CHONDRICHTHYES AND OSTEICHTHYES FROM THE EARLY PLEISTOCENE LEISEY SHELL PIT LOCAL FAUNA, HILLSBOROUGH COUNTY, FLORIDA

Sylvia J. Scudder[1], Erika H. Simons[2], and Gary S. Morgan[3]

ABSTRACT

The early Pleistocene (early Irvingtonian) Leisey Shell Pit ichthyofauna was recovered from two large commercial shell pits located less than 1 kilometer inland from Tampa Bay in Hillsborough County, Florida. The combined fish fauna from the two Leisey sites is composed of 73 species, including 23 species of sharks and rays and 50 species of bony fish. This is the largest fish fauna ever reported from the Cenozoic of Florida, and includes 34 taxa that represent new additions to the fossil record of the state. There are four extinct taxa in the fauna, all of which are Chondrichthyes: the mako shark *Isurus hastalis*, the nurse shark *Ginglymostoma serra*, the snaggletooth shark *Hemipristis serra*, and the guitarfish *Rhynchobatus* sp. The genera *Hemipristis* and *Rhynchobatus* are now restricted to the Indo-West Pacific region. The two sites comprising the Leisey Shell Pit Local Fauna, Leisey 1A and Leisey 3A, have somewhat different faunas. The most common fish from Leisey 1A in decreasing order of abundance are: alligator gar *Atractosteus spatula*; snook *Centropomus* sp.; mullet *Mugil* sp.; bull shark *Carcharhinus leucas*; and eagle ray *Myliobatis* sp. These species, as well as the majority of the remaining fauna, suggest a shallow marine or estuarine environment such as a coastal bay or mouth of a large river. In contrast, the Leisey 3A ichthyofauna is dominated by the freshwater sunfish family Centrarchidae, in particular, redear sunfish *Lepomis microlophus*, largemouth bass *Micropterus salmoides*, and redbreast sunfish *L. auritus*. Other common fish from Leisey 3A are found in freshwater habitats as well, including: *Mugil* sp.; freshwater catfish of the family Ictaluridae; bowfin *Amia calva*; lake chubsucker *Erimyzon sucetta*; killifish *Fundulus seminolis*, golden shiner *Notemigonus crysoleucas*; and pickerel *Esox* sp. The fish fauna from Leisey 3A is indicative of a low gradient freshwater habitat such as a large stream or river, probably well inland from its mouth. With only a few exceptions, the faunas from both Leisey sites are typical of modern Florida Gulf Coast fish communities. The Leisey ichthyofauna bears witness to the stability of Florida's aquatic environments on a paleontological time scale, and offers a baseline from which to view the rapidly changing community structure of today's coastal habitats.

[1] Ms. Scudder is a Senior Biologist in Zooarchaeology, Department of Anthropology, Florida Museum of Natural History, P. O. Box 117800, Gainesville FL 32611-7800, U.S.A..

[2] Ms. Simons is a Biologist in Vertebrate Paleontology, Department of Natural Sciences, Florida Museum of Natural History, P. O. Box 117800, Gainesville FL 32611-7800, U.S.A.

[3] Mr. Morgan is a Paleontologist at the New Mexico Museum of Natural History, 1801 Mountain Road N.W. Albuquerque NM 87104-1375, U.S.A. (formerly a Senior Biologist in Vertebrate Paleontology, Department of Natural Sciences, Florida Museum of Natural History).

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RESUMEN

Desde dos minas de conchuelas comerciales localizadas a menos de 1 km al interior de la Bahía de Tampa en el Condado de Hillsborough, Florida, se colectaron muestras de ictiofauna de la Excavación de Conchuelas de Leisey pertenecientes al Pleistoceno temprano (Irvingtoniano temprano). La fauna de peces combinada de los dos sitios de Leisey está compuesta por 72 especies, incluyendo 22 especies de tiburones y rayas y 50 especies de peces teleósteos. Esta es la fauna de peces más grande hasta ahora reportada para el Cenozoico de Florida, e incluye 34 taxa que son nuevas adiciones para el registro de fósiles del estado. Cuatro taxa de las representadas están extinctas, siendo todas peces Condroícteos: el tiburón mako *Isurus hastalis*, tiburón gata *Ginglymostoma serra*, tiburón sobrediente *Hemipristis serra* y el pez guitarra *Rhynchobatus* sp. Los géneros *Hemipristis* y *Rhynchobatus* se encuentran hoy restringidos a la Región Indopacífica Oriente. Las áreas Leisey 1A y Leisey 3A que componen la fauna local de la Excavación de Conchuelas de Leisey, albergan faunas algo diferentes. Los peces más comunes en Leisey 1A en orden de abundancia decreciente son: alligator gar *Atractosteus spatula*; róbalo *Centropomus* sp.; lisa *Mugil* sp.; tiburón cabeza de batea *Carcharhinus leucas*; y raya *Myliobatis* sp. Estas species, así como la mayoría de la fauna restante, sugieren la presencia de un ambiente marino de poca profundidad o estuarino tales como el de una bahía o la desembocadura de un gran rio. Por el contrario, la ictiofauna de Leisey 3A esta dominada por peces de agua dulce pertenecientes a la familia Centrarchidae, en particular por redear sunfish *Lepomis microlophus*, perca *Micropterus salmoides*, y redbreast sunfish *L. auritus*. Otros peces comunes en Leisey 3A tambien se encuentran en habitats de agua dulce incluyendo: *Mugil* sp.; siluros de agua dulce pertenecientes a la familia Ictaluridae; bowfin *Amia calva*; lake chubsucker *Erimyzon sucetta*; killifish *Fundulus seminolis*, golden shiner *Notemigonus crysoleucas*; y barracuda *Esox* sp. La fauna de peces de Leisey 3A es indicativa de un habitat de agua dulce con una gradiente pequeña, tal como la de una gran corriente o rio, probablemente bastante tierra adentro desde la desembocadura. Con sólo algunas excepciones, las faunas de los dos sitios de Leisey son típicas de comunidades modernas de peces de la Costa del Golfo de Florida. Desde una escala temporal paleontológica, la ictiofauna de Leisey da testimonio de la estabilidad de los ambientes acuáticos de Florida y ofrece una base desde donde es posible observar un rápido cambio de estructura de las comunidades de los habitas costeros de hoy.

INTRODUCTION

There are numerous faunal and taxonomic studies on late Pliocene and Pleistocene mammals, birds, reptiles, and amphibians from Florida. Yet no single comprehensive faunal analysis has ever been published on Florida fossil fish from this same time interval. A Master's Thesis on the fossil sharks of Florida (Tessman 1969) is the only thorough taxonomic study of a major group of Florida fossil fish, and that review concentrated on Miocene and early Pliocene sharks. Several taxa of marine fish have been described from Eocene and Oligocene limestones in the Florida panhandle (Gregory 1930; Conrad 1941; Dunkle and Olsen 1959; Swift and Elwood 1972). Caldwell (1958) reported incisiform teeth of three genera of sparids from the late Miocene Haile 6A Local Fauna (LF) in Alachua County. Webb and Tessman (1968) described the ichthyofauna from the late Miocene Manatee County Dam LF in Manatee County, consisting of ten species of sharks, three species of rays, and two species

of bony fish. Webb et al. (1981) listed 5 species of sharks and 11 species of bony fish from the late Miocene Love Bone Bed in Alachua County.

The paucity of published studies on Florida Cenozoic fish is by no means a reflection of their rarity in the fossil record. On the contrary, with the exception of terrestrially-derived cave and fissure deposits, most fossil vertebrate sites in Florida from the Eocene to the Pleistocene contain at least some identifiable fish remains, usually isolated skeletal elements. Some sites, especially those that sample freshwater, estuarine, or nearshore marine depositional environments, have extremely rich and well preserved ichthyofaunas. Literally thousands of unidentified fish fossils from more than 100 Cenozoic sites throughout Florida await study.

Initially our analysis of the fish fauna from the Leisey Shell Pit was undertaken to provide an indication of the paleoenvironment present at the time of deposition. Fish are often sensitive indicators of specific aquatic environments, and thus we suspected that the species composition of the ichthyofaunas from the various Leisey Shell Pit sites would provide an insight into the various freshwater, estuarine, and nearshore marine environments represented. This focus on the aquatic component of the site adds breadth to the concurrent analyses of the various groups of terrestrial vertebrates in the Leisey fauna. Further study of the Leisey fossil fish has permitted us to examine other interesting aspects of this fauna as well, including biogeographic changes, morphological differences between closely related taxa from the early Pleistocene and the Recent, and possible chronologic indicators.

The ichthyofauna from the Leisey Shell Pit is composed of 73 species, including 23 species of sharks and rays and 50 species of bony fish (Table 1). Based on a recently published checklist of the fossil vertebrates of Florida (Hulbert 1992), the Leisey fauna contains 34 taxa of fish never before reported from the Cenozoic of Florida. The fossil fish discussed in this paper were collected from two different sites in the Leisey Shell Pit, located about 7 km southwest of Ruskin and 1 km inland from Tampa Bay in Hillsborough County, Florida. These two sites, designated Leisey 1A and Leisey 3A by Hulbert and Morgan (1989), are less than 1 km apart and occur in two large commercial shell pits owned by the Leisey Shell Corporation. Because Leisey 1A and 3A are located in close proximity, occur at approximately the same stratigraphic level, and possess similar mammalian faunas, they were combined into the Leisey Shell Pit Local Fauna by Hulbert and Morgan (1989). The predominantly marine shell beds of the Leisey Shell Pit, as well as the thin, interbedded, organic layers containing the majority of the vertebrate fossils, have been placed in the Bermont Formation and assigned an early Pleistocene age (late early Irvingtonian Land Mammal Age) based on the biochronology of the land mammals (Morgan and Hulbert this volume). Maps, coordinates, stratigraphic sections, and other information on the individual Leisey Shell Pit sites are provided by Hulbert and Morgan (1989) and Morgan and Hulbert (this volume).

Table 1. Faunal list of rays, sharks, and bony fish from the Leisey Shell Pit Local Fauna, Hillsborough County, Florida. The presence (X) or absence (–) of each species in the two major sites comprising this fauna, Leisey Shell Pit 1A and 3A, is indicated in columns 1 and 2, respectively. Several species on this list are not found in Tables 2-5 (e.g. *Isurus hastalis*) because Table 1 includes the entire identified sample from Leisey 1A and 3A, while Tables 2-5 are quantitative samples comprising subsets of the Leisey 1A (Tables 2-4) and 3A faunas (Table 5). Column 3 indicates the generalized habitat preference(s) for each taxon, listed in order of most common occurrence. Abbreviations are freshwater (F), estuarine or brackish (E), and marine (M).

	Leisey 1A	Leisey 3A	Habitat
Chondrichthyes			
Rajiformes			
Rhynchobatidae			
+**Rhynchobatus* sp.[1]	X	X	M
Pristidae			
Pristis sp.	X	–	M
Myliobatiformes			
Dasyatidae			
Dasyatis-2 spp.	X	X	M,E,F
Myliobatidae			
**Aetobatus narinari*	X	X	M,E
Myliobatis sp.	X	X	M,E
**Rhinoptera bonasus*	X	X	M,E
Orectolobiformes			
Ginglymostomatidae			
Ginglymostoma cirratum	X	X	M
+*Ginglymostoma serra*[1]	X	–	M
Lamniformes			
Odontaspididae			
Odontaspis taurus	X	X	M
Lamnidae			
Carcharodon carcharias	X	X	M
+*Isurus hastalis*[1]	X	X[2]	M
**Isurus oxyrhincus*		X[2]	M
Carcharhiniformes			
Hemigaleidae			
+*Hemipristis serra*[1]	X	X[2]	M
Carcharhinidae			
Carcharhinus acronotus	X	X	M
Carcharhinus leucas	X	X	M,E,F
Carcharhinus limbatus	X	X	M,E
Carcharhinus obscurus	X	–	M
Carcharhinus plumbeus	X	X	M,E
Galeocerdo cuvier	X	X	M,E
Negaprion brevirostris	X	X	M,E
Rhizoprionodon terraenovae	X	X	M,E
Sphyrnidae			
**Sphyrna mokarran*	–	X[2]	M

Table 1 Continued

Osteichthyes			
Semionotiformes			
Lepisosteidae			
Atractosteus spatula	X	X	E,M,F
**Lepisosteus* cf. *L. oculatus*[3]	X	–	F,E
**Lepisosteus osseus*	X	–	F,E,M
Lepisosteus sp.	–	X	
Amiiformes			
Amiidae			
Amia calva	–	X	F
Elopiformes			
Elopidae			
**Elops saurus*	X	X	E,M,F
Megalops atlanticus	X	–	E,M,F
Anguilliformes			
Anguillidae			
**Anguilla rostrata*	X	X	F,E,M
Clupeiformes			
Clupeidae			
genus and species indet.	X	X	
Salmoniformes			
Esocidae			
Esox sp.	–	X	F
Cypriniformes			
Cyprinidae			
**Notemigonus crysoleucas*	–	X	F
Catostomidae			
**Erimyzon* cf. *E. sucetta*	–	X	F
Siluriformes			
Ariidae			
Arius felis[4]	X	–	M,E,F
**Bagre marinus*[4]	X	–	M,E
Ictaluridae			
**Ameiurus natalis*	–	X	F
**Ameiurus nebulosus*	–	X	F
genus and species indet.	X	–	
Batrachoidiformes			
Batrachoididae			
**Opsanus* sp.	–	X	M
Atheriniformes			
Atherinidae			
*cf. *Menidia* sp.	–	X	M,E,F
Cyprinodontidae			
**Cyprinodon variegatus*	X	–	M,E,F
*cf. *Floridichthys* sp.	X	–	M,E
**Fundulus* cf. *F. grandis*	X	–	M,E,F
**Fundulus seminolis*	X	X	F
**Fundulus majalis*	–	X	M,E
Exocoetidae			
*cf. *Hyporhamphus* sp.	–	X	M,E

Table 1 Continued

Perciformes			
Carangidae			
Caranx hippos	X	X	M,E,F
*cf. *Trachinotus* sp.	–	X	M,E
Centrarchidae			
**Lepomis* cf. *L. auritus*	–	X	F
Lepomis gulosus	–	X	F
**Lepomis microlophus*	X	X	F,E
Micropterus salmoides	X	X	F
Pomoxis nigromaculatus	–	X	F
Centropomidae			
Centropomus sp.	X	X	E,M,F
Ephippidae			
Chaetodipterus faber	X	–	M,E
Labridae			
**Lachnolaimus maximus*	X	–	M
Mugilidae			
Mugil sp.	X	X	M,E,F
Percichthyidae			
*cf. *Morone* sp.	–	X	M,E,F
Sciaenidae			
**Bairdiella* cf. *B. chrysoura*[4]	X	X	M,E
**Cynoscion* cf. *C. nebulosus*	X	X	M,E
**Micropogonias undulatus*[3]	–	X	M,E
Pogonias cromis	X	X	M,E
**Sciaenops ocellatus*	X	–	M,E,F
Sparidae			
Archosargus probatocephalus	X	X	M,E
**Calamus* sp.	–	X	M
Lagodon rhomboides	X	–	M,E
Sphyraenidae			
Sphyraena barracuda	X	X	M,E
Triglidae			
Prionotus sp.	X	X	M,E
Pleuronectiformes			
*Bothidae			
genus and species indet.	–	X	
Tetraodontiformes			
Balistidae			
Balistes sp.	X	–	M
Diodontidae			
**Chilomycterus schoepfi*	X	–	M
Diodon sp.	X	–	M
genus and species indet.	–	X	
Ostraciidae			
Lactophrys sp.	X	–	M

+ Extinct species.
* New to the fossil record of Florida.
[1] Possibly reworked from underlying Miocene Arcadia Formation (see text).
[2] Collected from Leisey Shell Pit 3.
[3] This specimen most closely resembles *L. oculatus*, although modern records do not record it from this area.
[4] Identified only from otoliths.

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MATERIALS AND METHODS

For the most current taxonomic nomenclature of Recent Osteichthyes and Chondrichthyes, we follow Robins et al. (1991). Names for extinct taxa, all of which are sharks and rays, follow Cappetta (1987). Information on habitat preferences for the modern species of fish discussed in the text and listed in Table 1 were obtained from a variety of sources, including Hoese and Moore (1977), McLane (1978a, b), Lee et al. (1980), Robins et al. (1986), Loftus and Kushlan (1987), Wolfe (1990), and Page and Burr (1991).

Because the majority of Late Cenozoic sharks, rays, and bony fish from Florida are referable to modern genera and even to extant species in many cases, the most important resource for study of the Florida fossil ichthyofauna is a comparative osteological collection of Recent fish. We were most fortunate to have access to the comparative collections of the Zooarchaeological Laboratory of the Florida Museum of Natural History (FLMNH), which houses one of the most complete skeletal collections of modern fish from Florida and the Caribbean region. The fossil cranial elements and vertebrae of bony fish identified from the two Leisey sites, as well as the teeth of most rays and sharks, show remarkable anatomical similarity to modern comparative specimens. The unidentified portion of the sample was problematic more in terms of fragmentation and damage to the diagnostic elements than in lack of modern species with which to compare them.

Osteichthyian bones from Leisey were identified using standard zooarchaeological techniques. Fossil bones were compared with modern identified skeletons from the FLMNH Zooarchaeology Collection. Identifications were made to the lowest possible taxon. Minimum numbers of individuals (MNI) were calculated using the most abundant paired elements, in combination with size (age) differences. MNI was calculated only for family, genus, and species level identifications, not the broader taxonomic categories. To prevent duplication of MNI values when there were several more specific categories within a larger taxon (i.e. genus or family), only individuals that numbered more than the sum of the other taxa were counted.

The number of identifiable specimens (NISP) was also counted for all taxa of Osteichthyes and Chondrichthyes. Although NISP is a useful method of quantification, caution must be used in analyzing these data. As discussed below, it is extremely difficult to calculate MNI for sharks and rays, and thus NISP provides the only overall indicator of abundance for these groups. The most accurate indicator of relative abundance for bony fish is MNI, owing to the differential preservation of certain skeletal elements. For example, Table 2 shows a total of 10,656 skeletal elements for the gar family Lepisosteidae from Leisey 1A (93.5% of all bony fish specimens identified). Included in this, however, are 8,048 scales (70.6% of the total NISP from Leisey 1A). Based on MNI, calculated from paired cranial elements, gar comprise only 38% of the

Leisey osteichthyian fauna. With the exception of a few large scales of the tarpon *Megalops atlanticus*, the fragile scales of other bony fish are not present in the Leisey sample, and thus the dense, ganoid scales of gar provide a tremendous overrepresentation for this family based on NISP.

Teeth and other fossil elements (vertebrae, dermal denticles, tail spines, etc.) of Chondrichthyes (sharks and rays) were identified using comparative material from both the Zooarchaeology Laboratory and Vertebrate Paleontology Collection of the FLMNH, as well as appropriate literature sources (e.g. Bigelow and Schroeder 1948, 1953; Tessman 1969; Compagno 1984; Cappetta 1987). MNI was not calculated for sharks and rays because of the difficulty in establishing the exact tooth position within the upper and lower jaws. Furthermore, sharks continually replace their teeth throughout life and dasyatid and myliobatid rays regularly replace their tail spines.

The fish faunas from Leisey 1A and Leisey 3A cannot be compared quantitatively because they were sampled using somewhat different methods. The larger bones and teeth were collected in the field using standard excavating techniques. In addition, sediments from both Leisey sites were screenwashed for microvertebrates using a 6.35 mm (¼ inch) screen and a standard 1.7 mm (1/16 inch) window screen. A sample of 120 kg (dry weight) of sediment from Leisey 1A was washed through a 1.0 mm brass screen. The amount of matrix processed from the two sites differed somewhat. Because Leisey 3A was very rich in terrestrial and freshwater microvertebrates, we screenwashed over 1 metric ton of matrix from this site. Leisey 1A had a much less diverse small vertebrate fauna, and as a consequence we screenwashed less than a metric ton.

The two Leisey sites also differed in their areal extent. Leisey 1A was a much larger site consisting of more than 200 quadrants, each approximately 4 m^2, whereas Leisey 3A included less than 50 4 m^2 quadrants. The analyzed sample from Leisey 1A summarized in Tables 2 and 3 is a subset of the total fish fauna from this site consisting of 72 quadrants covering nearly 280 m^2 (quadrants A1-A21, B1-B21, C1-C21, D1-D9). The Leisey 1A sample includes 120 kg of sediment from quadrant D9 that was washed through both a 1.7 mm window screen and a 1.0 mm brass screen. The analyzed sample from Leisey 3A summarized in Table 5 includes material from only 2 quadrants (E1 and F1), but most of the sediment from both quadrants was window-screened totalling more than 200 kg.

We also obtained a complete sample of fish remains from one of the 4 m^2 quadrants (D9) at Leisey 1A. All sediments excavated from the approximately 15 cm-thick vertebrate fossil-bearing layer in quadrant D9 (120 kg) were screenwashed. The combined sample of fish fossils excavated in the field and those removed from the washed matrix were identified to the lowest possible taxon (Table 4).

The fine-screened matrix from both Leisey sites, primarily the window screen fraction, enriched the faunal list by adding taxa not encountered in the

Table 2. Identified sample of Osteichthyes from Leisey Shell Pit 1A. Both the number of identifiable specimens (NISP) and minimum number of individuals (MNI) were calculated for each taxon. This sample is a subset of the total bony fish fauna from Leisey 1A consisting of the fossils from 72 quadrants (A1-A21, B1-B21, C1-C21, D1-D9), including 120 kg of fine-screened sediment (1.7 mm and 1.0 mm mesh) from quadrant D9.

Taxon	NISP	% Total NISP	MNI	% Total MNI
Atractosteus spatula	8940	78.37	76	16.56
Lepisosteus sp.	8	0.07	1	0.22
Lepisosteidae	1708	14.97	97	21.13
Elops saurus	2	0.02	1	0.22
cf. *Elops* sp.	1	0.01	1	0.22
Megalops atlanticus	5	0.04	5	1.09
Anguilla rostrata	8	0.07	1	0.22
Clupeidae	11	0.10	1	0.22
Arius felis	2	0.02	2	0.44
Bagre marinus	1	0.01	1	0.22
Ariidae	1	0.01	1	0.22
Ictaluridae	19	0.17	12	2.61
Siluriformes	2	0.02	–	–
Fundulus cf. *F. grandis*	5	0.04	2	0.44
Fundulus seminolis	28	0.25	11	2.40
Fundulus sp.	24	0.21	–	–
cf. *Fundulus* sp.	1	0.01	–	–
cf. *Floridichthys* sp.	1	0.01	1	0.22
Cyprinodon variegatus	5	0.04	1	0.22
cf. *Cyprinodon* sp.	5	0.04	–	–
Cyprinodontidae	37	0.32	–	–
Caranx hippos	4	0.04	4	0.87
Lepomis microlophus	13	0.11	6	1.31
Lepomis sp.	6	0.05	3	0.65
Micropterus salmoides	3	0.03	3	0.65
Centrarchidae	7	0.06	3	0.65
Centropomus sp.	299	2.62	95	20.70
Chaetodipterus faber	1	0.01	1	0.22
Labridae	1	0.01	1	0.22
Mugil sp.	164	1.44	68	14.81
Sphyraena sp.	3	0.03	1	0.22
Prionotus sp.	1	0.01	1	0.22
Bairdiella sp.	2	0.02	1	0.22
Pogonias cromis	39	0.34	18	3.92
Sciaenops ocellatus	1	0.01	1	0.22
Sciaenidae	6	0.05	6	1.32
Archosargus probatocephalus	7	0.06	4	0.87
Chilomycterus schoepfi	4	0.04	4	0.87
Diodon sp.	29	0.25	23	5.01
Diodontidae	1	0.01	1	0.22
Lactophrys sp.	2	0.02	1	0.22
Total	11407		459	

Table 3. Identified sample of Chondrichthyes from Leisey Shell Pit 1A. The number of identifiable specimens (NISP) was calculated for each taxon. This sample is a subset of the total shark and ray fauna from Leisey 1A consisting of the fossils from 72 quadrants (A1-A21, B1-B21, C1-C21, D1-D9), including 120 kg of fine-screened (1.7 mm and 1.0 mm mesh) sediment from quadrant D9.

Taxon	NISP	% Total NISP
Rhynchobatus sp.	3	0.6
Dasyatis spp.[1]	20	3.9
Myliobatis sp.	109	21.3
Myliobatiformes	38	7.4
Ginglymostoma serra	2	0.4
Odontaspis taurus	5	1.0
Carcharodon carcharias	20	3.9
Hemipristis serra	1	0.2
Carcharhinus spp.[2]	273	53.4
Galeocerdo cuvier	4	0.8
Negaprion brevirostris	30	5.9
Rhizoprionodon terraenovae	6	1.2
TOTAL	511	

[1] Includes at least two species of *Dasyatis*.
[2] Includes four species of *Carcharhinus* (*C. acronotus*, *C. leucas*, *C. limbatus*, and *C. plumbeus*). Because of the difficulty in separating many teeth of this genus, all *Carcharhinus* teeth have been lumped. However, the great majority (>90%) of all *Carcharhinus* teeth from Leisey 1A belong to the bull shark, *C. leucas*.

coarse fraction or in field excavations. Some of these fish are represented primarily by small individuals of species that reach a maximum length of 30 cm or more, e.g. *Anguilla rostrata*, Bothidae, *Erimyzon sucetta*, and *Notemigonus crysoleucas*. Several small species with maximum lengths less than 15 cm were also identified. Best represented among the smaller fish are several members of the speciose family Cyprinodontidae, including three genera and four species. The average maximum length for these fishes is 10 cm. Most of the fish recovered from the fine screen fraction were identified from their vertebrae.

Three species of killifish, genus *Fundulus*, are represented in the Leisey sample by vertebrae, hyomandibulars, premaxillaries, dentaries, and pharyngeal grinders. The pharyngeal grinders proved particularly helpful in identification to the species level. A problem arose with the identification of *Fundulus* cf. *F. grandis*. Morphological characters of *F. grandis* and *F. heteroclitus* are so similar that identification to the species level was based on distribution. *F.*

Table 4. Identified sample of Chondrichthyes and Osteichthyes from Square D-9, Leisey Shell Pit 1A. MNI was not calculated for sharks and rays (see discussion in text). This sample quantifies all identifiable hard parts for rays, sharks, and bony fish recovered from 120 kg of sediments removed from an approximately 2 m X 2 m quadrant. All sediment was washed through a set of three nested screens consisting of 1/4 inch hardware cloth (6.35 mm) screen, standard 1/16 inch (1.7 mm) window screen, and 24 mesh (1 mm) brass screen.

Taxon	NISP	% Total NISP	MNI	% Total MNI
Chondrichthyes				
Rhynchobatus sp.	3	0.42	–	–
Dasyatis sp.	20	2.81	–	–
Myliobatis sp.	7	0.98	–	–
Myliobatiformes	3	0.42	–	–
Ginglymostoma serra	2	0.28	–	–
Carcharhinus acronotus	2	0.28	–	–
Carcharhinus leucas	5	0.70	–	–
Carcharhinus limbatus	2	0.28	–	–
Carcharhinus plumbeus	1	0.14	–	–
Carcharhinus sp.	6	0.84	–	–
Carcharhinidae	20	2.81	–	–
Negaprion brevirostris	1	0.14	–	–
Rhizoprionodon terraenovae	6	0.84	–	–
Osteichthyes				
Atractosteus spatula	329	46.21	2	4.4
Lepisosteus sp.	8	1.12	1	2.2
Lepisosteidae	107	15.03	–	–
Elops saurus	2	0.28	1	2.2
cf. *Elops* sp.	1	0.14	–	–
Anguilla rostrata	8	1.12	1	2.2
Clupeidae	11	1.54	1	2.2
Ictaluridae	1	0.14	1	2.2
Arius felis	2	0.28	2	4.4
Bagre marinus	1	0.14	1	2.2
Fundulus cf. *F. grandis*	5	0.70	2	4.4
Fundulus seminolis	28	3.93	11	24.4
Fundulus sp.	24	3.37	–	–
cf. *Fundulus* sp.	1	0.14	–	–
cf. *Floridichthys* sp.	1	0.14	1	2.2
Cyprinodon variegatus	5	0.70	2	4.4
cf. *Cyprinodon* sp.	5	0.70	–	–
Cyprinodontidae	37	5.20	–	–
Lepomis microlophus	7	0.98	3	6.7
Lepomis sp.	2	0.28	–	–
Centrarchidae	4	0.56	–	–
Centropomus sp.	6	0.84	3	6.7
Mugil sp.	9	1.26	5	11.1
Bairdiella sp.	2	0.28	2	4.4
Pogonias cromis	17	2.39	1	2.2
Archosargus probatocephalus	3	0.42	1	2.2
Sparidae	1	0.14	–	–
cf. Sparidae	1	0.14	–	–

Table 4 Continued.

Taxon	NISP	% Total NISP	MNI	% Total MNI
Sphyraena sp.	3	0.42	1	2.2
Prionotus sp.	1	0.14	1	2.2
Diodontidae	1	0.14	1	2.2
Lactophrys sp.	1	0.14	1	2.2
Total	712		45	

heteroclitus is found schooling with *F. grandis* where their ranges overlap on the northern Atlantic Coast of Florida, whereas only *F. grandis* occurs in the Gulf of Mexico. Relyea (1983) suggested that *F. similis* and *F. majalis* are conspecific, with *F. majalis* having nomenclatural priority. *F. seminolis* was identified from its distinctive lower pharyngeal grinders and basioccipital. Two other cyprinodontids, *Cyprinodon variegatus* and cf. *Floridichthys* sp. were identified primarily from upper and lower pharyngeal grinders.

LEISEY SHELL PIT ICHTHYOFAUNA

Leisey Shell Pit 1A.– There were 30 families of fish identified from Leisey 1A, including 4 families of rays, 5 families of sharks, and 21 families of bony fish (Table 1). Within these families, 43 taxa were identified further to the genus level, and 28 of these were refined to the species level. The total quantitative sample of bony fish from 72 quadrants consisted of 11,402 identified bones and teeth, yielding a total MNI value of 454 (Table 2). Approximately 10% of this material was identifiable only as Osteichthyes.

The most abundant osteichthyian family in the Leisey 1A Site is the Lepisosteidae, the gar fishes, comprising 37.9% of the total sample MNI. *Atractosteus spatula*, the alligator gar, was unquestionably identified by its heavily textured, thickly enameled scales. The presence of *A. spatula* at Leisey is an interesting biogeographic anomaly since this species of gar no longer occurs in the Florida peninsula. The extant species of gar occurring in the Tampa Bay area include two members of the genus *Lepisosteus*, *L. osseus*, the longnose gar, and *L. platyrhincus*, the Florida gar. Scales of *L. osseus* have a slightly textured upper surface which, in water-worn specimens, could be confused with *A. spatula*. Scales of *L. platyrhincus* are smooth. A problem arose in the

Table 5. Identified sample of Osteichthyes from Leisey Shell Pit 3A. Both the number of identifiable specimens (NISP) and minimum number of individuals (MNI) were calculated for each taxon. This sample includes material from only 2 quadrants (E1 and F1), but most of the sediment from both quadrants was window-screened (1.7 mm) totalling approximately 200 kg.

Taxon	NISP	% Total NISP	MNI	% Total MNI
Atractosteus spatula	20	2.73	1	1.28
Lepisosteidae	107	14.62	1	1.28
Amia calva	42	5.74	2	2.56
Elops saurus	2	0.27	1	1.28
Anguilla rostrata	2	0.27	1	1.28
Clupeidae	25	3.42	1	1.28
Esox sp.	1	0.14	1	1.28
cf. *Erimyzon* sp.	25	3.42	2	2.56
Notemigonus crysoleucas	12	1.64	1	1.28
Ameiurus natalis	1	0.14	1	1.28
Ameiurus nebulosus	3	0.41	2	2.56
Ictaluridae	10	1.37	–	–
cf. *Menidia* sp.	3	0.41	1	1.28
Fundulus seminolis	2	0.27	2	2.56
Fundulus majalis	2	0.27	1	1.28
cf. *Fundulus* sp.	12	1.64	–	–
Cyprinodontidae	4	0.55	1	1.28
cf. *Hyporhamphus* sp.	4	0.55	1	1.28
Carangidae	1	0.14	1	1.28
Lepomis cf. *L. auritus*	8	1.09	4	5.13
Lepomis gulosus	6	0.82	2	2.56
Lepomis microlophus	104	14.21	18	23.08
Lepomis sp.	50	6.83	–	–
Micropterus salmoides	8	1.09	5	6.41
Pomoxis nigromaculatus	2	0.27	1	1.28
Centrarchidae	160	21.86	–	–
Centropomus sp.	3	0.41	2	2.56
Mugil sp.	47	6.42	16	20.51
cf. *Morone* sp.	1	0.14	1	1.28
cf. *Cynoscion* sp.	2	0.27	1	1.28
Pogonias cromis	45	6.15	2	2.56
Archosargus probatocephalus	2	0.27	1	1.28
Calamus sp.	1	0.14	1	1.28
Sparidae	2	0.27	–	–
Bothidae	10	1.37	1	1.28
Diodontidae	4	0.55	2	2.56
Total	733		78	

distinction between *Atractosteus* and *Lepisosteus* cranial elements due to the lack of a complete comparative specimen of *Atractosteus* in the FLMNH collections. Photographs of cranial elements in Wiley (1976) were used in some cases, but many elements were identified only as Lepisosteidae.

The second most abundant genus of bony fish in this sample is the snook *Centropomus* (95 MNI, 20.7%). Following snook in abundance are the mullet *Mugil* (68 MNI, 14.8%) and the porcupinefish *Diodon* (23 MNI, 5.0%). Most cranial elements of *Mugil* are quite thin and delicate, preserving poorly even in archaeological sites. The two major exceptions are the articulating portion of the operculum and the hyomandibular. The vertebrae of mullet preserve well, and the cervicals are very diagnostic at the generic level. None of the preserved elements of *Mugil* allowed identification to the species level. Three species of *Mugil* are known from Florida. The fantail mullet *M. gyrans* is uncommon in the vicinity of Tampa Bay, but its presence cannot be ruled out due to the lack of comparative material in the FLMNH collections. The other two species of *Mugil*, *M. curema* and *M. cephalus*, especially the latter, are extremely common on the modern Gulf Coast and comparative specimens of these two species closely match the fossil material. The Leisey fossils do not compare well with modern specimens of the mountain mullet, *Agonostomus monticola*, a fourth species of Mugilidae found in peninsular Florida. The family Diodontidae, including the porcupinefishes (*Diodon*) and the burrfishes (*Chilomycterus*) comprise 6.1% of the Leisey 1A sample. Both genera possess highly ossified and fused dentaries and premaxillae for crushing invertebrate prey. The premaxillae of *Chilomycterus* are slightly more beaked or pointed that those of *Diodon*, but the dentaries, especially if incompletely preserved, are extremely difficult to differentiate.

Less abundant species include the black drum *Pogonias cromis* (18 MNI, 3.9%), freshwater catfishes of the family Ictaluridae (12 MNI, 2.6%), the redear sunfish *Lepomis microlophus* (6 MNI, 1.3%), and the drum family Sciaenidae (6 MNI, 1.3%). Five individuals of the tarpon *Megalops atlanticus* were identified (1.1%), primarily from their very large, sturdy scales. Fewer numbers of 14 other taxa of bony fish identified from Leisey 1A are listed in Table 2.

Table 3 provides a complete identified sample of cartilaginous fish from 72 quadrants in the Leisey 1A site. Teeth of the shark genus *Carcharhinus* comprise over half (NISP 273, 53.4%) of the total identified sample of Chondrichthyes from Leisey 1A. Four species of *Carcharhinus*, including *C. acronotus*, *C. leucas*, *C. limbatus*, and *C. plumbeus*, were identified from this sample. The great majority of the *Carcharhinus* teeth present (>90%) belong to the bull shark, *C. leucas*, a common inhabitant of nearshore marine and estuarine waters along the Florida Gulf Coast. After *Carcharhinus*, the next most abundant cartilaginous fish is the eagle ray *Myliobatis*, based on isolated teeth comprising 21.3% (NISP 109) of the total identified sample. Following these two genera in decreasing order of abundance are the lemon shark *Negaprion brevirostris* (NISP 30, 5.9%), the stingray *Dasyatis* (NISP 20, 3.9%), and the

great white shark *Carcharodon carcharias* (NISP 20, 3.9%). The great white shark is generally considered a pelagic species; however, its relative abundance at Leisey (more than 100 teeth in the entire sample) in what is clearly a shallow marine or estuarine depositional environment suggests that this large shark was taking prey that occurred in shallow nearshore waters.

At least two species of *Dasyatis* and four species of *Carcharhinus* have been lumped together at the generic level in Table 3. Taking this into account, the quantified sample from Leisey 1A includes 15 of the 21 species of cartilaginous fish identified from the Leisey Shell Pit LF. As with the bony fish fauna, the diversity of the chondrichthyian fauna was significantly enhanced by screen-washing. Taxa added to the Leisey list through screening were the rays *Rhynchobatus* and *Dasyatis*, and three species of sharks, the Atlantic sharpnose shark *Rhizoprionodon terraenovae*, the blacknose shark *Carcharhinus acronotus*, and the blacktip shark *C. limbatus*.

Leisey Shell Pit 3A.– Three families of rays, five families of sharks, and 23 families of bony fish were identified from Leisey 3A, including 43 genera and 35 species. A total of 732 bone and ossified cartilage fragments were identified and 78 MNI calculated (Table 5). This MNI calculation reflects only the bony fishes.

In contrast to Leisey 1A, the two quadrants of Leisey 3A analyzed (quadrants E1 and F1) were dominated by the family Centrarchidae, the freshwater sunfishes, which comprised 38.5% of the total MNI of Osteichthyes. This percentage includes 18 individuals of *Lepomis microlophus* (23.1% of total MNI), 4 *L. auritus*, the redbreast sunfish (5.1%), 3 *L. gulosus*, the warmouth (2.6%), 5 *Micropterus salmoides*, the largemouth bass (6.4%), and 1 black crappie *Pomoxis nigromaculatus* (1.3%). The enlarged upper and lower pharyngeal grinders of *L. microlophus* are unmistakable, and the Leisey 3A sample includes a broad size range of individuals, some of much greater dimensions than any modern specimens available (at least in the FLMNH collection).

After *Lepomis microlophus*, the second most abundant taxon is *Mugil* representing 20.5% of the total MNI (16 individuals). The bowfin *Amia calva*, the lake chubsucker *Erimyzon sucetta*, the brown bullhead *Ameiurus nebulosus*, the seminole killifish *Fundulus seminolis*, *Centropomus* sp., *Pogonias cromis*, Sparidae, and Diodontidae each comprise 2.6% of the total MNI. Osteological differences were too slight to distinguish *Erimyzon sucetta* from the spotted sucker *Minytrema melanops*. Because *Minytrema* does not presently occur in the Florida peninsula, and probably never has, the Leisey 3A catostomid is tentatively identified as *Erimyzon*. However, a range extension of the spotted sucker into peninsular Florida during the Pleistocene must be considered a possibility. The golden shiner *Notemigonus crysoleucas* occurred only in Leisey 3A and was identified almost exclusively from its brancheal teeth (teeth of the first brancheostegal or gill arch). Table 5 lists all taxa identified from the two quadrants at Leisey 3A, including the 14 taxa at 1% or less of total MNI.

AGE OF THE LEISEY FISH FAUNA

The age of the Leisey Shell Pit and other Florida Pleistocene vertebrate sites is primarily determined by comparison of their land mammal faunas to the North American land mammal biochronology. Based on the land mammal faunas from Leisey 1A and 3A, the Leisey Shell Pit LF is securely placed in the early Irvingtonian Land Mammal Age (early Pleistocene) between approximately 1.5 and 1.0 Ma in age (Morgan and Hulbert this volume). At present there is no biochronology for Late Cenozoic Chondrichthyes and Osteichthyes in North America. Nonetheless, four species of sharks, one species of ray, and one bony fish from the Leisey Shell Pit LF provide some information relating to the age of the site.

The most common fish in Leisey 1A is the alligator gar *Atractosteus spatula*. This species no longer occurs in the Florida peninsula; the closest living populations are in the western half of the Florida panhandle. Despite its current absence from peninsular Florida, *A. spatula* is common in many Pliocene and early Pleistocene vertebrate sites in the southern half of the state, including (in addition to Leisey): the early Pliocene (late Hemphillian) Palmetto Fauna from the Bone Valley Formation in Polk County; the late Pliocene (late Blancan) Macasphalt Shell Pit LF in Sarasota County; St. Petersburg Times LF in Pinellas County; Kissimmee River LF in Okeechobee County; and Brighton Canal LF in Highlands County; and the latest Pliocene (earliest Irvingtonian) De Soto Shell Pit LF in De Soto County. The youngest peninsular record of *A. spatula* is in the middle Pleistocene (early Rancholabrean) Oldsmar LF in Pinellas County along the central Gulf Coast. The alligator gar apparently disappeared from the Florida peninsula sometime during or after the middle Pleistocene.

Three species of extinct sharks have been identified from Leisey, *Hemipristis serra*, *Isurus hastalis*, and *Ginglymostoma serra*. The genus *Hemipristis* no longer occurs in the Atlantic Ocean. The only living species of *Hemipristis*, *H. elongatus*, is found in tropical waters of the Indo-West Pacific region. *H. serra* and *I. hastalis* are relatively common in Florida Miocene and early Pliocene deposits, but neither has been previously reported from the late Pliocene or Pleistocene in the state (Tessman 1969). The Florida fossil record of the extinct nurse shark, *Ginglymostoma serra*, consists of a few teeth from the early Pliocene unit of the Bone Valley Formation in Polk County just east of Hillsborough County (Tessman 1969). Because Miocene beds of the Arcadia Formation underlie the Bermont Formation in the Leisey Shell Pit (see Morgan and Hulbert this volume), it is possible that the teeth of these three extinct sharks were reworked into the early Pleistocene Bermont Formation. However, two *Hemipristis serra* teeth from Leisey 1A and one from Leisey 3B, a small site very close to Leisey 3A, were collected in place, are in excellent condition, and have the same state of preservation as the rest of the shark teeth from this unit. These factors argue against the reworking hypothesis, as most of the Miocene shark

teeth from Leisey are waterworn and have a different color of preservation. The only two teeth of *Isurus hastalis* identified from Leisey, one each from Leisey 1A and 3B, both have broken roots and are waterworn, and thus reworking from the underlying Miocene sediments must be considered a distinct possibility. The age of the two teeth of *Ginglymostoma serra* from Leisey 1A is equivocal since this species is so rare in Florida. The extant nurse shark, *G. cirratum*, also occurs at Leisey 1A.

Teeth of the extinct guitarfish *Rhynchobatus* sp. are frequently encountered in Florida Cenozoic deposits ranging in age from late Oligocene to early Pleistocene; however, this genus has yet to be reported from Florida. Several isolated teeth of *Rhynchobatus* from both Leisey 1A and 3A represent the youngest record of this genus from Florida. As with the extinct sharks mentioned above, reworking from the underlying Miocene beds must be considered a possibility. Cappetta (1987) listed *Rhynchobatus* from the Eocene through the Miocene from various Old World localities, but did not mention the presence of this genus in the New World. Living species of *Rhynchobatus* are currently restricted to the Indo-West Pacific region.

Teeth of the living great white shark, *Carcharodon carcharias*, are fairly common at Leisey, comprising about 4% of the total number of chondrichthyian teeth from Leisey 1A (Table 3). This species also has been identified from the Pinecrest Beds in the late Pliocene Macasphalt Shell Pit LF (Waldrop and Wilson 1990) and Kissimmee River LF, but is generally absent in most Florida Pliocene and Pleistocene marine vertebrate assemblages. The oldest teeth of *C. carcharias* from Florida are from the early Pliocene unit of the Bone Valley Formation (Tessman 1969). Although *C. carcharias* first appears in the Miocene (Gillette 1984), the giant extinct great white shark, *C. megalodon*, is much more common and widespread in Florida during the late Miocene and early Pliocene. *C. megalodon* appears to have gone extinct during the early Pliocene in Florida, with specimens from the Bone Valley and Tamiami formations being the youngest well documented records in the state.

PALEOECOLOGY

The fish fauna probably provides more information on the paleocology of the two Leisey sites than does any other vertebrate group. It is generally agreed that both Leisey faunas were deposited under shallow freshwater or estuarine conditions. Therefore, aquatic taxa such as fish would seem to be more sensitive indicators of environmental conditions at the site of deposition than would large mammals or other terrestrial taxa, many of which may have been transported some distance. The abundance of fish and their excellent quality of preservation in both Leisey sites would suggest that this component of the faunas underwent minimal transport.

The dominance of *Atractosteus spatula*, *Centropomus* sp., *Mugil* sp., *Myliobatis* sp., and *Carcharhinus leucas* in the Leisey 1A fauna suggests a coastal or estuarine, brackish water environment. *A. spatula* inhabits large rivers, bays, and coastal marine waters, but is no longer found in the Florida peninsula. Its range has receded northwestward, and at present the easternmost occurrence of *A. spatula* is the Econfina River in the central panhandle (Lee and Wiley 1980). *Centropomus undecimalis* is the only species of snook that now occurs in the Tampa Bay vicinity. *C. undecimalis* favors estuarine habitats such as bays, mangrove swamps, and river mouths (Burgess 1980). Three other species of *Centropomus* are restricted to the southern third of the Florida peninsula, and are extremely susceptible to low temperatures. Mullet of the genus *Mugil* occur in waters with a wide range of salinities, from freshwater lakes and rivers to the open ocean. Four species of *Mugil* inhabit the Gulf Coast of Florida, *M. cephalus*, *M. curema*, *M. gyrans*, and *M. gaimardianus*. The fantail mullet *M. gyrans* is not common in the northern Gulf, and together with *M. gaimardianus* do not occur in fresh water. The other two species, especially *M. cephalus*, are extremely common on the modern Gulf Coast. The white mullet *M. curema* prefers a somewhat more saline environment than *M. cephalus*, the striped mullet, but both range widely along the coast and into freshwater habitats.

The bull shark *Carcharhinus leucas* and eagle rays of the genus *Myliobatis* are the two most abundant cartilaginous fish in the Leisey 1A fauna. The bull shark commonly enters shallow coastal waters, including bays and estuaries, and is the only Florida shark that is known to occur in fresh water (Burgess and Ross 1980; Loftus and Kushlan 1987). Species of *Myliobatis* occur in shallow bays and estuaries over sand and mud flats (Bigelow and Schroeder 1953). At Leisey and in most other Florida Plio-Pleistocene vertebrate faunas that sample shallow marine environments, *Myliobatis* is the numerically dominant ray. However, species of *Myliobatis* are apparently uncommon at present in Florida coastal waters where two other members of the family Myliobatidae are more abundant, the cownose ray *Rhinoptera bonasus* and the spotted eagle ray *Aetobatus narinari*. *Rhinoptera* and *Aetobatus* are rare or absent in most Florida fossil vertebrate faunas.

The remaining taxa from Leisey 1A, none of which individually comprises more than 6% of the total MNI, are either shallow water marine or freshwater species. Diodontids, including the porcupinefishes *Diodon* and the burrfishes *Chilomycterus*, commonly occur in bays and shallow water areas along the Gulf Coast. Four species of cyprinodontids have been identified from this fauna, including the sheepshead minnow *Cyprinodon variegatus*, the goldspotted killifish *Floridichthys carpio*, and two species of the killifish genus *Fundulus*. Most of these species are small schooling fishes that occur in bays, lagoons, tidal creeks, brackish marshes, and at the surfline. The Sciaenidae are represented by four species in the Leisey 1A fauna, including black drum *Pogonias cromis*, silver perch *Bairdiella chrysoura*, spotted sea trout *Cynoscion nebulosus*, and red

drum or redfish *Sciaenops ocellatus*. Sciaenids are bottom dwellers most often found in the shallow waters of bays and estuaries. The red drum occasionally enters fresh water (Loftus and Kushlan 1987). The tarpon *Megalops atlanticus* is a shallow water marine and estuarine species, but also commonly occurs in freshwater habitats in southern Florida, especially in deeper water (Loftus and Kushlan 1987). Species in the family Centrarchidae are principally freshwater inhabitants, although some species, including *L. microlophus* are known to occasionally venture into brackish water. Ictaluridae are primarily lake and river dwellers, with the exception of *Ictalurus punctatus*, the channel catfish, which regularly enters brackish water.

The dominance of the sunfish family Centrarchidae in the Leisey 3A fauna, including five species comprising 38.5% of the total MNI, indicates a more freshwater environment than the fauna from Leisey 1A. Most species of centrarchids prefer freshwater lakes, ponds, and the quiet backwaters of rivers and streams. The most abundant species from Leisey 3A, the redear sunfish *Lepomis microlophus*, is primarily found in freshwater habitats. However, this centrarchid species has been collected in tidewater areas in northern Florida (Swift et al. 1977) and in southern Florida occurs in brackish water in coastal rivers (Loftus and Kushlan 1987).

Leisey 3A also contains a substantial sample of *Mugil* (over 20% of MNI). The common presence of *Mugil* is not incompatible with a freshwater environment, although mullet tolerate a wide range of salinities. The Ictaluridae comprise 5.1% of the total MNI from Leisey 3A. The two identified species of ictalurids from this fauna, the yellow bullhead *Ameiurus natalis* and brown bullhead *A. nebulosus*, are strictly freshwater fishes. The bowfin *Amia calva*, which accounts for 2.6% of the Leisey 3A fish fauna, is a denizen of lowland freshwater habitats (Burgess and Gilbert 1980) and was not identified from Leisey 1A. Several other freshwater fishes were also identified only in Leisey 3A. Both species of *Esox* found in Florida, the chain pickerel *E. niger* and the redfin pickerel *E. americanus*, inhabit freshwater ponds, lakes and streams. The golden shiner *Notemigonus crysoleucas* schools in clear quiet streams, ponds, lakes. The lake chubsucker *Erimyzon sucetta* inhabits lakes, as well as ponds and sloughs. The freshwater eel *Anguilla rostrata* prefers freshwater streams or brackish water when not migrating or spawning at sea. Less abundant taxa in the Leisey 3A fauna are primarily shallow coastal marine and estuarine species, such as the stingray family Dasyatidae, the ladyfish *Elops saurus*, the herring family Clupeidae, the silverside *Menidia*, the halfbeak *Hyporhamphus*, killifish of the genus *Fundulus, Centropomus*, the flounder family Bothidae, the sheepshead *Archosargus probatocephalus*, and the porgy *Calamus*.

The two Leisey fish faunas are generally similar to modern Florida Gulf Coast fish communities. The primary difference between the ichthyofaunas from Leisey 1A and Leisey 3A is the greater abundance and diversity of freshwater species in Leisey 3A. Analysis of the habitat preferences of the 51 species of fish identified from Leisey 1A (Table 1, column 3), indicates that 47 species (92%)

occur primarily in shallow marine or estuarine habitats. The remaining four species (8%) are freshwater fish, all of which are very rare in the sample. The ichthyofauna suggests that Leisey 1A was probably deposited in a shallow nearshore marine or estuarine environment, such as a bay or near the mouth of a large river. Tampa Bay and the mouth of the Little Manatee River are located less than 1 km from the Leisey Shell Pit sites. Evidence from the fossil invertebrate fauna (Portell et al. this volume) also indicates that Leisey 1A was deposited in a shallow, nearshore marine habitat. The presence of various freshwater vertebrate and invertebrate taxa in the Leisey 1A fauna was probably a result of fluvial transport from further inland.

Examination of the habitat preferences of the 53 species of fish identified from Leisey 3A (Table 1, column 3) indicates that 37 of the species (70%) are restricted to shallow marine or estuarine habitats, whereas the remaining 16 fish (30%) are freshwater species. However, this provides an inaccurate picture of the Leisey 3A ichthyofauna because it does not take into account abundances of the individual taxa. The most common species from Leisey 3A are indicative of a fish community adapted to low gradient, freshwater habitats. A large stream or river well inland from where it entered the Gulf of Mexico seems the most likely habitat for Leisey 3A based on the composition of the ichthyofauna. The abundance of other freshwater vertebrates at Leisey 3A, such as sirens, natricine snakes, pond turtles, and alligators (Meylan this volume), further supports this paleoenvironmental interpretation. Slight fluctuations in sea level during the time interval that the Leisey 3A fauna was deposited would help explain the rather large number of species of estuarine and nearshore marine fish present in an otherwise predominantly freshwater fauna. Presumably, Leisey 3A was deposited during a minor regression when sea level was slightly lower and the Leisey Shell Pit was located farther from the Gulf of Mexico.

Although this discussion stresses the differences in composition between the two Leisey fish faunas, it is worthwhile to note that these faunas actually have 37 species of fish in common. An index of faunal similarity (Simpson Index: 37 species in common/51 species in the smaller fauna = an index of similarity of 0.73) demonstrates that the two Leisey faunas share almost 75% of their fish species. Nearly half of the species in common between the two Leisey faunas are sharks and rays, all of which are either marine or estuarine, including 18 of the 21 species (86%) of cartilaginous fish recorded from the combined Leisey Shell Pit LF. The two Leisey faunas have a rather similar composition of marine and estuarine fish in general, although this component is much more predominant at Leisey 1A.

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