dated at 730-430 ka (0.73-0.43 Ma; Burdette et al., 2013).

The boundary between the Anastasia Formation and underlying beds is not well defined. Most of these lithologically similar beds were deposited during times of high sea levels and marine

transgression in warm interglacial intervals, and then eroded during glacial intervals of lower sea levels. Scott (1992, 2001) grouped almost all shelly clastic sediments of latest Pliocene and Pleistocene age in peninsular Florida into an informal Okeechobee Formation. Previous attempts to codify the stratigraphic nomenclature of these sediments were based on biostratigraphic criteria without lithologic descriptions. Scott's Okeechobee Formation includes the Caloosahatchee, Bermont, Fort Thompson, and Nashua 'formations,' which are faunal units of invertebrate paleontologists such as Petuch and Roberts (2007). The overall depositional environment at DCP is comparable to those of other vertebrate localities from marine shell beds in South Florida, such as Leisey Shell Pit (Emslie, 1995a) and Shell Materials Pit (Emslie, 1998).

The vertebrate fossil layer at DCP lies just below the Anastasia Formation and was the lowest stratum regularly exposed above water (Fig. 3). While its lower boundary was not measured, this layer was only a few meters thick (Herrera et al., 2006). Fossil wood (unstudied) was recovered from the vertebrate fossil layer, as well as freshwater bivalves and both terrestrial and freshwater gastropods. Aquatic and marine vertebrate fossils included sharks, stingrays, freshwater and marine bony fish, freshwater turtles, and alligator. Terrestrial reptiles such as tortoises (*Hesperotestudo crassicutata*), box turtles (*Terrapene carolina*), and snakes also were found. Certain of the mammalian taxa are discussed below.

Strata below the vertebrate fossil layer occasionally were exposed at DCP. Petuch (2004) measured some sections and believed that these lower layers corresponded to the late Pliocene to early Pleistocene Nashua 'formation.' Burdette et al. (2013) dated a sample from those low layers (depth 14 m) at 1.37-0.61 Ma. If these age assessments are correct, then the fossil layer is certainly older than typical facies of the Anastasia Formation and should be included in Scott's Okeechobee Formation. It is likely that the vertebrate fossil bed represents a drowned tidal creek or marsh covered during an interglacial marine transgression, perhaps

during the high sea level stand of 10+ m at ca. 400 ka (Marine Isotope Stage 11; Hearty et al., 1999; but see Bowen, 2010).

After two direct hits by hurricanes Frances and Jeanne in September 2004 (Clark, 2004; Franklin et al., 2006), material dredged from DCP was used in a beach replenishment project on North Hutchinson Island (HI), St. Lucie County, Florida (Figs. 2, 5). The sand from DCP was delivered unwashed and fossils arrived mostly intact. The dark, fossiliferous replenishment material is easily differentiated from the native beach sand and subsequent beach fill. Hundreds of vertebrate fossils have been collected from the HI beach fill material and on the beach berm. The original DCP provenance of the HI specimens is clear because the fossil preservation is identical to that of fossils from DCP, the faunal composition is nearly the same, and no vertebrate fossil material had been found in the native beach sand on HI prior to beach replenishment.

VERTEBRATE BIOCHRONOLOGY OF THE DICKERSON COQUINA PIT

Hundreds of mammalian fossils were collected from the DCP and HI localities. Species such as the pampathere *Holmesina septentrionalis*, llama *Paleolama mirifica*, raccoon *Procyon lotor*, and jaguar *Panthera onca* place the maximum age of the vertebrate layer as Pleistocene rather than the Pliocene (Hulbert, 2001; Bell et al., 2004). First occurrence dates of the mammoth *Mammuthus columbi* in Florida are during the Irvingtonian NALMA (Bell et al., 2004; MacFadden and Hulbert, 2009); its presence at DCP thus restricts the site's age to the Irvingtonian or Rancholabrean NALMA rather than the preceding Blancan NALMA. Two other species of mammals found at DCP and HI place the vertebrate assemblage either in the late Irvingtonian or the Rancholabrean NALMA; the wolf *Canis dirus* and tapir *Tapirus veroenis* made their first appearance in the late Irvingtonian and become common in the Rancholabrean (Emslie and Morgan, 1995; Hulbert, 1995; Bell et al., 2004). While negative evidence is never absolute, fossils of bison (*Bison* spp.; the defining taxon of

Figure 5. North Hutchinson Island (HI) between Jenson Beach and Walton Rocks Beach where fill from the Dickerson Coquina Pit (DCP) was deposited. Photo by Paul Roth.

Rancholabrean faunas; Bell et al., 2004) were not recovered at DCP. The mammal fossils at DCP and HI suggests emplacement during the late Irvingtonian or early Rancholabrean, most likely the former.

The avifauna that we report below contains none of the terrestrial or freshwater species with western North American or Neotropical affinities recorded in the Plio-Pleistocene of Florida, especially from Blancan or Irvingtonian sites (Emslie, 1998; Morgan and Emslie, 2010). The turkey fossils from DCP (*Meleagris* cf. *M. gallopavo*) are similar in size and other characters to the transitional form from the late Irvingtonian Coleman 2A locality described by Steadman (1980); also see Species Accounts herein. The loss of the Short-tailed Albatross *Phoebastria albatrus* in the North Atlantic has been proposed independently to have taken place during the high sea-level stand at ca. 400 ka (Olson and Hearty, 2003), which also would support a late Irvingtonian rather than Rancholabrean age for DCP. The youngest late

Irvingtonian fauna with an absolute chronology is Cathedral Cave, Nevada, at ca. 150 ka (Jass and Bell, 2011). All marine mollusk specimens and two of the three echinoid specimens from strata above the vertebrate fossil layer represent living species (Herrera et al., 2006). Considering all evidence, we suggest a late Irvingtonian NALMA for the vertebrate fossil layer at DCP, a proposal supported by electron spin resonance optical dating (Burdette et al., 2013; see above).

MATERIAL AND METHODS

The fossils from DCP were collected by UF staff or donated to UF by private collectors until 2008, when the pits were allowed to flood and dredge mining began. In the years following the replenishment project on HI, beachcombers and amateur paleontologists also donated specimens to UF. Screenwashing was not performed at either locality, although some fossils were washed by the tides on the HI beach. Thus the fossil assemblage is biased toward relatively large species. Certain

fossils from DCP were cemented in a coquinoid matrix with calcite crystals that had to be removed to allow identification.

The bird fossils from DCP were identified by direct comparison with modern specimens from the UF Ornithology Collection as well as fossils from the UF Vertebrate Paleontology Collection. All measurements were taken with Fowler & NSK Max-Cal digital calipers, rounded to the nearest 0.1 mm. Specimens were photographed with a Canon EOS 5D Mark II camera and composed with Adobe Lightroom, Helicon Focus, and Adobe Photoshop CC. The anatomical terminology used follows Howard (1929) and Baumel et al. (1993). Unless stated otherwise, the comparative osteology of the Anatidae follows that of Woolfenden (1961). Taxonomy follows that of the American Ornithologists' Union (1998) through the 54th supplement (Chesser et al., 2013). The fossils are housed and catalogued in the UF Division of Vertebrate Paleontology. Most fossils in the Vertebrate Paleontology Collection and modern skeletons in the Ornithology Collection use the prefix UF, although some bird fossils that formerly were in the Pierce Brodkorb Collection use the prefix UF/PB.

Of the 26 species of birds reported below, 21 have been recorded previously from the Pleistocene of Florida (Lundelius et al., 1983, Emslie, 1998, Webb et al., 2004). Especially for the five remaining species, we will briefly put the fossils from DCP into geographical and chronological context.

SYSTEMATIC PALEONTOLOGY

Order ANSERIFORMES
Family ANATIDAE
Genus *Aix* Boie, 1828
Aix sponsa Linnaeus, 1758
Figure 6B, 6D

Material.−Right proximal humerus, UF 274109; left distal tibiotarsus, UF 274114.

Remarks.−The humerus shows the restricted circular opening of the pneumatic fossa common in perching ducks and also the curved, robust shaft and a lack of inflection of the humeral head that are diagnostic in *Aix*. Also as in *Aix*, the condyles of

the tibiotarsus are more medially displaced and the condylus medialis extends more anteriorly than the condylus lateralis.

Genus *Anas* Linnaeus, 1758
Anas cf. *A. americana* Gmelin, 1789
Figure 6H

Material.−Partial left proximal coracoid, UF 274123.

Remarks.−This specimen compares well with the coracoid of *A. americana* but is too fragmentary for definite identification. Aside from size (*A. americana* being medium-sized), the coracoids of dabbling ducks show few species-level diagnostic characters.

Anas discors (Linnaeus, 1758)
Figure 6F

Material.−Left partial carpometacarpus, UF 274131.

Remarks.−The carpometacarpus in *Anas* can be distinguished from that in diving ducks by the straighter and more proximally located processus extensorius. The small carpometacarpus of *A. discors* is differentiated from that of the even smaller *A. carolinensis* by the deeply excavated anterior carpal fossa.

Anas cf. *A. platyrhynchos* or *A. rubripes* Linnaeus, 1758
Figure 7

Material.−Left coracoid, UF 274124; left proximal scapula, UF 274127; right shaft of humerus, UF 274156; left distal ulna, UF 274159; left distal femur, UF 274148.

Remarks.−The elements listed here are not easily distinguishable among species of *Anas* except for size, with *A. platyrhynchos* and *A. rubripes* agreeing with the fossils in being the largest. These two species are very similar osteologically (Campbell, 1980).

Genus *Aythya* Boie, 1822
Aythya collaris (Donovan, 1809)
Figure 8B, 8C, and 8E

Material.−Right proximal coracoid, UF 274145; left proximal humerus, UF 274105; right proximal humerus, UF 274110.

Figure 6. Pectoral and hindlimb elements of dabbling ducks (Anatidae) from Dickerson Coquina Pit compared with modern specimens. Right humerus in anconal aspect (A, B) and left tibiotarsus in anterior aspect (C, D) of *Aix sponsa*. A, C. UF 47798, modern. B, D. UF 274109, 274114, fossil. Left carpometacarpus in internal aspect (E, F) of *Anas discors*. E. UF 47143, modern. F. UF 274131, fossil. Left coracoid in dorsal aspect (G, H) of *Anas americana*. G. UF 47091, modern. H. UF 274123, fossil. Scale bar = 20 mm.

Figure 7. Pectoral and hindlimb elements of *Anas* cf. *A. platyrhynchos* or *A. rubripes* from Dickerson Coquina Pit compared with modern specimens of *A. platyrhynchos*. Right humerus in palmar aspect (A, B), left coracoid in dorsal aspect (C, D), left scapula in dorsal aspect (E, F), left ulna in dorsal aspect (G, H), and left femur in posterior aspect (I, J). A, C, E, G, I. UF 47807, modern. B, D, F, H, J. UF 274124, 274156, 274127, 274154, 274148, fossils. Scale bar = 20 mm.

Remarks.–The coracoid in *Aythya* is distinct in having the ventral portion of the head reduced and in the bicipital muscle attachment being a thin groove. The more gracile depth of the shaft further distinguishes *Aythya* from other diving ducks. Unlike in dabbling ducks, the humerus in *Aythya* has a closed pneumatic fossa and a thinner shaft. *Aythya* also can be distinguished from *Clangula* and *Lophodytes* by the well-formed impressio brachialis anticus. As in *A. collaris*, these specimens are smaller than in congeneric species.

Genus *Bucephala* Baird, 1858
***Bucephala clangula* (Linnaeus, 1758)**
Figure 8G, 8I

Material.–Left distal humerus, UF 274134; right proximal humerus, UF 274143.

Remarks.–The humerus of *Bucephala* can be separated by that of mergansers (*Mergus*, *Lophodytes*) by its relatively small and rounded crista deltopectoralis and from that in eiders (*Somateria*) by its shallow, closed fossa pneumotricipitalis and curved shaft. The two humeri from DCP conform

Figure 8. Wing elements of diving ducks (Aythyini and Mergini) from Dickerson Coquina Pit compared with modern specimens. Left (A, B) and right (C) humerus in anconal aspect, and right coracoid in dorsal aspect (D, E) of *Aythya collaris*. A, D. UF 43819, modern. B, C, E. UF 274105, 274110, 274145, fossils. Right humerus in anconal aspect (F-G) and left humerus in palmar (H-I) aspect of *Bucephala clangula*. F, H. UF 46119, modern. G, I. UF 274134, 274143, fossil. Scale bar = 20 mm.

in size to those of *B. clangula* (much larger than in *B. albeola*).

The ducks from DCP are generally common year-round or winter residents in Florida today, inhabiting a variety of brackish and freshwater wetlands. *Bucephala clangula*, the Common Goldeneye, is the only species that is uncommon in Florida today. A colder water species, *B. clangula* is now an occasional winter resident in St. Lucie County; it typically ranges no farther south than northern Florida (Stevenson and Anderson, 1994). The only other Pleistocene record of *B. clangula* in Florida is from the Ichetucknee River (Campbell, 1980).

Order GALLIFORMES
Family PHASIANIDAE
Genus *Meleagris* Linnaeus, 1758
Meleagris cf. *M. gallopavo* Linnaeus, 1758
Table 1, Figures 9–10

Material.–Two right proximal coracoids, UF 274125, UF 274126; right proximal humerus, UF 274122; right distal ulna, UF 274161; right proximal radius, UF 274166; left distal femur, UF 274106; two left distal tibiotarsi, UF 274116, UF 274136; left partial shaft of a tarsometatarsus, UF 274169; two phalanges, UF 274152, UF 274153.

Remarks.–Qualitatively, the turkey fossils from DCP resemble modern specimens of *M. gallopavo*, but they are, on average, slightly smaller (Table 1). They are also similar to specimens from the late Irvingtonian Coleman 2A locality, which Steadman (1980) described as an intergrade between *M. anza* or *M. leopoldi* (Blancan and early Irvingtonian NALMAs) and *M. gallopavo* (Rancholabrean NALMA and Holocene). In the only qualitative character that distinguishes some of the fossils from Coleman 2A from those of modern *M. gallopavo* that could be evaluated in the fragmentary fossils from DCP (caput humeri protrudes more anconally above deltoideus muscle attachment, = character 3 of the humerus in Steadman, 1980), the specimen for DCP (UF 274126) resembled individuals in both groups.

The tarsometatarsus is especially diagnostic in turkeys (Steadman, 1980), but the only such specimen from DCP (UF 274169) lacks the bony spur of adult and subadult male turkeys, so it probably represents a female. The least width of the shaft of UF 274169 is greater than average modern female turkeys and only slightly larger than in Coleman 2A females. Measurements of the coracoids of turkeys from DCP are slightly smaller than those of modern male specimens, and smaller than male turkeys from Coleman 2A, but larger than those of most females. The proximal width of the humerus is similar to that in male specimens from Coleman 2A, smaller than average in modern males, and greater than in modern females. In the femur, the distal width, depth of the internal condyle, external condyle, and fibular condyle are most similar to those of the male specimens from Coleman 2A and smaller than average modern males. In the tibiotarsus, the distal width and depths of the internal and external condyles are within the range of modern female turkeys and certainly smaller than in modern males. The phalanges of the turkey from DCP are shorter and thinner than modern specimens. The ulna and radius of the turkey from DCP are too fragmentary to be diagnostic. Thus we refer to the turkey from DCP to *Meleagris* cf. *M. gallopavo.*

Bones of turkeys likely washed into the DCP fossil deposit from nearby woodlands. *Meleagris gallopavo* is extremely common in Florida's Rancholabrean, having evolved in the late Irvingtonian or early Rancholabrean from forms such as that found at Coleman 2A (Steadman, 1980) and DCP.

Order PODICIPEDIFORMES
Family PODICIPEDIDAE
Genus *Podilymbus* Lesson, 1831
Podilymbus podiceps (Linnaeus, 1758)
Figure 11

Material.–Left distal humerus, UF 274130; right proximal tarsometatarsus, UF 274165; left shaft tarsometatarsus, UF 274168.

Remarks.–UF 274130 agrees with the humerus of *Podilymbus* rather than *Podiceps* by its more gradually widening distal end. UF 274165 and 275168 resembles *Podilymbus* rather than *Podiceps* by their stouter corpus tarsometatarsi, which furthermore are wider than they are deep.

Table 1. Measurements (in mm, with mean, range, and sample size) of various skeletal elements in select Irvingtonian and modern *Meleagris*. The number of specimens examined is in parentheses. Standard deviation provided when N ≥10. Asterisks denote slightly damaged specimens. Characters are from Steadman (1980). Measurements of turkeys from Coleman 2A and modern turkeys were reported by Steadman.

		Coleman 2A *Meleagris* sp. ♂ fossils	modern *M. gallopavo* ♂	DCP *M.* cf. *M. gallopavo* fossils	Coleman 2A *Meleagris* sp. ♀ fossils	modern *M. gallopavo* ♀
Coracoid	head through scapular facet	37.80 37.0-38.7 (7)	40.00 ± 1.74 35.3-43.1 (39)	34.46* 33.8*-35.12 (2)	31.40 31.0-31.8 (2)	31.08 ± 1.52 28.0-34.2 (32)
	depth of head	14.84 ± 0.49 14.2-15.8 (8)	15.60 ± 0.89 13.3-17.2 (40)	12.94 12.23-13.65 (2)	11.85 11.8-11.9 (2)	11.64 ± 0.84 10.0-13.8 (32)
Humerus	proximal width	36.83 33.6-37.8 (7)	40.19±1.52 36.0-43.2 (39)	37.2 - (1)	31.33* 30.1*-32.0 (3)	31.23 ± 1.36 28.2-34.1 (31)
Tarsometatarsus	least width of shaft	9.60 ± 0.48 9.1-10.5 (11)	9.26 ± 0.61 8.0-10.8 (45)	7.55 - (1)	8.0 - (1)	7.21 ± 0.44 6.3-8.2 (34)
Tibiotarsus	distal width	21.09 ± 0.47 20.3-21.6 (10)	21.66 ± 1.03 19.0-23.5 (39)	18.86 - (1)	17.88 17.0-18.8 (5)	17.12 ± 0.86 15.7-19.3 (28)
	depth of internal condyle	21.08 20.6-21.8 (6)	21.38 ± 1.10 18.1-23.1 (38)	15.65 - (1)	17.8* 17.2-18.7* (4)	17.00 ± 0.86 15.4-19.6 (28)
	depth of external condyle	18.95 ± 0.25 18.6-19.5 (12)	19.29 ± 0.74 17.0-20.4 (38)	17.24 - (1)	16.05 15.6-16.5 (2)	15.43 ± 0.66 14.2-17.3 (28)
Femur	distal width	28.70 28.2-29.4 (5)	29.38 ± 1.29 26.0-32.0 (40)	28.63 - (1)	23.7 - (1)	22.36 ± 1.23 20.0-25.0 (30)
	depth of internal condyle	23.56* 22.3*-24.7* (5)	24.45 ± 1.00 21.6-26.0 (38)	23.62 - (1)	21.2* - (1)	18.92 ± 0.80 17.8-21.4 (30)
	depth of external condyle	23.50 22.4-24.8 (7)	23.93 ± 0.98 21.4-25.5 (38)	23.42 - (1)	20.10 19.7-20.5 (2)	18.26 ± 0.83 16.9-20.6 (30)
	depth of fibular condyle	20.47 19.6-21.7 (6)	20.87 ± 0.90 19.0-22.5 (39)	19.55 - (1)	16.9* - (1)	15.90 ± 0.86 14.8-18.6 (30)

Figure 9. Pectoral and hindlimb elements of *Meleagris* from Dickerson Coquina Pit compared with modern specimens. Right proximal coracoid in dorsal aspect (A-C), right proximal humerus in anconal aspect (D-E), left distal femur in posterior aspect (F-G), and right distal ulna in medial aspect (H-I). A, D, F, H. *M. gallopavo*, UF 42955, modern ♂. B, C, E, G, I. *M.* cf. *M. gallopavo*, UF 274125, 274126, 274122l, 274106, 274161, fossils. Scale bar = 20 mm.

Order PROCELLARIIFORMES
Family DIOMEDEIDAE
Genus *Phoebastria* Reichenbach, 1853
***Phoebastria* cf. *P. albatrus* (Pallas, 1769)**
Table 2, Figure 12

Material.–Right partial coracoid, UF 274144; left proximal carpometacarpus, UF 274140.

Remarks.–The two albatross specimens from DCP most closely resemble those of the genus *Phoebastria*. The available species of "great albatrosses" (*Diomedea*) are much larger than the fossils from DCP. Olson and Rasmussen (2001) and others (Harrison and Walker, 1978; Dyke et al., 2007) have compared fossil albatrosses from

Figure 10. Additional forelimb and hindlimb elements of *Meleagris* from Dickerson Coquina Pit compared with modern specimens. Right proximal radius in palmar aspect (A, B), left distal tibiotarsus in anterior aspect (C-E), left tarsometatarsus in internal aspect (F-G), and pedal phalanges in dorsal aspect (H-K). A, C, F, H, J. *M. gallopavo*, modern ♂, UF 42955. B, D, E, G, I, K. *M.* cf. *M. gallopavo*, UF 274166, 274116, 274136, 274169, 274152, 274153, fossils. Scale bar = 20 mm.

across the North Atlantic and have generally based their diagnoses on the size of the specimens in addition to the osteological details of the humerus, tarsometatarsus, and other elements not recovered at DCP.

UF 274144 and 274140 are slightly larger than average modern *P. albatrus* in several respects, although the sample size for both carpometacarpi and coracoids is small (Table 2). UF 274140 is generally intermediate in size between the modern specimens of *P. albatrus* and a Pliocene fossil species (*P. anglica*) from Florida (Brodkorb,

1960; Olson and Rasmussen, 2001). We refer the specimens from DCP to *Phoebastria* cf. *P. albatrus* because of agreement in the length of the step in the sternal margin of extremitas sternalis, the curvature of the processus procoracoideus, and the positions of the foramen nervi supracoracoidei and impressio musculi sternocoracoidei.

Although albatrosses are rare vagrants in the North Atlantic today, they occur as fossils in Pliocene sites from Florida, North Carolina, and England (Olson and Rasmussen, 2001). The Pliocene taxa were closely related to extant albatrosses of the

Figure 11. The left humerus in palmar aspect (A, B), and right (C, D) and left (E) tarsometatarsus in acrotarsial aspect (C-E) of *Podilymbus podiceps* from Dickerson Coquina Pit compared with modern specimens. A, C. UF 22422, modern. B, D, E. UF 274130, 274165, 274168, fossils. Scale bar = 20 mm.
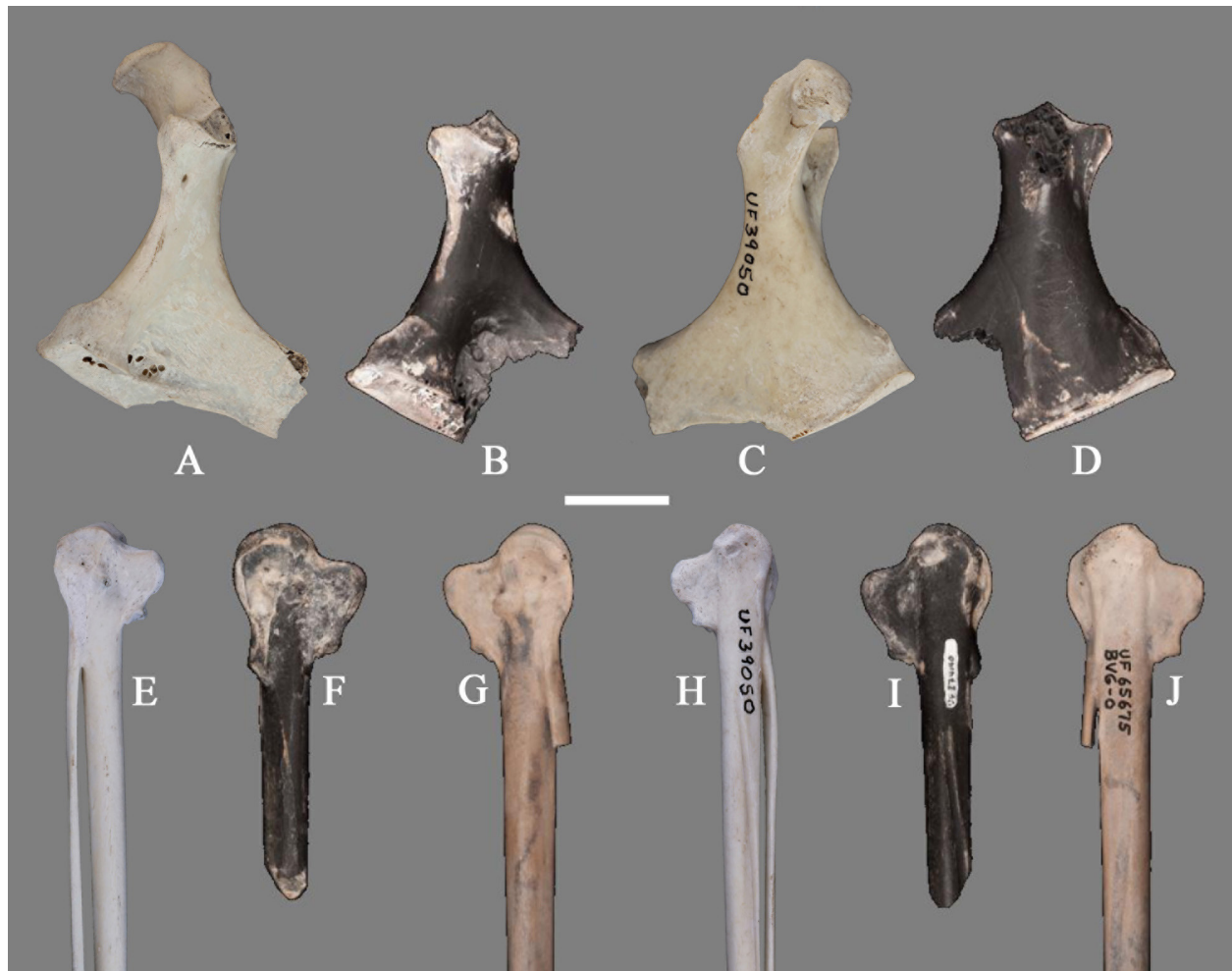
Figure 12. The right coracoid in dorsal (A, B) and ventral (C, D) aspects and the left carpometacarpus in medial (E-G) and lateral (H-J) aspects of *Phoebastria*. A, C, E, H. *P. albatrus* UF 39050, modern (composite). B, D. *Phoebastria* cf. *P. albatrus*, Dickerson Coquina Pit, UF 274144, fossil. F, I. *Phoebastria* cf. *P. albatrus*, Dickerson Coquina Pit, UF 274140, fossil. G, J. *P. anglica,* Bone Valley, Florida, UF 65765, fossil. Scale bar = 20 mm.

Table 2. Measurements (mm ± SD) of the carpometacarpus in *Phoebastria*.

Species	Proximal breadth	Proximal depth	Distance between bridge of metacarpal process and pollical facet	Minimum shaft depth
P. cf. *P. albatrus,* Dickerson Coquina Pit (UF 274140)	22.8	9.6	17.5	6.2
P. anglica, Bone Valley (UF 65765)	24.0	10.3	18.0	7.0
P. albatrus modern (n = 4)	20.7 ± 0.5	9.1 ± 0.3	15.2 ± 0.2	6.0 ± 0.5

genus *Phoebastria*, the three living species of which breed today in the North Pacific. The extant *P. albatrus* is threatened with extinction and now is restricted to a few islands in the northwestern Pacific Ocean. Nevertheless, *P. albatrus* nested in the middle Pleistocene on Bermuda (Olson and Hearty, 2003). A single, previously unreported carpometacarpus (UF 205745) from Cochran Shell Pit (Hendry County; Blancan NALMA?) is the only other possibly Pleistocene albatross fossil from Florida. There remains no evidence of naturally occurring *Diomedea* in the North Atlantic, past or present (AOU, 1998; Olson and Rasmussen, 2001).

Order CICONIIFORMES
Family CICONIIDAE
Genus *Ciconia* Brisson, 1760
Ciconia maltha Miller, 1910
Figure 13

Material.–Left distal radius, UF 274158; left proximal carpometacarpus, UF 274138; partial right distal tarsometatarsus, UF 274120; partial right distal tarsometatarsus, UF 274121.

Remarks.–These fossils resemble bones of living *Ciconia ciconia* but are much larger, approaching *Jabiru mycteria* in size. The fossils are also much larger than in the extinct *Mycteria wetmorei*, and the tarsometatarsus lacks the "abruptly flared" distal portion that is characteristic of species of *Mycteria* (Suárez and Olson, 2003). They compare well with *C. maltha* fossils (UF/PB 1234, UF 80433, UF 15708) from the Ichetucknee River and Leisey Shell Pit, Florida. While only the distal ends of the tarsometatarsi were preserved, UF 274121 has an "anteroposteriorly compressed" shaft and UF 274120 has a less posteriorly situated outer trochlea as noted by Suárez and Olson (2003). The foramen vasculare distale is rounded posteriorly and the muscle scars on the dorsal face are similar to those in other *C. maltha* specimens.

Order SULIFORMES
Family SULIDAE
Genus *Morus* Vieillot, 1816
Morus bassanus (Linnaeus, 1758)
Figure 14B

Material.–Right distal partial dentary, UF

273107.

Remarks.–This specimen agrees with that of living *Morus bassanus* rather than that of *Sula* spp. in its sharper crista tomialis and deeper medial groove. This is the first Pleistocene fossil of *M. bassanus* in Florida. Pleistocene specimens are known from Virginia (Spencer and Campbell, 1987) and possibly England (Seward et al., 2006). A Holocene specimen was found in the Summer Haven archaeological midden in Florida (Brodkorb, 1960). *Morus bassanus* winters commonly today in shallow water off Florida's Atlantic coast (Stevenson and Anderson, 1994), where dead, ill, or injured individuals regularly wash up on beaches (Kratter et al., 2002).

Family ANHINGIDAE
Genus *Anhinga* Brisson 1760
Anhinga anhinga (Linnaeus, 1766)
Figure 14D

Material.–Partial synsacrum, UF 274146.

Remarks.–This specimen agrees with the synsacrum of *Anhinga* rather than that of *Phalacrocorax* in its deeper sulcus ventralis synsacri and its more circular (less oblong) pairs of distal foramina. The size and shape of the fused synsacro-lumbar vertebrae and the recesses between the synsacro-caudal vertebrae are also characteristic. Another species of *Anhinga* from the early to late Pleistocene of Florida, *A. beckeri*, was much larger than *A. anhinga* (Emslie, 1998), as was the late Miocene *A. grandis* (Becker, 1987).

Family PHALACROCORACIDAE
Genus *Phalacrocorax* Brisson, 1780
Phalacrocorax cf. *P. auritus* (Lesson, 1831)
Figure 15B, 15F

Material.–Left proximal femur, UF 274117; left proximal tarsometatarsus, UF 274149.

Remarks.–These specimens resemble *Phalacrocorax auritus* in size (smaller than in *P. carbo*) but are too fragmentary and eroded for definitive identification or standard measurements.

Phalacrocorax carbo (Linnaeus, 1758)
Figure 15C

Material.–Left femur, UF 274118.

Figure 13. The left proximal carpometacarpus in dorsal aspect (A, B) and right distal tarsometatarsus in acrotarsial (C-F) and plantar (G-J) aspects of fossil storks (Ciconiidae). A. *Ciconia maltha*, Ichetucknee River, Florida, UF/PB 001234. B. *C. maltha*, Dickerson Coquina Pit, UF 274138, fossil. C, G. *C. maltha*, Leisey Shell Pit, Florida, UF 80433, fossil. D, H. *C. maltha,* Dickerson Coquina Pit, UF 274121, fossil. E, I. *C. maltha*, Dickerson Coquina Pit, UF 274120, fossil. F, J. *Mycteria wetmorei*, Ichetucknee River, Florida, UF 15594, fossil. Scale bar = 20 mm.

Remarks.–UF 274118 is identified as *Phalacrocorax carbo* by its large size and the relatively larger, more protrudent trochlea fibularis. The total length of UF 274118 is 63.23 mm, compared to 60.36-64.69 mm (N=3) in modern *P. carbo*, and 54.57-60.88 mm (N=4) in *P. auritus*. The distal width of UF 274118 is 19.01 mm, compared to 16.94-18.05 mm (N=3) in modern *P. carbo*, and 15.76-17.06 mm (N=4) in *P. auritus*. Unlike the Old World forms, the North American subspecies of Great Cormorant, *P. carbo carbo*, is strictly marine. It is common in and near its breeding colonies in the Canadian Maritime Provinces and northern New England (Erskine, 1972). Non-breeding individuals may range as far south as Florida (Stevenson and Anderson, 1994). The bird's pre-colonial distribution is not well known, although specimens have been recovered from the late Holocene in Florida at Lewis Camp Mound, Jefferson County (Kratt, 2005) and Shield's Mound, Duval County (Marrinan, 2005). Modern records of *P. carbo* in Florida increased in the 1970s coinciding with the gradual overall recovery of the species at that time. The femur from DCP is the first Pleistocene fossil of *Phalacrocorax carbo* from North America.
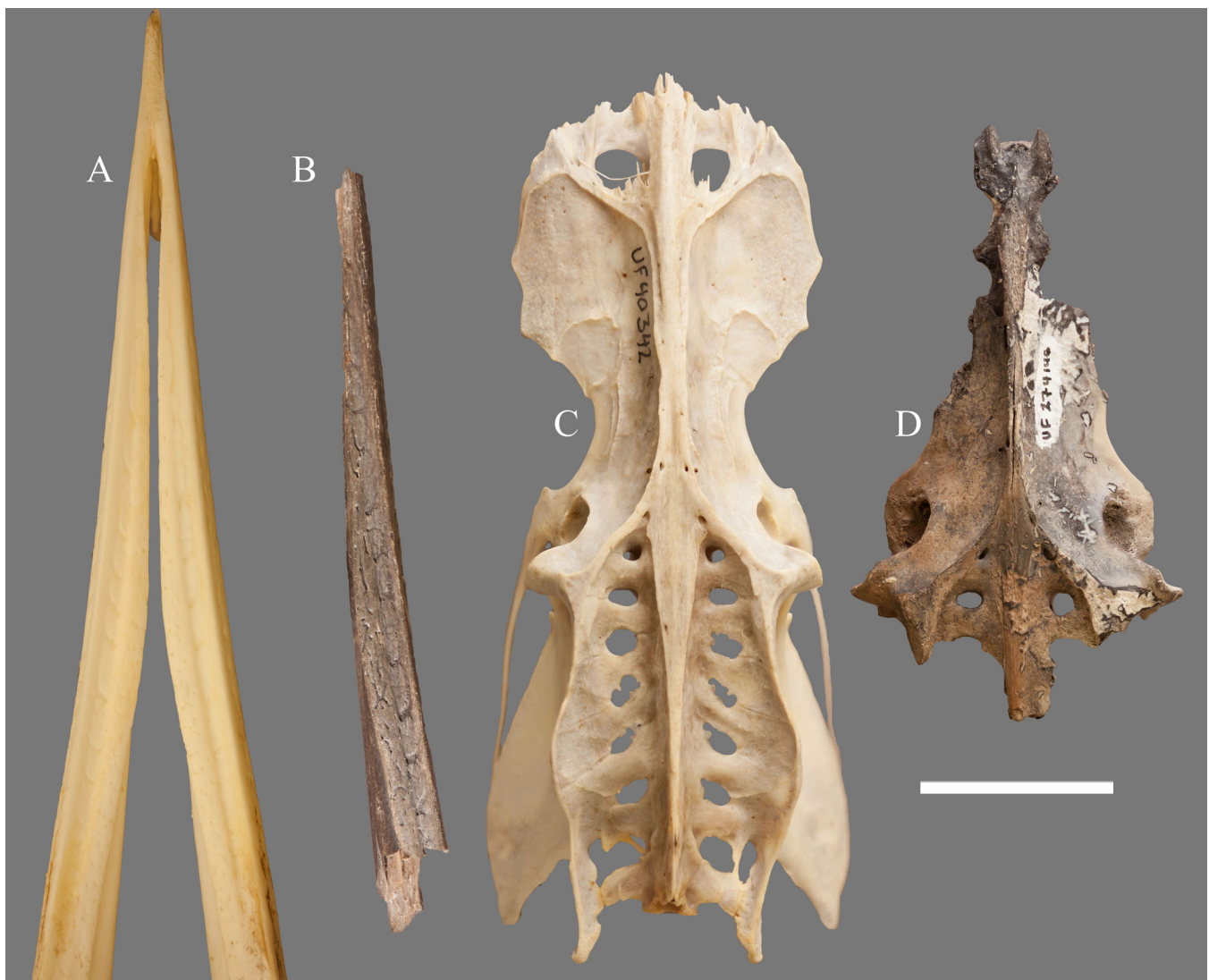

Figure 14. The right distal dentary in dorsal aspect (A, B) of *Morus bassanus* and the synsacrum in dorsal aspect (C, D) of *Anhinga anhinga* from Dickerson Coquina Pit compared with modern specimens. A. UF 42081, modern. B. UF 274107, fossil. C. UF 40342, modern. D. UF 274146, fossil. Scale bar = 20 mm.

Figure 15. Fossils of *Phalacrocorax* from Dickerson Coquina Pit compared with modern specimens. Left femur in anterior aspect (A-D), left proximal tarsometatarsus in acrotarsial aspect E, F), left distal ulna in dorsal aspect G, H), and left distal tibiotarsus in anterior aspect (I, J). A, E. *P. auritus*, UF 22806, modern. D, G, I. *P. carbo*, UF 22784, modern. B. *Phalacrocorax* cf. *P. auritus*, UF 274117, fossil. C. *P. carbo*, UF 274118, fossil. F. *Phalacrocorax* cf. *P. auritus*, UF 274149, fossil. H. *Phalacrocorax* sp., UF 274162, fossil. J. *Phalacrocorax* sp., UF 274115, fossil. Scale bar = 20 mm.

***Phalacrocorax* sp. (Linnaeus, 1758)**
Figure 15H, 15J

Material.–Left distal ulna, UF 274162; left distal tibiotarsus, UF 274115.

Remarks.–These fragmentary specimens are slightly smaller than modern specimens of *Phalacrocorax carbo* but larger than in *P. auritus*.

Order PELECANIFORMES
Family ARDEIDAE
Genus *Ardea* Linnaeus, 1758
***Ardea herodias* Linnaeus, 1758**
Figure 16B

Material.–Left distal tibiotarsus, UF 274108.

Remarks.–This specimen resembles the tibiotarsus of *Ardea herodias* in its large size. It is distinguished further from the smaller *A. alba* by its better defined crista fibularis and a relatively narrow pons supratendineus.

Genus *Nyctanassa* Stejneger, 1887
***Nyctanassa violacea* (Linnaeus, 1758)**
Figure 16D

Material.–Right partial quadrate, UF 274113.

Remarks.–We refer this specimen to *Nyctanassa violacea* rather than *Nycticorax nycticorax* because of the less concave lateral surface at the junction of processus oticus and processus orbitalis, and the more dorso-ventrally expanded lateral surface of the capitulum squamosum.

Family THRESKIORNITHIDAE
Genus *Eudocimus* Wagler, 1832
***Eudocimus albus* (Linnaeus, 1758)**
Figure 16F

Material.–Left humeral end of coracoid, UF 274133.

Remarks.–We identify this specimen as *Eudocimus* based on its intermediate size compared

Figure 16. Fossils of herons and ibises from Dickerson Coquina Pit compared with modern specimens. The left distal tibiotarsus in anterior aspect (A, B) of *Ardea herodias*. A. UF 23074, modern. B. UF 274108, fossil. The right quadrate in posterior aspect (C, D) of *Nyctanassa violacea*. C. UF 22983, modern. D. UF 274113, fossil. The left humeral coracoid in dorsal aspect (E, F) of *Eudocimus albus*. E. UF 23123, modern. F. UF 274133, fossil. Scale bar = 20 mm.

to the coracoid in *Plegadis* (smaller) or *Ajaia* (larger) as well as its slightly more concave facies articularis humeralis. Another early Pleistocene species, *E. leiseyi*, was smaller and more gracile than in modern specimens and that from DCP (Emslie, 1995a).

Order ACCIPITRIFORMES
Family ACCIPITRIDAE
Genus *Haliaeetus* Savigny, 1809
Haliaeetus leucocephalus (Linnaeus, 1766)
Figure 17B, 17D, and 17F

Material.–Right proximal scapula, UF 274164; digit IV, pedal phalanx 1, UF 274137; digit II, pedal phalanx 3 (ungual), UF 274468.

Remarks.–The large fossil scapula resembles that in *Haliaeetus* rather than in *Aquila* or *Buteogallus* by having the medial (costal) margin of the facies articularis perpendicular in anterior aspect (obtuse angle in others), and a smaller tuberculum coracoideum. The size of the scapula and ungual phalanx is closest to that of a male *H. leucocephalus*, whereas UF 294468, being relatively large, is likely from a female.

Genus *Buteo* Lacépède, 1799
Buteo lineatus (Gmelin, 1788)
Figure 17H, 17J

Material.–Left distal humerus, UF 274167; right distal tarsometatarsus, UF 274119.

Remarks.–The humerus agrees with that of *Buteo* in its relatively shallow (less concave) fossa musculo brachialis, and in its narrow processus supracondylaris in distal aspect. The tarsometatarsus agrees with that of *Buteo* in its small but deep fossa metatarsi I, and small tendinal groove on the disto-lateral surface of corpus humeri. Within *Buteo*, both UF 274167 and 274119 resemble *B. lineatus* in size and are smaller than in *B. jamaicensis*, *B. swainsonii*, *B. regalis*, and *B. lagopus* but larger than in *B. platypterus* or *B. brachyurus*.

Order GRUIFORMES
Family RALLIDAE
Genus *Rallus* Linnaeus, 1758
Rallus elegans Audubon, 1834
Figure 18B

Material.–Right humerus, UF 274142.

Remarks.–This humerus agrees with that of male *Rallus elegans* in size, being larger than female *R. elegans* or *R. longirostris* of either sex.

Genus *Fulica* Linnaeus, 1758
Fulica americana Gmelin, 1789
Figure 18D, 18F

Material.–Right distal ulna, UF 274163; right distal tibiotarsus, UF 274128.

Remarks.–The ulna agrees with that in *Fulica* rather than other North American genera of potentially similarly sized rails (*Rallus*, *Gallinula*, *Porphyrio*) in its elongated condylus dorsalis which joins corpus ulnae gradually rather than abruptly. UF 274128 is referred to *Fulica* based on characters summarized by Kirchman and Steadman (2006, 2007).

Family GRUIDAE
Genus *Grus* Brisson, 1760
Grus sp.
Table 3, Figure 19

Material.–Right distal tibiotarsus, UF 274132; pedal phalanx, UF 274157.

Remarks.–We compared UF 274132 to modern and fossil tibiotarsi of *Grus* from North America (Table 3). It is larger than in either extant North American species (*G. americana* and the smaller *G. canadensis*), but compares well to a distal tibiotarsus (UF 91223) from the Irvingtonian Shell Materials Pit. Emslie (1995a) recorded this large crane from the Shell Materials and Leisey Shell pits of Hillsborough County as *Grus* sp., and believed it to be closely related to or possibly even conspecific with *G. cubensis*. Regarded as flightless by its discoverers, *G. cubensis* lived in the late Pleistocene of Cuba (Fischer, 1968; Fischer and Stephan, 1971). If *G. cubensis* was flightless, the Florida specimens would unlikely be from this species. Because *G. cubensis* material was not available for direct comparison, we refrain from assigning a species name to the large species of *Grus* from DCP.

Compared to pedal phalanges of other large walking/wading birds (*Ardea*, *Ciconia*, *Jabiru*, and *Grus*), UF 274157 is most similar to that in *G. americana* in the relative width of the shaft, the

Figure 17. Fossils of hawks and eagles from Dickerson Coquina Pit compared with modern specimens. The right proximal scapula in dorsal aspect (A, B) and pedal phalanges in dorsal (C, D) and lateral (E, F) aspects of *Haliaeetus leucocephalus*. A, E. UF 23837, modern ♂. B. UF 274164, fossil. C. UF 23842, modern ♀. D. UF 274137, fossil. F. UF 274468, fossil. The left distal humerus in palmar aspect (G, H) and right distal tarsometatarsus in acrotarsial aspect (I, J) of *Buteo lineatus*. G, I. *B. lineatus*, modern ♀, UF 23893. H, J. UF 274167, 274119, fossils. Scale bar = 20 mm.

angular nature of the tuberculum, and the shape of the trochlea, although it is larger.

Order CHARADRIIFORMES
Family ALCIDAE
Genus *Pinguinus* Bonnaterre, 1791
***Pinguinus impennis* (Linnaeus, 1758)**
Figures 20–21

Material.–Right proximal scapula, UF 274102; right proximal humerus, UF 274101; left proximal ulna, UF 274104; left ulna, UF 274103; right ulna, UF 266756; right proximal radius, UF 274139; right proximal tibiotarsus, UF 274155.

Remarks.–These specimens correspond in all details to bones (nearly all major elements represented) of *Pinguinus impennis* from historic middens on Funk Island, Newfoundland, Canada

Figure 18. The right humerus of *Rallus elegans* in anconal aspect (A, B), and right distal tibiotarsus in anterior aspect (C, D) and right distal ulna in ventral aspect (E, F) aspect of *Fulica americana* from Dickerson Coquina Pit compared with modern specimens. A. UF 24313 (formerly PB 19078), modern. B. UF 274164/274142, fossil. C, E. UF 46733, modern. D. UF 274128, fossil. F. UF 274163, fossil. Scale bar = 20 mm.

(UF 25277, 25278, 33837). Two of the DCP fossils (UF 274103, 274104) have the porous surface characteristic of juvenile individuals. No modern radii of *P. impennis* were available for study; nevertheless, UF 274139 is less dorso-ventrally compressed than the radii of even the largest living species of alcids such as *Alca torda* and *Uria lomvia*, and is the correct length to match the ulna of *Pinguinis impennis*. The only available measurement of UF 274139 is 6.01+ mm for the width of the eroded distal end, which is roughly comparable to the distal width of 7.2 mm reported for the larger Pliocene species *Pinguinis alfrednewtoni* by Olson and Rasmussen (2001).

The Great Auk was the second most common avian taxon identified at DCP. Bones of *P. impennis*
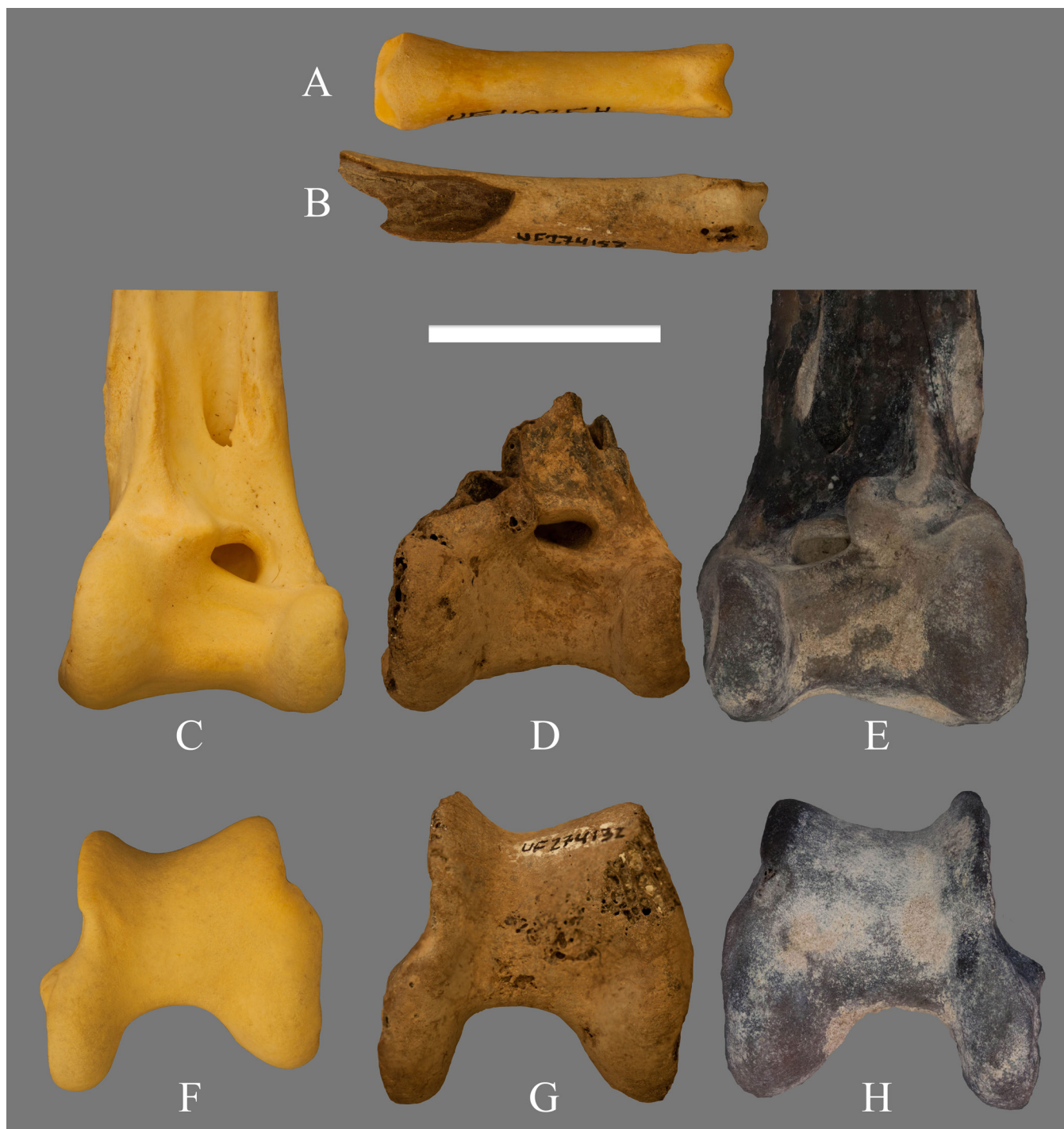
Figure 19. Pedal phalanx in plantar aspect (A, B) and right distal tibiotarsus in anterior (C-E) and distal (F-H) aspects of *Grus* from Dickerson Coquina Pit compared with modern specimens. A, C, F. *G. americana*, UF 40254, modern. B. *Grus* sp., UF 274157, fossil. D, G. *Grus* sp., UF 274132, fossil. E, H. *Grus* sp., Shell Materials Pit, Florida, UF 91223, fossil. Scale bar = 20 mm.

Table 3. Measurements (mm ± SD) of the distal tibiotarsus in *Grus*. Measurements of *G. cubanensis* from Fischer and Stephan (1971).

Species	Sex	Distal width	Medial condyle depth
DCP fossil (UF 274132)	—	25.6	26.1
Shell Materials fossil (UF 91223)	—	26.5	27.2
G. cubanensis fossils	—	27.0-32.0	25.6-31.0
G. americana (n = 8)	M	22.0 ± 0.5	20.7 ± 0.3
G. americana (n = 8)	F	21.1 ± 0.7	19.7 ± 0.8
G. canadensis (n = 8)	M	19.2 ± 0.8	18.3 ± 0.9
G. canadensis (n = 8)	F	18.6 ± 1.0	17.9 ± 0.8

have been recovered from at least five late Holocene archeological sites on the Atlantic coast of Florida: Cotton midden, Volusia County (Hay, 1902); the Castle Windy site, Volusia County (Weigel, 1958); Green Mound midden, Volusia County (Hamon, 1959); Summer Haven midden, St. Johns County (Brodkorb, 1960); and Boca Weir, Palm Beach County (Fradkin, 1980). While a fossil specimen has also been reported from the middle Pleistocene of Bermuda (Olson, 2003), the specimens from DCP are the first Pleistocene fossils of *P. impennis* from Florida. By the mid-nineteenth century, Great Auks had been hunted to extinction at their last breeding colonies on Funk Island, and on Eldey Island, Iceland (Meldgaard, 1988).

The presence of both adult and juvenile Great Auk fossils at DCP may indicate the presence of more southerly breeding colonies in the middle Pleistocene, although young individuals of *P. impennis* were at least moderately precocial and may have left their nesting areas shortly after hatching to join their parents at sea (Gaskell, 2004; Houston et al., 2010). Juvenile birds may have needed a number of months to complete skeletal development (Meldgaard, 1988). The presence of immature *P. impennis* specimens in the Holocene middens of Herriko Barra (northern Spain) further suggests that the young birds may have traveled hundreds of kilometers from their breeding areas before their bones were fully ossified (Stewart, 2002).

Another possible explanation for the Great Auk specimens at DCP is that they represent a die-off event caused by a storm that forced these individuals southward to Florida. For example, the unusual weather in the western Atlantic brought about by Hurricane Sandy (late October, 2012) may be what caused another large species of alcid, the Razorbill (*Alca torda*), to disperse well south of its normal winter range. In December 2012 and January 2013, hundreds of Razorbills were found emaciated or dead on the beaches along both Florida coasts (Pranty, 2013).

Order STRIGIFORMES
Family STRIGIDAE
Genus *Bubo* Duméril, 1805
***Bubo virginianus* (Gmelin, 1788)**
Figure 22B, 22D

Material.–Right distal tibiotarsus, UF 274111; right distal tarsometatarsus, UF 274147.

Remarks.–UF 27411 agrees with *Bubo virginianus* in having the external ligamental prominence located more proximally than in Florida's other large owl, *Strix varia*. UF 274147 also agrees with *B. virginianus* in having, in distal aspect, a much larger lateral flange on trochlea for digit III than in *S. varia*. Both of the fossils resemble bones of *B. virginianus* in size, being much larger than in the next regularly occurring owl in Florida, *S. varia*. The size of UF 274111 suggests a male of *B. virginianus*, whereas UF 274147 is closer in size to that of a female.

Figure 20. Right proximal humerus in anconal (A, B) and palmar (C, D) aspects, scapula in ventral (E, F) and dorsal (G, H) aspects, and right proximal tibiotarsus in anterior (I, J) and posterior (K, L) aspects of *Pinguinus impennis* from Dickerson Coquina Pit compared with modern specimens. A, C, E, G, I, K. UF 33837, modern. B, D. UF 274101, fossil. F, H. UF 274102, fossil. J, L. UF 274155, fossil. Scale bar = 20 mm.

Genus *Strix* Linnaeus, 1758
Strix varia Barton, 1799
Figure 22F

Material.–Right proximal femur, UF 274135.

Remarks.–This femur agrees in size with male *Strix varia*, being smaller than in *Bubo virginianus*. UF 274135 also resembles *Strix* rather than *Bubo* or *Asio* in having the area of impressions obturatoriae more bulbous in lateral aspect.

Order PSITTACIFORMES
Family PSITTACIDAE
Genus *Conuropsis* Salvadori, 1891
Conuropsis carolinensis (Linnaeus, 1758)
Figure 23

Material.–Left humerus missing distal end, UF 274112.

Remarks.–UF 274112 is a psittacid based on its relatively pointed caput humeri, deep depression

Figure 21. Ulna of *Pinguinus impennis* in anconal (A-C) and palmar (D-F) aspects from Dickerson Coquina Pit compared with modern specimens. A, D. UF 33837, modern. B, E. UF 266756, fossil (mirror image). C, F. UF 274103, fossil (juvenile). Scale bar = 20 mm.

Figure 22. Right distal tibiotarsus in anterior aspect (A, B) and right distal tarsometatarsus in acrotarsial aspect (C, D) aspect of *Bubo virginianus* and right proximal femur in anterior aspect (E, F) of *Strix varia* from Dickerson Coquina Pit compared with modern specimens. A. UF 40631, modern ♂. B. UF 274111, fossil. C. UF 40642, modern ♀. D. UF 274147, fossil. E. UF 40369, modern. F. UF 274135, fossil. Scale bar = 20 mm.

just distal to turberculum dorsale, parallel fossae pneumotricipitalis, and round cross-section of corpus humeri. While no osteological material of the extinct, medium-sized *Conuropsis carolinensis* was available, the fossil specimen (midshaft width 3.93 mm, midshaft depth 3.51 mm) is identical in shape and proportions to the drawings by Shufeldt (1886), shown in Figure 23.

Few prehistoric records of North America's only parakeet exist. Parmalee (1958, 1967) identified several bones of *C. carolinensis* from archeological sites in central Illinois. Three bones also were found at an Amerindian burial site in southwestern Ontario (Prevec, 1984). A fossil parrot humerus from the Miocene of Nebraska was included in the genus *Conuropsis* by Wetmore (1926), although the validity of this generic placement is questionable (Olson, 1985).

The specimen from HI is the earliest record of *Conuropsis carolinensis* and the first known pre-Holocene fossil. Historically, *C. carolinensis* lived mostly in the southern United States along the Gulf of Mexico from Texas to Florida to the Carolinas, as well as north and west along major waterways. Last seen in St. Lucie County sometime in the 1880s (McKinley, 1985), the species became extinct in the 1920s or 1930s (Snyder and Russell, 2002).
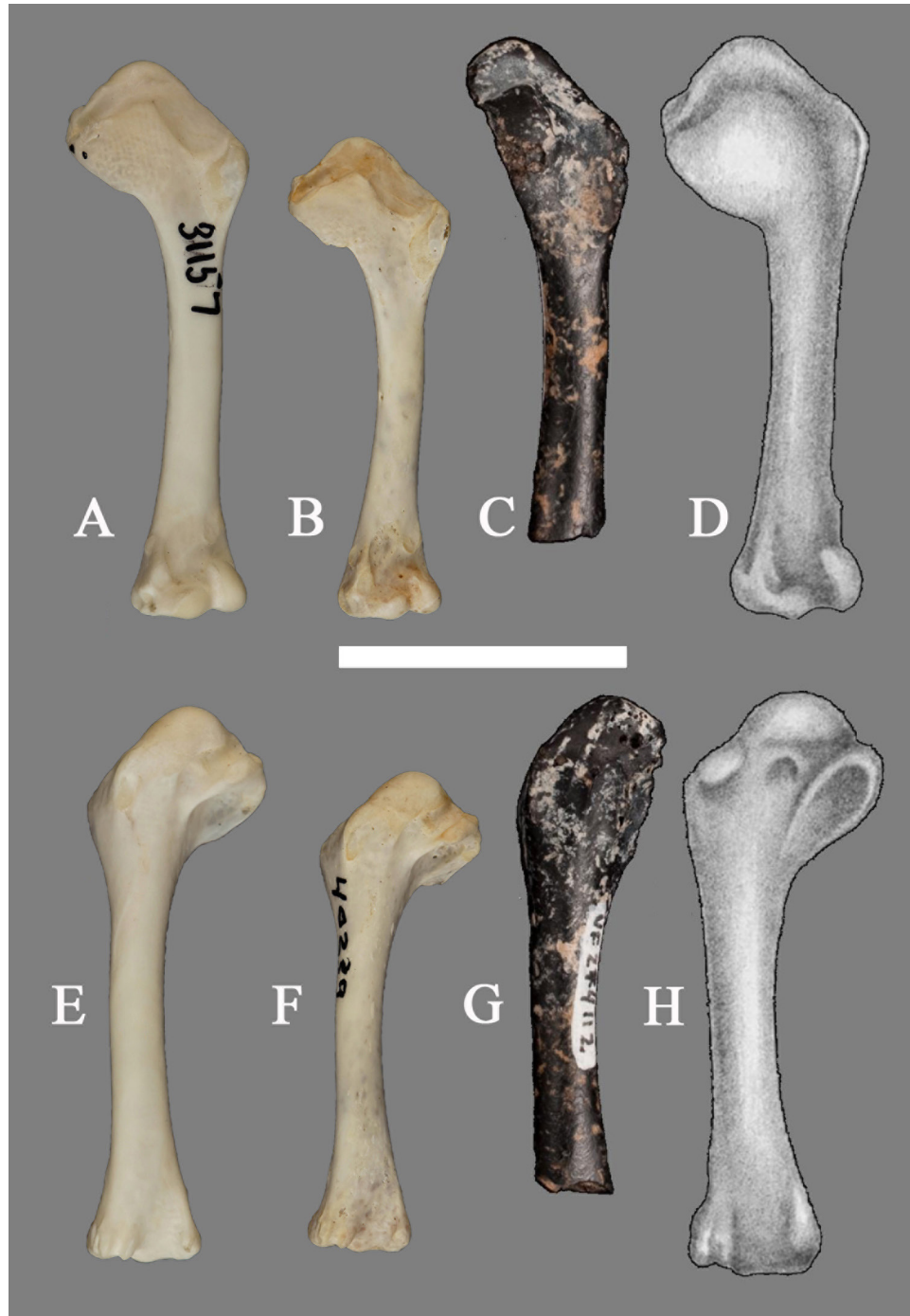

Figure 23. Left humerus of parakeets in palmar (A-D) and anconal (E-H) aspects. A, E. *Nandayus nenday*, UF 26047 (formerly PB 31157), modern. B, F. *Aratinga solstitialis*, UF 25934 (formerly PB 40238), modern. C, G. *Conuropsis carolinensis,* Dickerson Coquina Pit, UF 274112, fossil. D, H. *C. carolinensis,* modern, adapted from illustration in Shufelt (1886). Scale bar = 20 mm.

DISCUSSION

The composite avifauna of the DCP and HI sites is based on 65 individual fossils representing 12 orders, 16 families, and 26 species (Table 4). Two genera (*Pinguinus*, *Conuropsis*) and four of the species (*Ciconia maltha, Grus* sp., *Pinguinus impennis, Conuropsis carolinensis*) are extinct. In two families (Diomedeidae, Psittacidae), indigenous species no longer occur in Florida.

The DCP locality was likely an open embayment with several stream mouths nearby during fossil deposition, a situation akin to that of other shell beds with vertebrate fossils in South Florida (Pratt and Hulbert, 1995; Emslie, 1995a; Emslie, 1998). The remains of species such as *Aix sponsa, Meleagris* cf. *M. gallopavo, Buteo lineatus, Bubo virginianus, Strix varia,* and *Conuropsis carolinensis* may have been transported to DCP from nearby woodlands and riparian areas. Some of the mammals found at the site, such as the llama *Paleolama mirifica* and horse *Equus* sp., suggest that prairies or grasslands existed nearby, as would the crane *Grus* sp. and stork *Ciconia maltha*, the last two also inhabiting marshes

Over one-half (15 of 26) of the species represented at DCP are freshwater and/or estuarine species that still exist in Florida. Dabbling ducks (*Anas* spp.) and coots (*Fulica americana*) prefer shallow bodies of fresh water with emergent vegetation during most of the year. They also use coastal bays, lagoons, and other brackish habitats during winter (Brisbin et al., 2002). The diving ducks recovered at DCP (*Aythya collaris* and especially *Bucephala clangula*) are typically found in somewhat deeper waters (<5 m deep) where they feed on underwater vegetation or small mollusks and crustaceans (Eadie et al., 1995; Roy et al., 2012).

Aside from coots and the various ducks, the assemblage from DCP features wading birds (e.g., *Ardea herodias, Nyctanassa violacea, Eudocimus albus*) that feed on invertebrates and small vertebrates in shallow water and muddy areas. *Rallus elegans* inhabits shallow freshwater and brackish marshes with abundant plant cover (Pickens and Meanley, 2015). While the living

North American stork (*Mycteria americana*) feeds almost exclusively in aquatic habitats, *C. maltha* may have foraged occupied open uplands in addition to aquatic habitats (Steadman and Martin, 1984, Suárez and Olson, 2003).

The Double-crested Cormorant (*Phalacrocorax auritus*) forages in fresh water or in shallow (<8 m deep) salt water within sight of the shoreline (Hatch and Weseloh, 2014), whereas Great Cormorants (*P. carbo*) forage deeper (<20 m deep), sometimes up to 30 km from shore (Hatch et al., 2000). *Anhinga anhinga* prefers shallow, sheltered waters with nearby drying and sunning perches, such as bays, lagoons, lakes, and tidal and freshwater streams (Frederick and Siegel-Caussey, 2000). We note here, however, that habitat preferences of aquatic and shallow-water marine birds can vary even through short intervals of time. For example, the Brown Pelican (*Pelecanus occidentalis*) was considered strictly marine until about two decades ago when it began to colonize inland freshwater lakes in Florida (Paul and Hodgson, 2015).

Bones of seabirds such as *Phoebastria* cf. *P. albatrus*, *Morus bassanus,* and *Pinguinus impennis* could have been deposited at DCP by storm overwash. Such fossils may represent stray individuals that became sick and/or malnourished and washed ashore, which occurs regularly today among seabirds along Florida's Atlantic coast (Kratter and Steadman, 2003; Kratter and Small, 2007). The presence at DCP of northern, nearshore, and marine taxa such as *Bucephala clangula, Phalacrocorax carbo,* and *Pinguinus impennis*, may indicate that sea surface temperatures were cooler at the time of fossil emplacement than at present. Cyclical cold and warm climatic variations are well known from even within the last glacial cycle (Heinrich, 1988; Dansgaard et al., 1993; NGRIP members, 2004).

Nevertheless, the species of birds present at a fossil site such as DCP may not unfailingly reflect the species that were regularly present in the area. Knowing that most fossil assemblages are death assemblages (thanatocenoses) rather than life assemblages (biocenoses), we must consider

Table 4. Birds identified from the Dickerson Coquina Pit (DCP) and from beach fill derived from DCP on North Hutchinson Island (HI), St. Lucie County, Florida. Current status in Florida categories: E, extinct; e, extralocal; V, vagrant; MI, migrant; R, resident; W, widespread. Generalized habitat categories: A, aquatic (fresh or brackish water); MA, marine; T, terrestrial (non-aquatic). Taxa in brackets are not necessarily different from ones identified with greater precision.

FAMILY Species	DCP	HI	Current status	Habitat
ANATIDAE				
Aix sponsa (Wood Duck)	—	2	R, W	A
Anas cf. *americana* (probable American Wigeon)	—	1	MI, W	A
Anas cf. *A. platyrhynchos* or *A. rubripes* (probable Mallard or Black Duck)	4	1	R, W	A
Anas discors (Blue-winged Teal)	—	1	MI, W	A
Aythya collaris (Ring-necked Duck)	1	2	MI, W	A
Bucephala clangula (Common Goldeneye)	2	—	MI	A, MA
PHASIANIDAE				
Meleagris cf. *M. gallopavo* (transitional Wild Turkey)	3	8	R, W	T
PODICIPEDIDAE				
Podilymbus podiceps (Pied-billed Grebe)	—	3	R, W	A
DIOMEDEIDAE				
Phoebastria cf. *P. albatrus* (albatross)	1	1	e	MA
CICONIIDAE				
Ciconia maltha (large stork)	1	3	E	T, A
SULIDAE				
Morus bassanus (Northern Gannet)	1	—	MI, W	MA
PHALACROCORACIDAE				
Phalacrocorax cf. *P. auritus* (probable Double-crested Cormorant)	1	1	R, W	A
Phalacrocorax carbo (Great Cormorant)	—	1	V	A, MA
[*Phalacrocorax* sp. (cormorant)]	—	2	V	A, MA
ANHINGIDAE				
Anhinga anhinga (Anhinga)	1	—	R, W	A
ARDEIDAE				
Ardea herodias (Great Blue Heron)	1	—	R, W	A
Nyctanassa violacea (Yellow-crowned Night-Heron)	v	1	R, W	A
THRESKIORNITHIDAE				
Eudocimus albus (White Ibis)	1	—	R, W	A
ACCIPITRIDAE				
Haliaeetus leucocephalus (Bald Eagle)	—	3	R, W	A
Buteo lineatus (Red-shouldered Hawk)	—	2	R, W	T

Table 4. Continued.

FAMILY Species	DCP	HI	Current status	Habitat
RALLIDAE				
Rallus elegans (King Rail)	1	—	R, W	A
Fulica americana (American Coot)	1	1	R, W	A
GRUIDAE				
Grus sp. (large crane)	1	1	E	A
ALCIDAE				
Pinguinus impennis (Great Auk)	5	2	E	MA
STRIGIDAE				
Bubo virginianus (Great Horned Owl)	1	1	R, W	T
Strix varia (Barred Owl)	—	1	R, W	T
PSITTACIDAE				
Conuropsis carolinensis (Carolina Parakeet)	—	1	E	T

that individual aquatic and marine birds occurring outside of their normal range may have high mortality rates and thus be more likely to end up in a bone deposit (Jehl, 1996; Kratter and Steadman, 2003). A late Pliocene assemblage from western Florida contained hundreds of individuals of a single species of cormorant that likely died from a series of toxic red tides (Emslie, 1995b; Emslie et al., 1996). We also note that *Phalacrocorax carbo* and *Pinguinus impennis* specimens have been recovered in Holocene shell mounds when conditions were only slightly colder than at present (see their accounts above).

CONCLUSIONS

Fossils from the Dickerson Coquina Pit provide new insight into the late Irvingtonian avifauna of Florida's Atlantic Coast. These specimens portray a coastal wetland bird community similar in some regard (common presence of ducks, cormorants, herons, coots, etc.) to those seen in the area today, but with a strong component of extinct and extralocal species. Although some of the marine species have possible northern affinities, none of the fossils represents the species with western or tropical influences that were especially characteristic of earlier (Blancan, early Irvingtonian) Plio-Pleistocene localities in Florida (Morgan and Emslie, 2010).

Only a handful of terrestrial vertebrate localities have been identified from the Okeechobee Formation or from the late Irvingtonian of Eastern Florida (i.e., on or near the Atlantic Coast). While the avifauna from Dickerson Coquina Pit was not thoroughly sampled when collecting was possible, a surprising number of species from disparate habitats is represented. The fossils of truly marine species, such as the Great Auk (*Pinguinus impennis*), Northern Gannet (*Morus bassanus*), and Short-tailed Albatross (*Phoebastria* cf. *P. albatrus*), likely werw derived from diseased or malnourished individuals that washed ashore, as happens fairly routinely on Florida's Atlantic coast today (Kratter and Steadman, 2003; Kratter and Small, 2007). Bones of upland species, such as the turkey *Meleagris* cf. *M. gallopavo*, extinct stork *Ciconia maltha*, extinct large crane *Grus* sp., Red-shouldered Hawk *Buteo lineatus*, and extinct Carolina Parakeet *Conuropsis carolinensis*, may have been washed into the deposit by a freshwater stream. The other species from Dickerson Coquina Pit inhabited the tidal streams, marshes, and shallow embayments that typify the depositional environment of the site.

ACKNOWLEDGMENTS

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