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FRESHWATER FISHES OF SOUTHERN FLORIDA

William F. Loftus and James A. Kushlan

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FRESHWATER FISHES OF SOUTHERN FLORIDA

William F. Loftus and James A. Kushlan*

ABSTRACT

This paper presents the results of the first systematic study of the distribution of fishes in southern Florida's fresh waters. Prior to this study, the known ranges of many fishes at the southern tip of Florida were either poorly understood or in error. The presence of 92 species of fishes in fresh water is documented for extreme southern Florida. The status and distribution of the fishes and the ecological factors that affect them are discussed.

Individual species accounts describe each fish's range in southern Florida and provide life history and ecological data. Locations and descriptions of collection sites, an artificial key to juvenile Lepomis species, and a bibliography of southern Florida freshwater fishes are included.

This study produced records for several species, such as Carcharhinus leucas, Floridichthys carpio, Fundulus similis, and Agonostomus monticola, that were not well known from southern Florida fresh waters. It also documents freshwater penetration by nine euryhaline species that were not listed from fresh water by Robins et al. (1980): Adinia xenica, Floridichthys carpio, Fundulus similis, Epinephelus itajara, Caranx hippos, Oligoplites saurus, Sphyraena barracuda, Gobionellus smaragdus, and Lophogobius cyprinoides. The centrarchids Lepomis gulosus and Lepomis punctatus were collected at their highest recorded salinity, 12.5 $^{o}/oo$. New distributional data have extended the known freshwater ranges of 15 species into extreme southern Florida. Records for freshwater occurrence or persistence by 11 species in southern Florida are regarded as erroneous or dubious. The presence of 12 non-native species is documented, one of which, Cichlasoma citrinellum, is a recent introduction.

Distinct distributional patterns exist for several groups of species: large centrarchids occur primarily in canals, cypress sloughs, and headwater rivers; most euryhaline species do not

* William F. Loftus is a fishery biologist with the U.S. National Park Service at the South Florida Research Center, Everglades National Park, P.O. Box 279, Homestead FL 33030. James A. Kushlan, formerly a research biologist at the South Florida Research Center, is an associate professor in the Department of Biology, East Texas State University, Commerce TX 75428.

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penetrate far inland; the majority of exotic species are most numerous in the canal system; and many small cyprinodontoids are widely distributed in all habitats. The relative abundance of fish species usually varies among habitats.

All native primary and secondary freshwater fish species in southern Florida are derived from temperate North American waters. Most are widespread in the southeastern United States. All established non-native species originated in tropical or subtropical regions.

RESUMEN

Este artículo presenta los resultados del primer estudio sistemático de peces de aguas continentales ("agua dulce") en el sur de la Florida. Antes de este estudio, los rangos de distribución de muchas especies en el extremo sur de Florida eran poco conocidos o erróneos. Se documenta la existencia de 92 especies de peces continentales y se discuten los factores ecológicos que afectan su status y distribución.

Se hace también una descripción del rango de distribución por especie y se da información pertinente acerca de su historia natural y ecología. Se incluye la localización y descripción de áreas de recolección, una clave artificial para los juveniles de Lepomis sp., así como una bibliografía sobre peces continentales del sur de Florida.

La recolección de especímenes y la revisión de literatura permitieron hacer registros de especies no bien conocidas de aguas continentales del sur de Florida. Entre ellas: Carcharhinus leucas, Floridichthys carpio, Fundulus similis, Epinephelus itajara, Caranx hippos, Oligoplites saurus, Sphyraena barracuda, Gobionellus smaragdus, y Lophogobius cyprinoides. Dos centrárquidos, Lepomis gulosus y Lepomis punctatus, fueron recolectados en aguas cuya salinidad es la máxima registrada para estas especies, 12.5 $^{o}/oo$. Nueva evidencia permite extender el rango distribucional de 15 especies en el extremo sur de Florida. Previos registros acerca de la existencia de 11 especies en aguas continentales del sur de Florida, son considerados erróneos o dudosos. Se documenta la presencia de 12 especies no nativas, una de las cuales, Cichlasoma citrinellum, fue recientemente introducida.

Existen patrones distribucionales distintos para varios grupos de especies. Los centrárquidos grandes habitan principalmente en canales, pantanos de cipreses y cabeceras de ríos; la mayoría de las especies eurihalinas no penetran en el interior; la mayoría de las especies exóticas son mas numerosas en los sistemas de canales; mientras que muchos ciprinodontoides están ampliamente representados en la mayoría de los hábitats. La abundancia relativa de estas especies generalmente varía de acuerdo al hábitat.

Todas las especies primarias y secundarias de aguas continentales, provienen de zonas templadas de America del Norte. La mayoría de ellas están ampliamente distribuídas en el sudeste de los Estados Unidos. Todas las especies no nativas establecidas en el área provienen de regiones tropicales y subtropicales.

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INTRODUCTION

The Everglades, Big Cypress Swamp, and contiguous freshwaters in southern Florida offer one of the most extensive wetland environments in the United States. It is, therefore, surprising that study of freshwater fishes in southern Florida has been neglected in comparison with that of freshwater areas farther north or with that of marine fishes in southern Florida. Although the component species of the ichthyofauna had been described and listed in works by Evermann and Kendall (1900), Fowler (1945), Carr and Goin (1955), and Briggs (1958), just one distributional study had been conducted in this region, based upon limited collections in and near Everglades National Park (Kilby and Caldwell 1955). Available distributional data for freshwater fishes in southern Florida were summarized by Kushlan and Lodge (1974). This situation is reflected in the incomplete distribution maps in the work by Lee et al. (1980) on North American fishes.

Life history and ecological studies of fishes are somewhat more substantial. They include work on food habits (Hunt 1953; Odum 1971) and seasonal ecology in the Big Cypress Swamp (Kushlan 1974a, 1976a), in the Everglades marshes (Tabb 1963; Kolipinski and Higer 1969; Kushlan 1976b, 1980a), and in the mangrove zone (Tabb and Manning 1961; Tabb et al. 1974). Several studies document changing distribution of introduced fishes in southern Florida (Courtenay and Robins 1973; Courtenay et al. 1974; Hogg 1976a). Ichthyological studies in areas adjoining ours include those from the northern Everglades Water Conservation Areas (Clugston 1966; Crowder 1974; Dineen 1974), the Fakahatchee Strand (Carter et al. 1973), northern Big Cypress Swamp (Carlson and Duever 1977), Lake Okeechobee (Ager 1971), the St. Lucie River (Gunter and Hall 1963a), and the Caloosahatchee River (Gunter and Hall 1965). The paucity of information on southern Florida freshwater fishes is critical in view of their central ecological role in freshwater marshes and swamps (Kushlan et al. 1975; Ogden et al. 1976; Kushlan 1979a, 1980b).

The study of freshwater fishes in southern Florida has been limited by the inaccessibility of much of the region and by technical sampling problems. Roadways are few through the Everglades and Big Cypress Swamp, and most travel must be by airboat, swamp buggy, or helicopter--all relatively expensive modes of transport. Secondly, it is difficult to obtain adequate and representative samples in habitats that do not lend themselves to the use of ordinary fish-sampling gear and techniques. These difficulties have resulted in the development of new techniques for quantitative sampling in marsh habitats in southern Florida (Higer and Kolipinski 1967; Kushlan 1974b, 1981).

This survey of the freshwater fish fauna of extreme southern Florida was the first step of a larger study of fish ecology in the Everglades. Our sampling program extended from December 1976 through April 1983. The purposes of the study were to document the distribution and composition of the ichthyofauna, to search for geographical differences in the ichthyofauna within the study area, to obtain qualitative data on habitat occurrence, and to determine the present extent of invasions by exotic fishes. In reviewing the literature from our study area, we found records for a number of species that we did not collect in our sampling. We include these in this paper. These baseline data on native and exotic fish species and their present ranges will allow future changes in their distribution to be measured.

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DESCRIPTION OF THE STUDY AREA

The study area included all freshwater habitats on the mainland of southern Florida (Fig. 1) south of the Tamiami Trail (U.S. Hwy. 41), from Miami west to Everglades City, including Cape Sable (Fig. 2). Except for the canalized, developed zone along the eastern and western coasts, most of southern Florida is covered with seasonally flooded marshes and swamps. The two major natural drainages in this area are the Everglades marsh system called Shark River Slough (south of Tamiami Trail) and the Big Cypress Swamp (Fig. 3). The third drainage system is the artificial network of canals that dissect the southern Everglades and the eastern coastal ridge. These generally follow the course of pre-existing transverse glades that drained the coastal pinelands to Biscayne Bay (Fig. 3). The hydrology of the area has been described by Parker et al. (1955) and Klein et al. (1970).

Although some pools of fresh water occur on the Florida Keys, we did not include the keys within our study area. Most of these pools occur on the

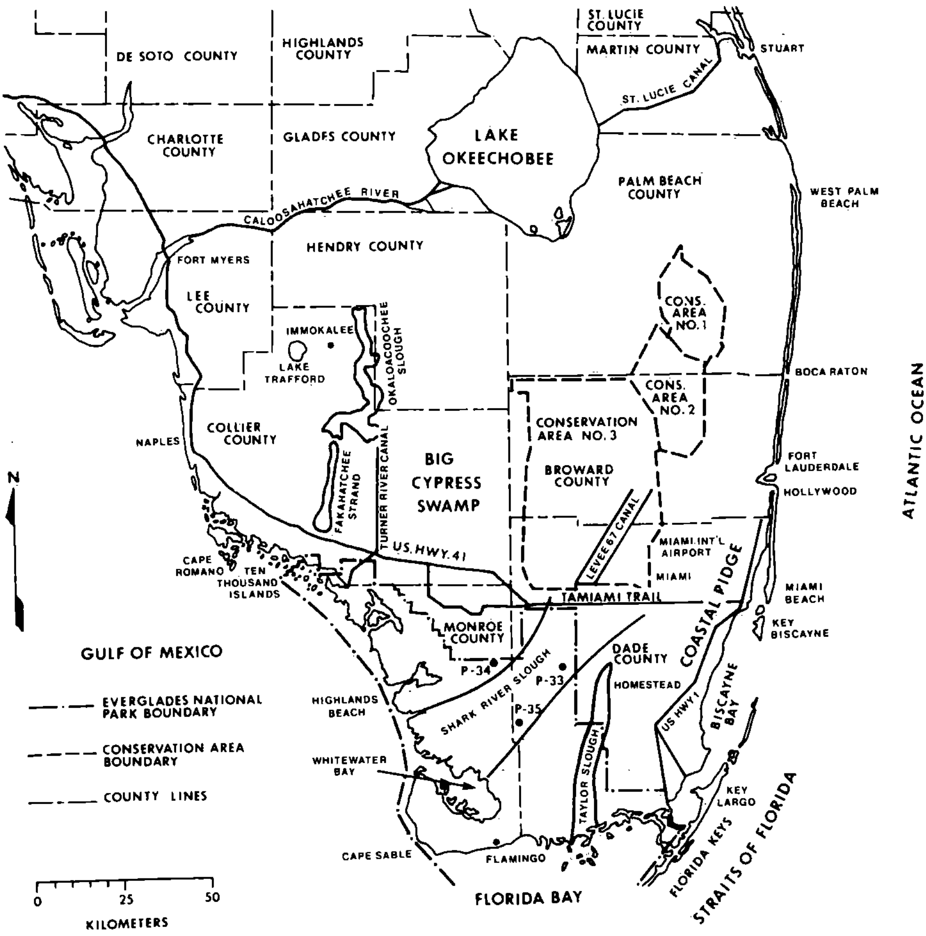

Figure 1.– Map of Florida, south of Lake Okeechobee, showing geographical features.

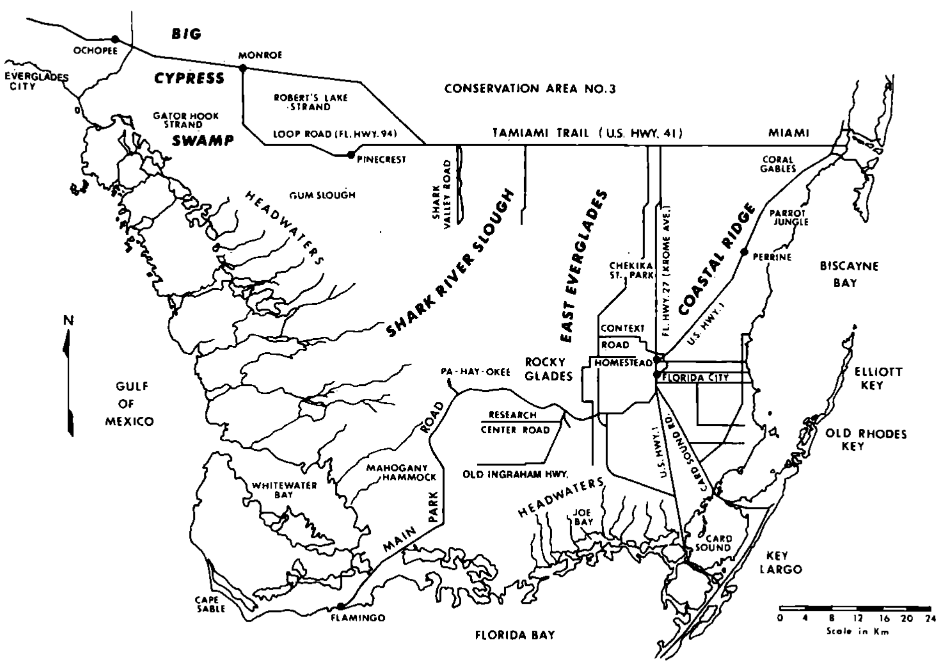

Figure 2.-- Map of the study area in southern Florida showing geographical features.

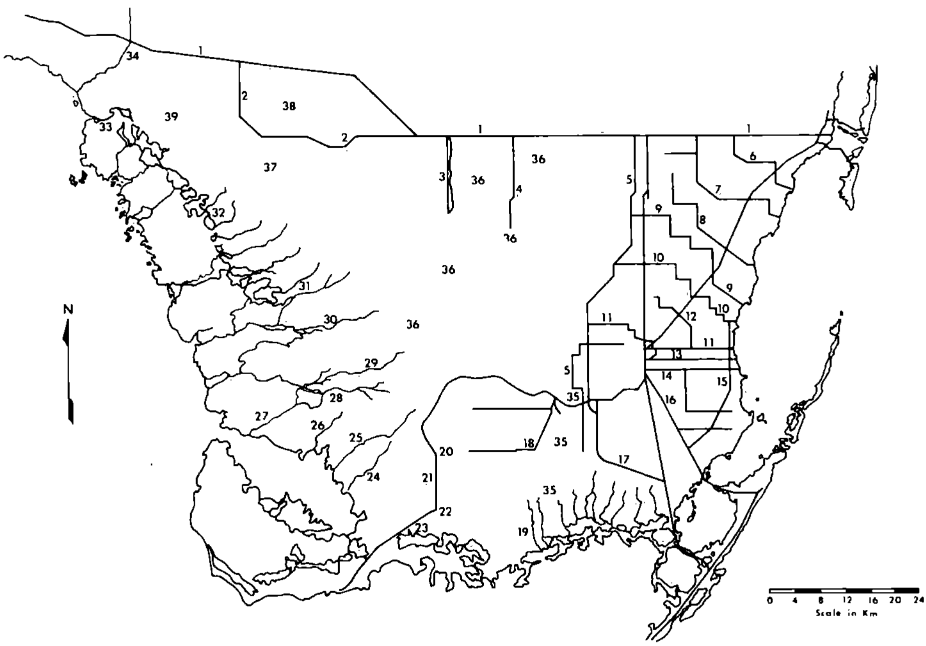

Figure 3.-- Major inland waters and drainages of southern Florida: (1) Tamiami Canal; (2) Loop Road Canal; (3) Shark Valley Canal; (4) L-67 Canal Extended; (5) L-31 N and L-31 W Canals; (6) Coral Gables Waterway; (7) Snapper Creek (C-2 Canal); (8) C-100 Canal; (9) Black Creek (C-1 Canal); (10) C-102 Canal; (11) C-103 Canal; (12) C-103 N Canal; (13) North Canal; (14) Florida City Canal: (15) L-31 E Canal; (16) Card Sound Canal; (17) C-111 Canal; (18) Homestead Canal; (19) Taylor River; (20) Sweet Bay Pond; (21) Paurotis Pond; (22) Nine-mile Pond; (23) West Lake; (24) Roberts River; (25) North River; (26) Watson River; (27) Shark River; (28) Squawk Creek; (29) Rookery Branch; (30) Broad River; (31) Lostmans River; (32) Dad's Bay; (33) Lopez River; (34) Turner River; (35) Taylor Slough; 36) Shark River Slough; 37) Gum Slough; 38) Roberts Lake Strand; (39) Gator Hook Strand.

lower Florida Keys and hold fresh or brackish water for part of the year. A large, artificial rockpit, the Blue Hole on Big Pine Key in the Key Deer Refuge, has a diverse fauna that includes *Lepomis macrochirus*, many cyprinodontids and poeciliids, and the exotic Texas cichlid *Cichlasoma cyanoguttatum*. It is not clear whether the native species reached the lower keys naturally. Many of these pools are seasonally brackish (pers. observ.; C.R. Robins pers. comm.) and most of the ichthyofauna rather salt tolerant. It is especially probable that the centrarchids were introduced on Big Pine Key.

The freshwater aquatic communities of southern Florida depend for their existence upon local rainfall and overland water flow, both of which are seasonally and annually variable. Nearly 85% of the 150 cm average annual rainfall arrives during the wet season, May through October (Fig. 4). This variation in rainfall causes the seasonal fluctuation of water levels (Fig. 5) that characterizes southern Florida wetlands (Kushlan 1979a). The annual dry season varies in duration and intensity. During the most severe dry seasons, water depths decrease rapidly, forcing fishes to concentrate in deep-water habitats such as alligator ponds and canals. Fish mortality, caused by predation and oxygen depletion, can be very high during such dry-downs (Kushlan 1974a). Annual variation in air temperatures is not extensive, the means varying less than 10°C from winter to summer (Fig. 6). Frosts occur infrequently in the freshwater marshes, where standing water moderates air temperatures.

Freshwater habitats within Big Cypress Swamp and its drainage include alligator ponds, sawgrass marshes, cypress strands and sloughs, and prairies (Craighead 1971). The swamp is dissected by several major canals and highways. The southern portion of the swamp, included in our study area, is hydrologically continuous with and receives surface water flow from areas north of the Tamiami Trail. During the wet season, surface-water flow occurs over the entire land surface of the swamp, as well as through elongated drainages called cypress strands. Flow in the southern Big Cypress Swamp is generally toward the southwest into the headwaters of rivers emptying into the Gulf of Mexico in northwestern Everglades National Park (Fig. 3).

The southern Everglades is the southern terminus of the vast freshwater marsh system that formerly extended north to Lake Okeechobee. Much of this area is included within Everglades National Park. The southern Everglades system drains through two major sloughs: the extensive Shark River Slough and the smaller Taylor Slough. The Shark River Slough receives much of its water by managed discharges from the Everglades Water Conservation Areas to the north. Water flows southwesterly into headwaters of the Shark River and other tidal streams, eventually emptying into the Gulf of Mexico and Whitewater Bay. Taylor Slough drains the area south and east of Shark River Slough. Much of its former drainage area has been developed

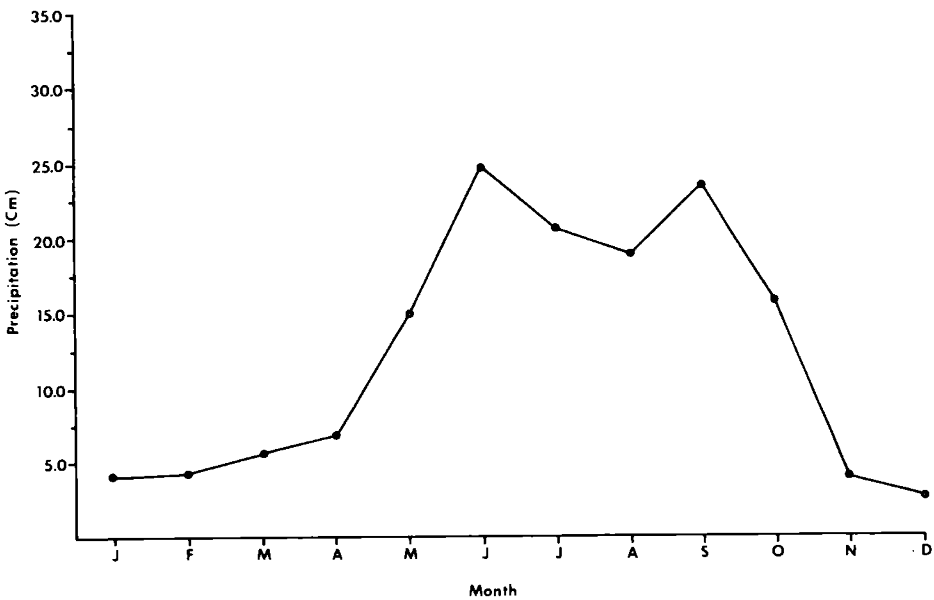

Figure 4.– Mean monthly precipitation regime in southern Florida. Collected at 40-mile Bend, the eastern intersection of Tamiami Trail and Loop Road (Fig. 2): 1941-1979 (N.O.A.A. 1979).

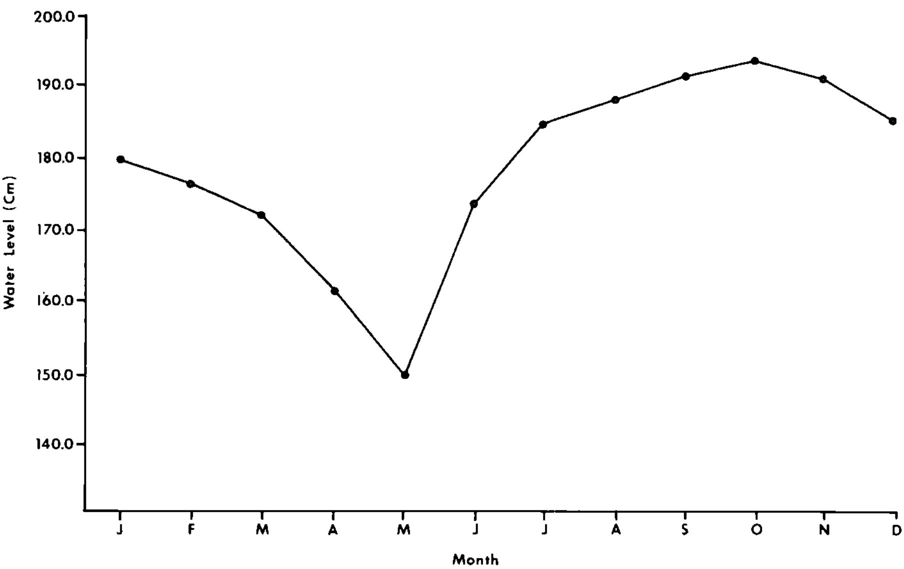

Figure 5.-- Mean monthly water levels (above mean sea level) in Shark River Slough, Everglades National Park: 1953-1977 (Rose 1977).

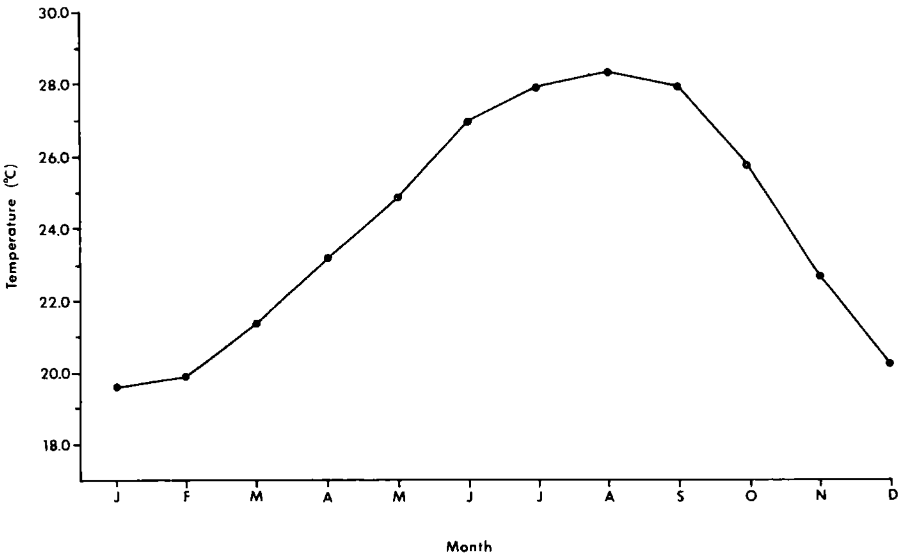

Figure 6.-- Mean monthly air temperatures in southern Florida. Collected at 40-mile Bend, at the eastern intersection of Tamiami Trail and Loop Road (Fig. 1): 1941-1979 (N.O.A.A. 1979).

for agriculture, and waters that once moved through the slough are now intercepted by levees and canals. As a result, Taylor Slough experiences much longer and more frequent periods of droughts than does the Shark River Slough. Waters in Taylor Slough flow southward into Taylor River and other streams that empty into Northeastern Florida Bay.

The southern Everglades includes most of the major aquatic habitats found in southern Florida, including marshes, alligator ponds, canals, and solution holes (Fig. 7). Bordering Shark River Slough on the east and Taylor Slough on the north and east is an area of intermittent marsh referred to as rocky gladelands. This area is slightly higher than the two sloughs and so has a very short hydroperiod. Rocky gladelands are usually covered by *Muhlenbergia* prairie and mixed-species marshes. Water there is held in solution holes, but because the area dries rapidly and frequently, there are few truly permanent aquatic habitats (other than canals) in the rocky gladelands. The rocky gladelands area outside of Everglades National Park has been referred to as the East Everglades in recent years.

The eastern coastal ridge is a zone of slightly elevated land east of the Everglades marshes that extends along the Florida Atlantic coast and into Everglades National Park, where it forms Long Pine Key. This ridge is a preferred area for urban and agricultural development, and most of the natural vegetation of pinelands and hardwood hammocks has been destroyed. Transverse glades and springs that originally carried water across the ridge (Kohout and Kolipinski 1967; Thorhaug et al. 1976) have been replaced by canals and smaller ditches that drain water into Biscayne Bay, thus preventing the flooding of farmlands and suburban and urban developments. Some of these canals are also used to move water coastwards from the interior marshes during the dry season to replenish well fields and to prevent saltwater intrusion into the aquifer. Canals and borrowpits created by the removal of limestone are the major freshwater habitats in this highly urbanized section of the study area. The freshwater character of most of these canals is maintained year round by salinity dams near the coast, but water levels fluctuate based upon rainfall, movement of waters through the canal system, and the opening of the dams.

During the wet season most of our study area is covered by fresh water. For convenience in this study, we have divided the freshwater habitats in our study area into seven major types: Everglades marsh prairies, Everglades sawgrass marsh, Everglades alligator ponds, the Big Cypress Swamp and associated habitats, canals that dissect natural habitats, canals and borrowpits along the eastern coastal ridge, and mangrove streams and ponds along the coasts.

Most of the study area is characterized by shallow water (< 1 m deep) that is often shaded by periphyton mats or emergent plants. In the Everglades

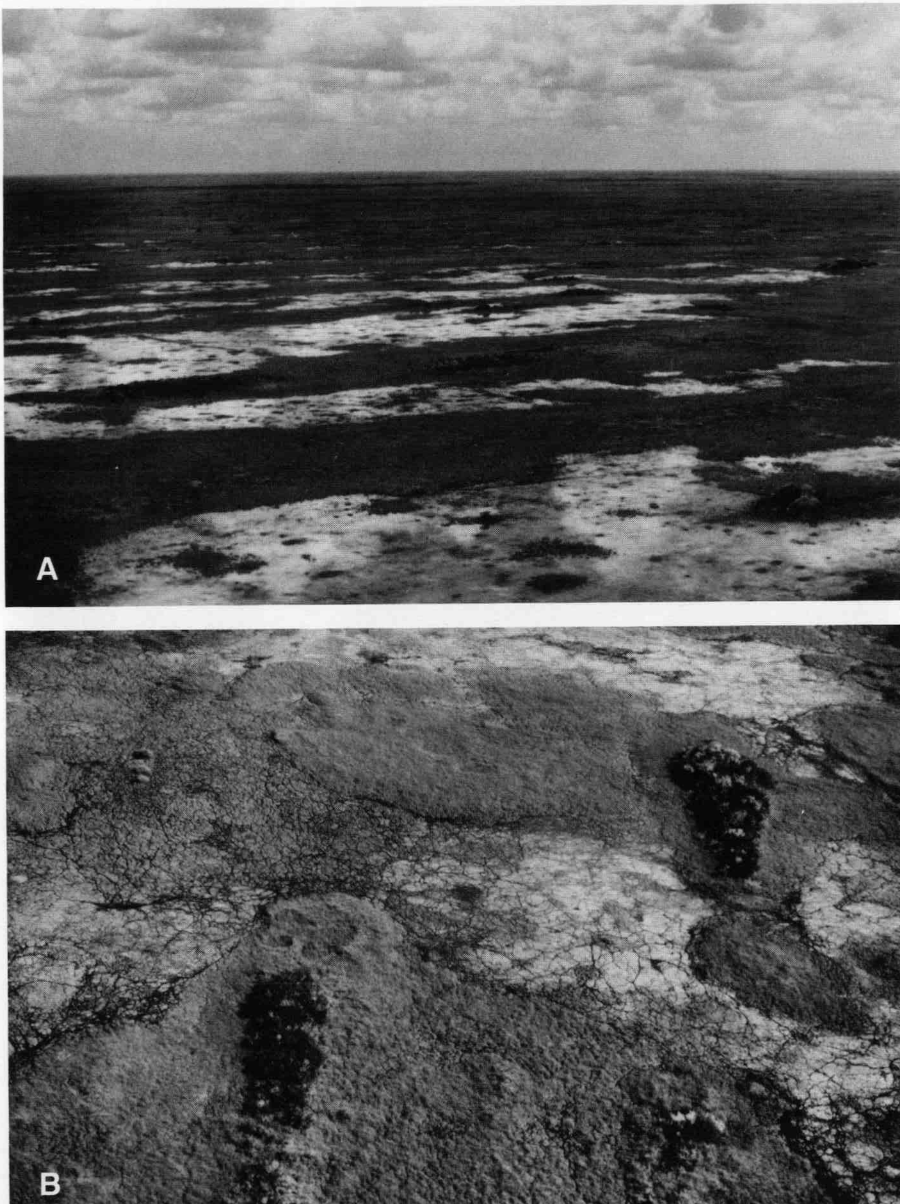

Figure 7.-- Two aerial overviews of the Everglades marsh in Shark River Slough showing the mosaic of habitats: (A) View to the east during the wet season (open areas are marsh prairies); (B) View to the northeast. Crisscrossed lines in the marsh prairies are made by alligator and deer movements through the periphyton mat.

marsh, the periphyton community sometimes exceeds the associated macrophytes in biomass and has a great influence on diurnal water chemistry (Swift 1981; Browder 1982). Physicochemical characteristics of such shallow habitats are highly variable. Even in deep-water habitats such as canals and ponds, these parameters are also variable, especially on a seasonal basis.

Fluctuations in dissolved ion levels are measured by the specific conductance of the water. Specific conductance in the southern Everglades ranges from 400 to 700 μmhos·cm^{-1} during dry periods (Flora and Rosendahl 1981). In very dry years, when brackish water intrudes into these usually freshwater habitats, the specific conductance of tidal creeks that drain the Everglades marsh rises to 15,000 μmhos·cm^{-1}. Annual trends of specific conductance values in canals and in the Big Cypress Swamp are similar to those in the Everglades marsh (Kushlan and Hunt 1979; Waller 1982).

Dissolved oxygen values in the Everglades marsh vary from 0.7 to 14.2 mg·l^{-1} (=ppm), with similar variation (0.6-12.5 mg·l^{-1}) recorded in canals (Waller 1982) and the Big Cypress Swamp (Kushlan and Hunt 1979). Dissolved oxygen concentrations fluctuate diurnally and seasonally. Supersaturation is common during afternoon hours in the warmer months (Kushlan 1979b). The lowest values occur at night and also under dry season conditions, when both shallow- and deep-water areas become deoxygenated and fish kills often result (Kushlan 1974a).

Turbidity (JTU) and color (Pt-Co-units) range from 2.0 to 40.0 and 10.0 to 120.0 units respectively in the Everglades marsh (Waller 1982). During wet seasons in the Big Cypress Swamp, turbidity varies from 5.0 to 15.0 JTU and color from 10.0 to 40.0 units. Conditions during dry season fish kills greatly increase turbidity to 165 JTU and color to 85-380 units in the swamp. The hue of such waters changes from slightly brown to green (Kushlan and Hunt 1979). The waters are slightly basic and pH is fairly constant among seasons and habitats, ranging from 7.0 to 8.5 in the Everglades marsh (Waller 1982) and from 7.1 to 8.4 in the Big Cypress Swamp (Kushlan and Hunt 1979). Diurnal variation in pH is normally quite low.

Concentrations of most major ions in the Everglades marshes (Waller 1982) and in the Big Cypress Swamp (Kushlan and Hunt 1979) are considerably higher during the dry season than in the wet season (Table 1). Major ion concentrations in Everglades canals are similar to those reported from marsh stations (Waller 1982). Trace element concentrations for Everglades marsh stations and for the Big Cypress Swamp are presented in Table 2.

Nutrient concentrations at Everglades marsh and canal stations (Flora and Rosendahl 1982) and in the Big Cypress Swamp (Kushlan and Hunt 1979) are generally low but do vary seasonally (Table 3). Dry season values for all nutrients are much greater than wet season values. Ammonia is the dominant

Table 1. Major ion concentrations ($mg \cdot l^{-1}$) at Everglades freshwater marsh stations (Waller 1982) and in Big Cypress Swamp (Kushlan and Hunt 1979) during wet and dry seasons. Fish kill data are from a Big Cypress Swamp pond during dry season (Kushlan 1974a).

Ion and Season	Everglades Marsh (range)	Big Cypress Swamp
Potassium		
Wet	0.0- 6.4	0.6
Dry	- -	1.9
Fish kill	- -	-
Calcium		
Wet	25.0- 98.0	34.0
Dry	26.0-173.0	56.0
Fish kill	- -	86.0
Magnesium		
Wet	0.5 - 12.0	1.6
Dry	0.7- 20.0	2.9
Fish kill	- -	5.1
Sodium		
Wet	4.4- 58.0	7.6
Dry	4.8-166.0	20.0
Fish kill	- -	-
Chloride		
Wet	7.0-140.0	11.0
Dry	9.0-400.0	29.0
Fish kill	- -	60.0
Sulfate		
Wet	0.0-130.0	0.0
Dry	0.0-130.0	0.8
Fish kill	- -	34.0
Bicarbonate		
Wet	48.0-442.0	-
Dry	98.0-534.0	-
Fish kill	- -	-

Table 2. Average and maximum concentrations ($mg \cdot l^{-1}$) of trace elements in water in Everglades National Park, 1959-1977 (Waller 1982), and the range of concentrations measured in the Big Cypress Swamp (Kushlan and Hunt 1979).

	Everglades National Park		Big Cypress Swamp
Trace element	Average	Maximum	Range
Aluminum	215.0	4700.0	70.0-190.0
Arsenic	4.2	20.0	0.0- 10.0
Cadmium	1.5	35.0	- -
Chromium	2.0	20.0	0.0- 0.0
Copper	2.7	14.0	0.0- 0.0
Cobalt	0.9	10.0	- -
Iron	723.0	9500.0	50.0-220.0
Manganese	28.0	260.0	0.0- 0.0
Mercury	0.4	6.7	- -
Nickel	5.8	41.0	- -
Lead	16.0	190.0	0.0- 0.0
Lithium	-	-	0.0- 20.0
Zinc	27.0	100.0	10.0- 20.0

Table 3. Nutrient concentrations ($mg \cdot l^{-1}$) in the Everglades freshwater marsh and canal system (Flora and Rosendahl 1982) and the Big Cypress Swamp (Kushlan and Hunt 1979) during the wet and dry seasons. Values for the fish kill refer to measurement from a Big Cypress Swamp pond during the dry season (Kushlan 1974a).

Parameter and season	Everglades marsh	Canal	Big Cypress Swamp
Ammonia			
Wet	0.02 - 0.24	0.01 - 0.82	0.02
Dry	0.50 - 1.60	0.06 - 1.10	0.02
Fish kill	-	-	-
Nitrate + Nitrite			
Wet	0.00 - 0.08	0.01 - 0.47	0.01(NO_2); 0.10(NO_3)
Dry	0.00 - 0.43	0.02 - 0.49	0.017(NO_2); 0.10(NO_3)
Fish kill			0.12(NO_2); 2.0(NO_3)
Total Nitrogen			
Wet	0.53 - 2.31	1.00 - 4.08	0.87
Dry	0.57 -13.00	1.10 - 3.10	0.87
Fish kill	-	-	-
Orthophosphate			
Wet	0.00 - 0.020	0.00 - 0.110	0.00
Dry	0.001- 0.107	0.004- 0.013	0.08
Fish kill	-	-	13.00
Total Phosphorus			
Wet	0.00 - 0.04	0.010- 0.036	0.15
Dry	0.002- 0.20	0.013- 0.260	0.90
Fish kill	-	-	-
Total Carbon			
Wet	42.00 -101.00	4.40-75.00	-
Dry	47.00 -136.00	48.00-98.00	-
Fish kill	-	-	-
Total Organic Carbon			
Wet	1.00 - 62.00	16.00-50.00	-
Dry	4.00 - 73.00	19.00-49.00	-
Fish kill	-	-	-

inorganic nutrient; concentrations of orthophosphate and total phosphorus are quite low because of plant assimilation and binding to limestone substrates (Waller 1982).

A detailed study of a Big Cypress Swamp alligator pond during a dry season fish kill found outstandingly high concentrations of all major ions and nutrients (Kushlan 1974a; Kushlan and Hunt 1979) (Tables 1 and 3). Such abnormally high values result from several factors related to the dry season, including concentration due to reduced water volumes, rapid decomposition of animal and plant material, and the reduction of normally bound compounds in bottom sediments during anaerobic conditions (Kushlan and Hunt 1979).

In general, water quality parameters and ionic and nutrient concentrations exhibit significant seasonal fluctuations with relation to the wet season-dry season cycle in southern Florida. For much of the year, most natural freshwater habitats are characterized by alkaline pH, low turbidity and color, relatively low nutrient levels, and diurnally fluctuating dissolved oxygen levels. Major ions include chloride, carbonate, calcium, sulfate, and sodium. Dramatic increases in ionic and nutrient concentrations occur during the seasonal dry-down. Everglades canals exhibit water quality characteristics and chemical constituents that are similar to those of natural habitats in the study area.

Characteristic plant communities of each habitat type in the study area have been described by Davis (1943), Craighead (1971), and Olmsted et al. (1980). The periphyton community has been studied by Van Meter (1965) and Browder (1981; 1982). Marsh prairies of the Everglades include a diverse array of single- and mixed-species plant associations, on deep peat substrate in the Shark River Slough and on marl in Taylor Slough and the rocky gladelands (Fig. 8). Marsh prairies in Shark River Slough are dominated by spikerush (*Eleocharis cellulosa*) or beakrush (*Rhynchospora tracyi*), and maidencane (*Panicum hemitomon*) is also locally common. Spider lily (*Hymenocallis latifolia*), white water lily (*Nymphaea odorata*), floating heart (*Nymphoides aquatica*), pickerelweed (*Pontederia lanceolata*), and arrowhead (*Sagittaria lancifolia*) are also common in depressions or along airboat trails in the marsh. The characteristic plant of the Everglades, sawgrass (*Cladium jamaicense*), also occurs in sparse stands in marsh prairies. The interstices between plants in sparsely vegetated marshes are often filled by periphyton-covered bladderwort (*Utricularia purpurea*). In Taylor Slough and adjacent uplands, intermittent marshes are dominated by sawgrass, muhly (*Muhlenbergia filipes*), and black rush (*Schoenus nigricans*).

Sawgrass marshes (Fig. 8) occupy slightly higher ground than marsh prairies and are usually underlain by deep peat substrates. This habitat is dominated by sawgrass that, in many areas, forms vast expanses of nearly monospecific stands up to 3 m tall. Arrowhead, arrow arum (*Peltandra*

Figure 8.-- (A) Dense Everglades sawgrass marsh at collection site #54; (B) Everglades marsh prairie at collection site #54.

virginica), and the fern (*Blechnum serrulatum*) sometimes occur within the sawgrass marsh. Buttonbush (*Cephalanthus occidentalis*), willow (*Salix caroliniana*), and cocoplum (*Chrysobalanus icaco*) are woody shrubs that are sometimes present in the sawgrass marshes. Standing water recedes rapidly from sawgrass marshes during the dry season, but the deep peat substrate acts as a sponge to hold ground water for a long period.

Alligator ponds in the southern Everglades occupy basins in the limestone bedrock (Fig. 9). Water depths average 1-2 m during the wet season. The temperature and oxygen regime has been characterized by Kushlan (1979b), as have the limnological characteristics of similar habitats in the Big Cypress Swamp (Kushlan and Hunt 1979). Everglades ponds are surrounded either by typical marsh prairie or sawgrass vegetation or by hardwood trees, especially willows. The pond surface and water column can either be open or occupied by spatterdock (*Nuphar luteum*), southern naiad (*Najas guadalupensis*), and bladderworts. Willow forests surrounding ponds often include pickerelweed, sawgrass, buttonbush, alligator flag (*Thalia geniculata*), and pond apple (*Annona glabra*). Such ponds are the naturally occurring deep-water habitats of the Everglades and are originated and maintained by the American alligator (*Alligator mississippiensis*) (Kushlan 1974c).

The Big Cypress Swamp is a complex mosaic of swamp, marsh, and upland communities (Craighead 1971). The major substrate in the Big Cypress is sand overlain by marl in areas with short hydroperiods or by peat in deeper water areas. The most characteristic plant community is cypress forest occurring in strands, domes, or scrub, and dominated by bald cypress (*Taxodium distichum*) and pond cypress (*T. ascendens*) (Fig. 10). Swamp hardwoods such as popash (*Fraxinus caroliniana*), willow, buttonbush, and red maple (*Acer rubrum*) are common subcanopy species in the swamp. Vast areas are occupied by sparse marsh prairies, and alligator ponds are common (Fig. 10). The large strands have extensive areas of deep ponds and pond apple sloughs. Water depths during the wet season vary from 0.3 m in the dwarf cypress areas to nearly 2 m in the center of cypress sloughs or ponds.

Canals and borrowpits are artificial deep-water habitats constructed for drainage, levee fill, or mining operations. All natural drainages of any significance along the extreme southeastern coast of Florida have been replaced by canals (Beck 1965). Canals through the Everglades or Big Cypress Swamp usually are bordered on one side by natural aquatic habitats, and on the other side by a levee or road (Fig. 11). The sloping canal edges are lined by marsh or swamp vegetation, particularly sawgrass, willow, or cattail (*Typha latifolia*). Submerged vegetation is normally abundant along the margins of these canals. In the Big Cypress Swamp canals, *Salvinia rotundifolia* and *Pistia stratiotes* are locally abundant surface plants. On the eastern coastal ridge, canals and borrow pits have steep-sided banks that reduce the available littoral

Figure 9.-- (A) Everglades alligator willow-pond near collection site #53; (B) an Everglades alligator marsh-pond near collection site #53.

zone. These canals range from 2 to 7 m deep and are 3 to 10 m wide (Fig. 11). Riparian cover is normally sparse. Many urban canals are bordered by tall Australian pines (*Casuarina* sp.) that shade the water surface, reducing the amount of submerged vegetation in the canals. In both types of canals, large sections may be choked by *Hydrilla verticillata* and *Najas guadalupensis* and the water surface covered by water hyacinth, *Eichornia crassipes*. Because these plants obstruct water flow in the canals, both chemical and mechanical methods of removal are frequently employed.

Freshwater marshes and swamps give way to mangrove swamps near the coast (Tabb et al. 1967; Craighead 1971) (Fig. 12). Most coastal mangrove swamps are estuarine with salinities varying from hypersaline in the dry season to completely fresh during the wet season. In the headwaters, where coastal streams meet the Everglades marsh, red mangrove (*Rhizophora mangle*) occurs along the edges of the small finger creeks (Fig. 12). These creeks coalesce into progressively larger streams toward the coast. In addition to red mangrove, the streams are often bordered by willow, pond apple, cattail, and sawgrass. Inland, the habitat between the streams consists of marshes of sawgrass, cattail, cordgrasses (*Spartina* spp.), and black rush (*Juncus roemerianus*). Farther seaward, mangrove swamp predominates, and red mangrove-lined pools are common. The substrate in these swamps is deep mangrove peat. During highwater periods, when water outflow from the marshes results in the streams being completely fresh, water depths range from 1 to 2 m, and the bottom is often scoured to the bedrock.

The Cape Sable region is the southwestern tip of the Florida mainland. The area supports mangrove-dominated wetlands, lakes and ponds, of which most are brackish or saline. However, on the northcentral portion of the cape is a small basin with freshwater marshes similar in character to those of the lower Shark River Slough. These marshes seem to result from the retention of localized rainfall by the poorly drained marl substrates. The marshes consist of large areas of *Eleocharis cellulosa*, interspersed by stands of sawgrass and mangrove clumps. Pools and shallow channels bordered by cattails are common. Additional descriptions of specific sections of the study area are provided in Appendix I.

METHODS

Because of the wide variety of freshwater habitats in southern Florida, we used several sampling techniques. In the Everglades marsh, conventional sampling techniques, such as seining, were useless because of dense plant and periphyton cover. Representative samples were obtained with rotenone-based


A

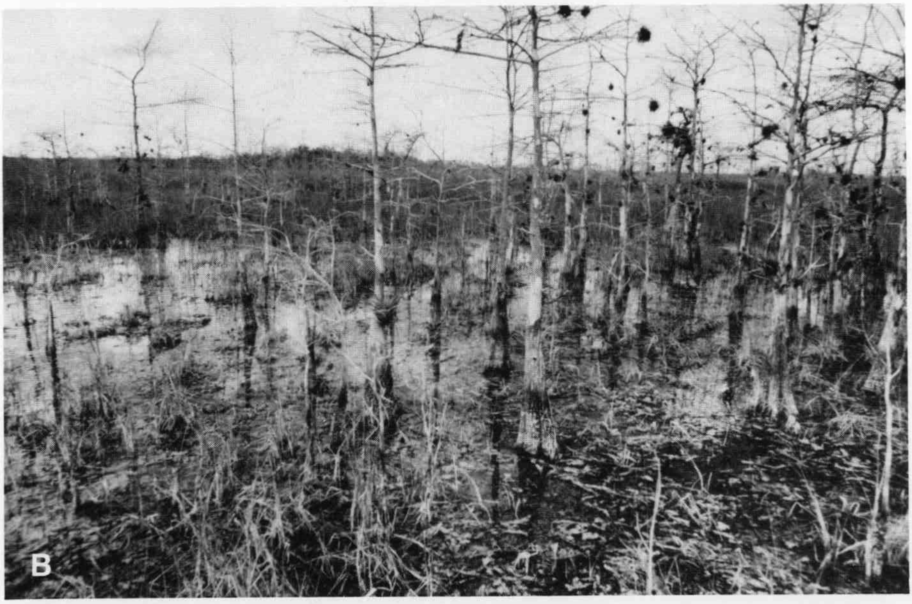
B

Figure 10.-- Cypress habitats: (A) Roberts Lake cypress strand near collection site #35; (B) Cypress prairie near collection site #36; (C) Tamiami Canal dissecting cypress swamp near collection site #6.


A
B

Figure 11.-- Major artificial habitats: (A) Tamiami Canal and water control structure in the Everglades marsh near collection site #40; (B) Bird Road Canal on the urbanized coastal ridge near collection site #152; (C) Sweet Bay Pond along Park Road at collection site #108; (D) Park Road culvert at collection site #100.

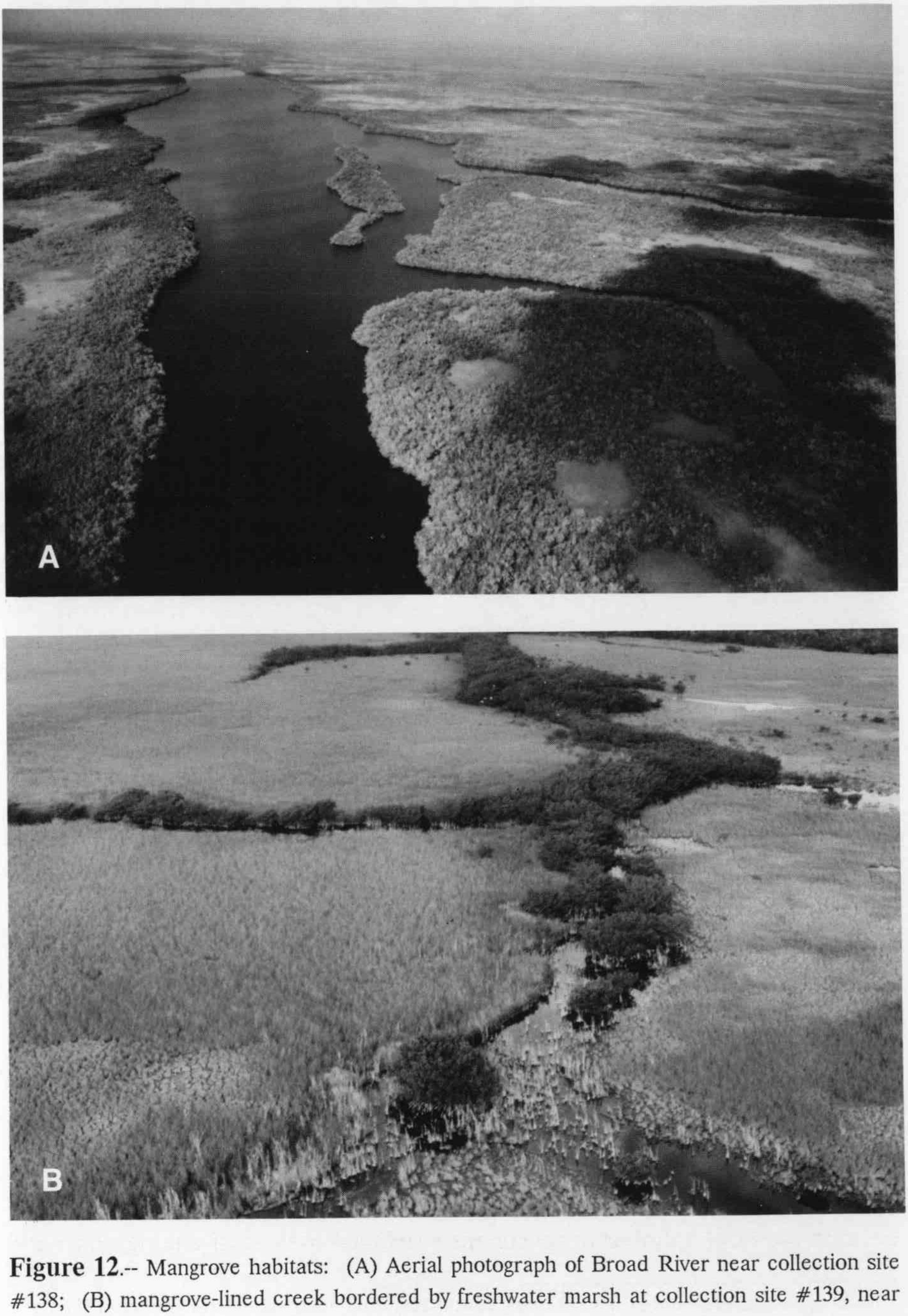

Figure 12.-- Mangrove habitats: (A) Aerial photograph of Broad River near collection site #138; (B) mangrove-lined creek bordered by freshwater marsh at collection site #139, near Rookery Branch.

toxicants (Noxfish^c^ and Pronox-Fish^c^) and with Smith-Root^c^ electroshocking units[1]. The toxicant was applied by using a hand-sprayer to mix it well into the water column. Rotenone was effective in all habitats, but we used it sparingly. We obtained additional records of marsh fishes by using pull-up traps, throw traps (Kushlan 1981), cast nets, and angling. Quantitative information on relative abundance of fishes was obtained from the traps. We sampled mangrove-lined creeks and pools in the headwaters region with gill nets and cast nets in the main channels, and with rotenone in the feeder creeks. Electrofishing was very effective in these streams at night when we shocked fishes as they rested near the bottom. We collected fishes from road culverts and small ditches using rotenone, dip nets, and electrofishing. Canals and rockpits proved more difficult to sample effectively, as the steep banks and deep water precluded the use of most gear. We obtained the best results using a combination of gill nets, electrofishing, and limited applications of rotenone along the shoreline.

We sometimes relied on sight observations to document the occurrence of certain fish species, especially larger fish that were difficult to capture. Sight observations were made in two ways: using polaroid sunglasses and binoculars, we walked along canal and rockpit banks while recording the fishes observed; or, in selected canals and rockpits, observers snorkeled and recorded the observed species on underwater slates. In the clear, shallow waters of southern Florida, experienced observers can easily and unequivocally identify by sight the rather limited number of fish species present, so that little error is associated with this technique.

We collected fishes at 181 sites. The fishes were preserved in 10% buffered formalin and were later transferred to 40% isopropanol. Because of the large number of collection sites, we could not save all specimens. Instead, we designated 39 voucher sites approximately 12-16 km apart throughout the study area to provide a representation of the freshwater ichthyofauna of the region (Fig. 13). The voucher locations were either single collection localities or a series of nearby collection sites in similar habitats along a continuous watercourse. The collection sites are listed and described in Appendix I; the collection sites included in each voucher location are listed in Appendix II. For each collection site, we include the precise location by township, range, and section, the date(s) of collection, method(s) of collection, and any site-specific habitat information. All species of fishes taken at each site are listed; those species observed are indicated by an asterisk following the species number. We do not report the numbers and lengths of each species taken at each location because the large number of specimens precluded individual enumeration and

[1] Reference to trade names does not imply endorsement by the National Park Service, U.S. Department of the Interior.

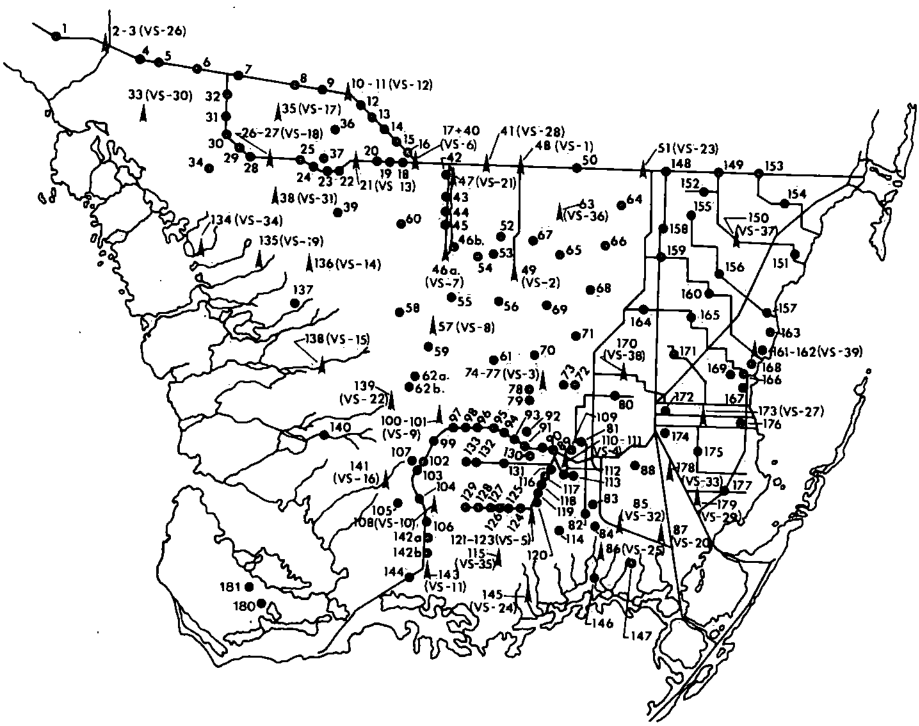

Figure 13.-- Locations by number of the 181 collection sites and 39 voucher sites within the study area.

measurement. Because physical features within each habitat type are usually quite uniform, only when a collection site departed from the overall description given for that habitat do we provide general habitat information in Appendix I. Unless otherwise noted, salinities at all collection sites were 0°/oo, as measured by an American Optical[c] refractometer. We took salinity measurements both at the surface and near the bottom in rivers and ponds to detect salinity wedges. This procedure was not necessary in very shallow ponds and marshes.

We attempted to collect large series of specimens at each voucher location, and we also saved rare or unusual specimens from collection sites outside of the voucher locations. All voucher specimens from this study have been deposited in the Florida State Museum, University of Florida, Gainesville. Several centrarchid specimens were deposited at the University of Michigan Museum of Zoology, Ann Arbor. Catalogue numbers for the specimen lots are listed in Appendix II in conjunction with the appropriate voucher samples.

For all fish identifications we followed Carr and Goin (1955), Brown (1957), Dawson (1969), and Eddy and Underhill (1978). Several centrarchid and cichlid identifications that proved difficult were confirmed by C.R. Gilbert and R.M. Bailey. Existing keys to southern Florida freshwater fishes proved adequate, except for the juveniles of *Lepomis*. We have constructed an artificial key to their identification (Appendix III). The nomenclature used in this paper follows Robins et al. (1980) for both common and scientific fish names.

SPECIES ACCOUNTS

We present species accounts for all fishes recorded from fresh water in extreme southern Florida. The species accounts are ordered by family and follow the format of Gilbert and Kelso (1971). In the heading for each account, we give the scientific and common names and the classification of the fish as a primary (I), secondary (II), or peripheral (III-VI) freshwater species (Myers 1938, 1949, 1951). We also list the pertinent voucher sites (VS) at which the species was collected. An asterisk next to the site number indicates a sight record.

Each map shows the collection sites at which the species was taken, with solid symbols representing specimen records and open symbols indicating sight observations. To present the freshwater range of each species as completely as possible, the distribution maps include a number of incidental observations from locales not designated as collection sites. The maps also include records from previous studies and the references for those records if the locations differed from those at which we recorded the species.

Each account contains all past distributional data from our area of study, a regional overview of distribution in adjoining areas of southern Florida, a summary of findings from our sampling, a discussion of habitat, relative abundance, and pertinent ecological data. In the accounts of euryhaline species collected within the study area, we cite all other southern Florida freshwater records from the literature, even if the records were from localities at which salinities slightly exceeded $0.0^{o}/oo$ (e.g. Gunter and Hall 1963a, 1963b, 1965). If a subspecific epithet is recognized for the species in our region, it is given in the account. We have also provided distributional information from data obtained during a fish monitoring program in the Everglades from 1966 to 1972 (Kushlan 1980a). Notes on species whose reported occurrence or persistence in our region is doubtful are presented separately in a section following the species accounts.

CARCHARHINIDAE -- requiem sharks

1. *Carcharhinus leucas* (Valenciennes) - bull shark (VI)
VS 15 Figure 14

We collected two small specimens of the bull shark in a gill-net set during early November in the main channel of Broad River, at the junction of a small tributary 22 km from its mouth. One juvenile male specimen was saved. Its lengths were 58.0 cm precaudal, 65.5 cm fork, and 76.5 cm total. The lengths of both specimens were similar and were in the range for newborn bull sharks from the Florida Gulf coast (Clark and von Schmidt 1965). This is the second time that specimens of the bull shark have been collected in fresh water in extreme southern Florida, and it represents a new freshwater record for the area (Burgess and Ross 1980). The first specimen was taken in Watson River in 1966 (Tabb et al. 1974). Odum (1971) also observed sharks, most probably this species, in North River. Two newborn specimens of *C. leucas* were taken in a gill net set in Shark River in May 1980 at $0.8^{o}/oo$ salinity (D. Wright and T. Kranzer pers. comm.), just downstream from the freshwater section of this creek. The small size of the freshwater specimens suggests that the Everglades estuaries may serve as birthing and nursery grounds for the bull shark, as does the Indian River Lagoon system to the north (R.G. Gilmore pers. comm.). Our collection of newborns in November differs from Clark and von Schmidt's (1965) finding that spring is the season of birth.

We did not take *C. leucas* in our other river samples, although it undoubtedly enters fresh water in other Florida coastal areas (Gilmore 1977). Bull sharks are noted for their ability to ascend long distances into fresh water, occurring in rivers, lakes, and estuaries along the Atlantic, Gulf, and Caribbean

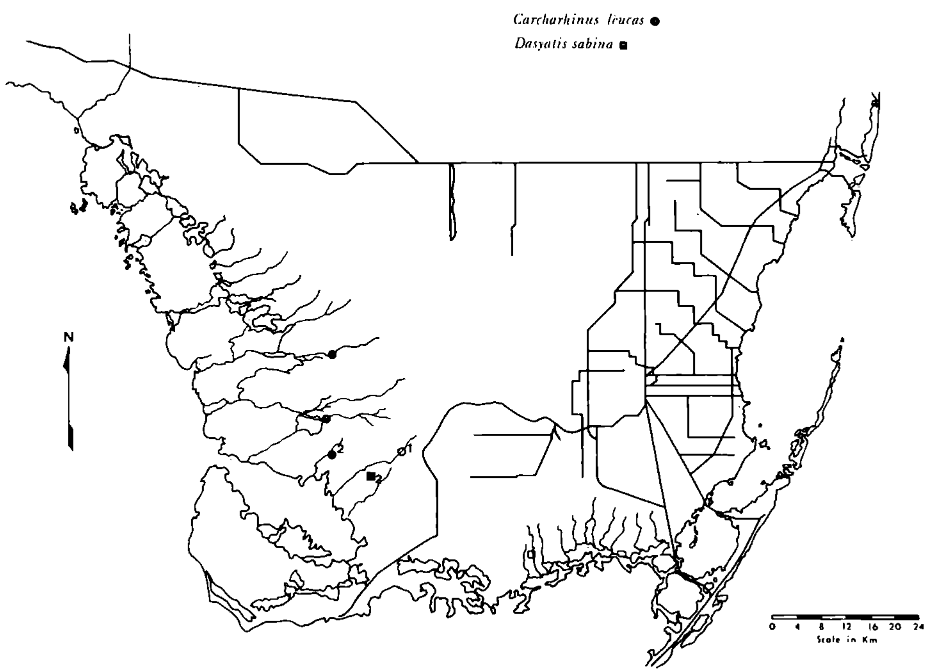

Figure 14.-- Distribution of Carcharhinus leucas and Dasyatis sabina in fresh water in southern Florida. Open symbols signify sight records. 1 = Odum (1971); 2 = Tabb et al. (1974).

coasts (Gunter 1938; Bigelow and Schroeder 1948; Miller 1966; Thorson et al. 1966; Swift et al. 1977; Burgess and Ross 1980).

DASYATIDAE -- stingrays

2. *Dasyatis sabina* (Lesueur) - Atlantic stingray (VI)
VS 24* Figure 14

A stingray that we observed in a mud-bottomed pool in Taylor River was most likely this species, because it is the only North American stingray that commonly enters fresh water (Ross and Burgess 1980). Freshwater specimens were collected in our study area in 1966 by Tabb et al. (1974), and we believe that *D. sabina* is more widespread in estuarine and fresh waters than our collection data indicated. This species has previously been reported from fresh water in the St. Lucie (Gunter and Hall 1963a) (0.2-0.3^{o}/oo) and the Caloosahatchee rivers (Gunter and Hall 1965) and in the Indian River region (Gilmore 1977).

LEPISOSTEIDAE -- gars

3. *Lepisosteus platyrhincus* De Kay - Florida gar (II)
VS 1, 2, 3, 4*, 5*, 6, 7, 8, 9, 10, 12, 13*, 15, 16*, 21, 22, 23, 24, 25, 26, 27, 28*, 29, 31, 32, 37 Figure 15

The Florida gar is a common resident of southern Florida's fresh waters, where it is perhaps the most abundant large fish species in deep-water habitats. It occurs in all habitats in Lake Okeechobee (Ager 1971) and ranges southward through the Everglades Water Conservation Areas (Dineen 1974) and Big Cypress Swamp into the southern Everglades. The Florida gar is most abundant in well-established canals and rockpits, alligator ponds, and mangrove-lined headwater creeks. Belshe (1961) stated that gar were uncommon in urban and agricultural canals, and our findings support his conclusion. The canals of eastern Dade County held far fewer gar than canals in the Everglades region. Gar occur in the open marshes of the Everglades year round. During the wet season, they are widely dispersed throughout the marshes and are difficult to capture. As water levels decrease during the dry season, gar concentrate in alligator ponds (Kushlan 1974a), and it is then possible to take several hundred from a small pond. Each pond concentrates gar from large areas of marsh and serves as a dry season refuge, as do canals in the northern Everglades (Dineen 1974). During the dry season, such dense concentrations of gar have been reported to be susceptible to parasitic infestations of *Argulus* sp., which sometimes results in high mortality

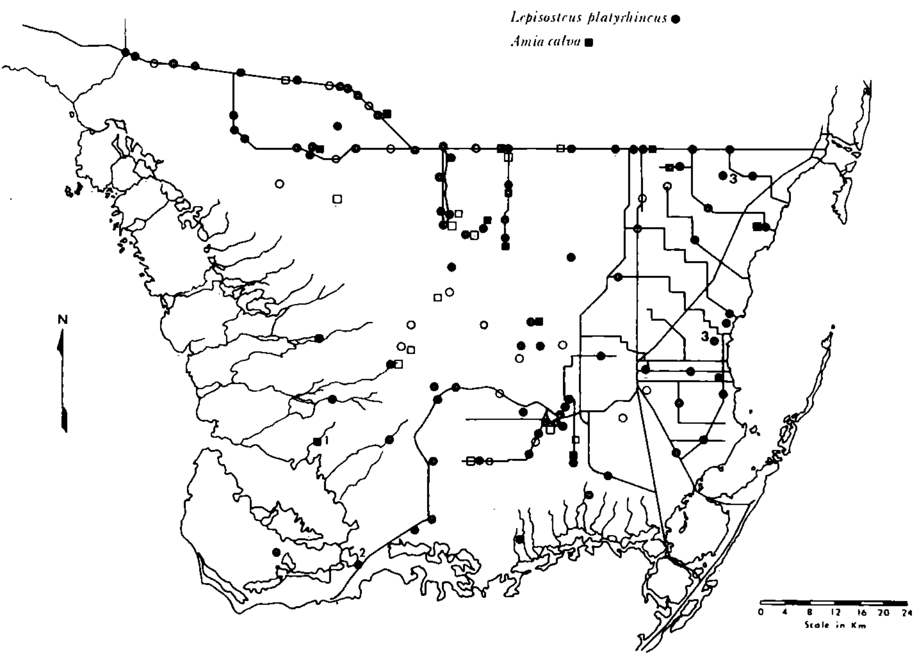

Figure 15.-- Distribution of Lepisosteus platyrhincus and Amia calva in fresh water in southern Florida. Open symbols signify sight records. 1 = Tabb et al. (1974); 2 = Tabb and Manning (1961); 3 = Mark Hudy (pers. comm.).

(Kolipinski 1969). The gar uses its swim bladder for aerial respiration (McCormack 1967), enabling the fish to survive low oxygen conditions during the dry season.

We rarely collected small gar in our samples, nor were many collected during the 1965-1972 sampling program in the southern Everglades (Kushlan 1980a). Dineen (1974) and Ager (1971), despite their extensive sampling programs, have also commented on the difficulty of collecting small gar. We did collect a series of juveniles, ranging from 190 mm to 210 mm TL, from sawgrass strands in the spring, indicating that this habitat may serve as a nursery for the young. However, we still lack adequate data on the early life history of *L. platyrhincus* in the Everglades.

L. platyrhincus occurred in most of the coastal rivers sampled during this study and was especially numerous in Shark River and Squawk Creek in winter. Odum (1971) and Tabb and Manning (1961) stated that Florida gar became abundant in the Everglades mangrove belt during the wet season; however, we often observed this species in the mangrove region even during the dry season when waters were quite saline. Kilby and Caldwell (1955) reported several sight observations in this region in habitats with estimated salinities in excess of $25^{o}/oo$. For this reason, we would classify the Florida gar as a secondary freshwater fish in southern Florida. Other authors have considered *L. platyrhincus* to be a primary freshwater fish on the basis of their collections (Suttkus 1964; Swift et al. 1977). Osmoregulation by the Florida gar was studied by Zawodny (1975).

AMIIDAE - bowfins

4. *Amia calva* (Linnaeus) - bowfin (I)
VS 1, 2, 8*, 22* Figure 15

The bowfin reaches the southern limit of its range in extreme southern Florida, where it is rarely abundant (Burgess and Gilbert 1980). Bowfin occurred in large numbers in the study area only in L-67E Canal and in the Everglades portion of Tamiami Canal. These Everglades canals seemed to provide very suitable habitat, and we were able to capture numerous specimens by electrofishing. Nearly all of the fish collected were large adults. We collected only one small (67.5 mm TL) bowfin in southern Florida during five years of sampling. Dineen (1974) also had difficulty collecting small bowfin in the Everglades Water Conservation Areas.

Many of our records for bowfin in southern Florida were observations of individuals in deep-water habitats, especially canals. We have only four observations of bowfin in the Everglades marsh. Dineen (1968) collected a large number of bowfin in northern Everglades canals and marshes. He found that *Amia calva* comprised a major portion of the biomass in the canals, and that it was one of the first large fishes to be found in newly flooded marshes. Neither of these situations appears to hold for the southern Everglades.

The bowfin is better able to survive Everglades dry season conditions than many other native species. It is capable of aestivating (Neill 1950), and Dineen (1974) reported finding live bowfin buried in the sediment of freshly-dried Everglades marshes. This adaptation may allow the fish to survive a short dry-down. In addition, the bowfin is capable of using the swim bladder for absorbing atmospheric oxygen, an important adaptation in oxygen-deficient waters during the dry season. We have also found that the bowfin is an important predator on large centrarchids in Everglades canals during the dry season.

ELOPIDAE - tarpons

5. *Elops saurus* Linnaeus - ladyfish (VI)
VS 15, 16, 22 — Figure 16

This species is a common inhabitant of salt and brackish waters along the Florida coast. Ladyfish enter fresh water in most coastal rivers that drain the Everglades marsh. We caught several large series of specimens in gill nets set in the main river channels. Our collections included adults, which had been poorly represented in most earlier collections from Florida fresh water (Odum 1971). Juvenile ladyfish had been previously collected in southern Florida fresh waters in mangrove-lined ponds and lakes (Tabb and Manning 1961). Odum (1971) collected many juveniles, all less than 346 mm SL, in the mangrove zone of North River and remarked on the river's importance as a nursery for ladyfish. The same is probably true of most of the rivers that drain the southern Everglades.

6. *Megalops atlanticus* Valenciennes - tarpon (VI)
VS 1*, 2, 22 — Figure 16

The tarpon is a widespread inhabitant of southern Florida fresh waters, where it is restricted to deep-water habitats. We took only a few specimens during our sampling, even though adult and juvenile tarpon are frequently taken by anglers in coastal freshwater rivers. Tarpon penetrate the Everglades region by using canals during high-water periods. They occur in freshwater canals throughout the Everglades, the Big Cypress Swamp, and along both coasts (Kushlan and Lodge 1974) but are relatively uncommon there. We have a number of sight records from the larger canals in our study area, especially Tamiami Canal, C-111, and L-31N Canal. A population of

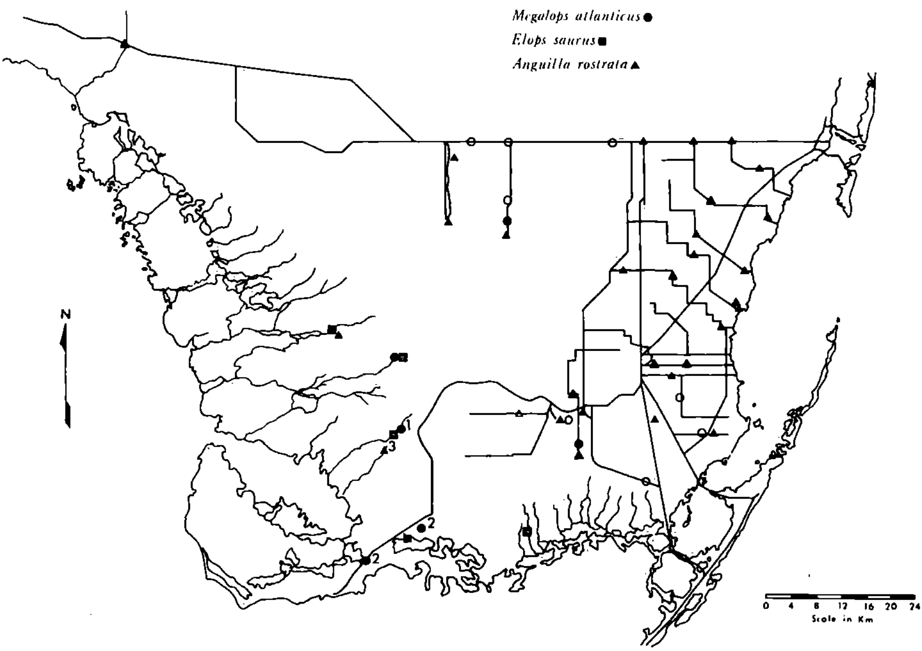

Figure 16.-- Distribution of Megalops atlanticus, Elops saurus, and Anguilla rostrata in fresh water in southern Florida. Open symbols signify sight records. 1 = Odum (1971); 2 = Tabb and Manning (1961, 1962); 3 = Tabb et al. (1974).

adults inhabited L-67E Canal until killed by freezing temperatures in January 1977. Most of the fish exceeded 1.5 m in length. Tarpon were not seen again in the canal until July 1978, and they persisted through the end of our study. We collected and photographed a 1.0 m TL specimen there on 15 January 1981. Ager (1971) reported sighting tarpon in Lake Okeechobee, and Dineen (1974) found large tarpon in canals in Everglades Conservation Area 3-A.

During high-water periods, tarpon apparently can move across inundated marshes to reach deeper bodies of water. Their irregular appearances in isolated borrow ponds, such as those at Anhinga Trail, are evidence of these movements.

ANGUILLIDAE - freshwater eels

7. *Anguilla rostrata* (Lesueur) - American eel (V)
VS 2, 7, 15, 21, 27, 33, 37, 39 Figure 16

The American eel is one of the few catadromous fishes in southern Florida and is the only one that commonly inhabits the southern Everglades. It was fairly common in our collections from rockpits and canal margins in the upper Shark River Slough. The eels may use the deeper waters of airboat trails to reach these inland sites 50-60 km from salt water, but it is more likely that the system of drainage canals provides the means of access to the Shark River Slough. Eels also penetrate into the northern Everglades where they commonly occur in canals (Dineen 1974).

The American eel inhabits headwater rivers and creeks where we collected them mainly from undercut banks. Odum (1971) found eels in similar habitats in North River. We also collected *A. rostrata* from drainage canals along the east coast where they were quite numerous. In all habitats, eels occur in cavities in the rocky sides of rivers and canals during daylight hours. It is likely that *A. rostrata* occurs in all streams and canals with access to salt water in southern Florida (Kushlan and Lodge 1974). Our collections show that *A. rostrata* has a larger range in extreme southern Florida than that presented by Lee (1980a).

CLUPEIDAE - herrings

8. *Dorosoma cepedianum* (Lesueur) - gizzard shad (IV)
CS 155, 172* Figure 17

The gizzard shad is a rare species in southern Florida fresh waters, where it is restricted to the canal system. It is apparently much more common in lakes and canals in central Florida (Ager 1971; Wegener and Williams 1974;

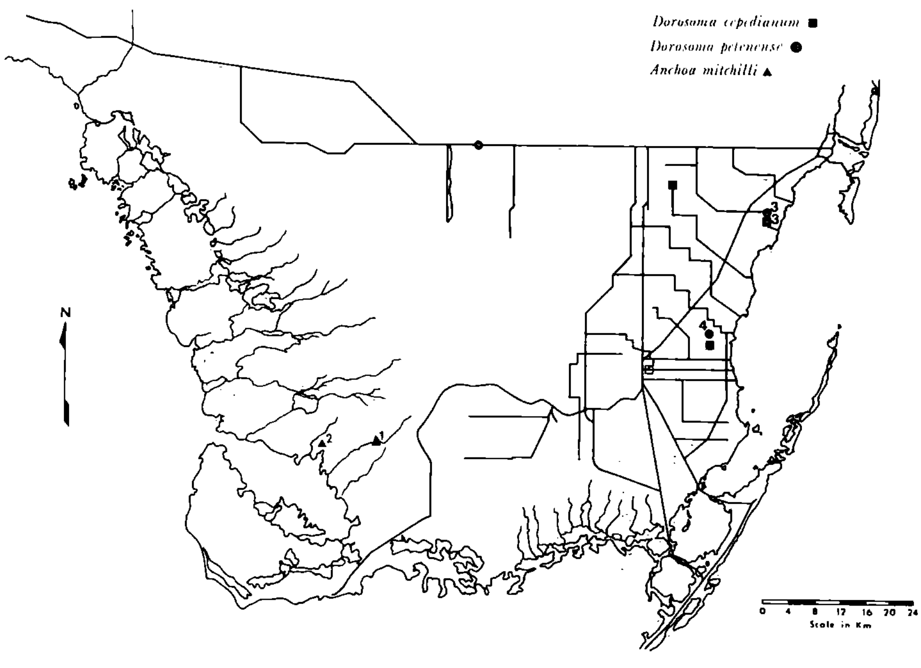

Figure 17.– Distribution of Dorosoma cepedianum, Dorosoma petenense, and Anchoa mitchilli in fresh water in southern Florida. 1 = Odum (1971); 2 = Tabb and Manning (1961); 3 = Hogg (1974); 4 = Mark Hudy (pers. comm.).

Gilmore 1977). The only *D. cepedianum* collected during this study was a large, recently dead specimen found in C-100 Canal. We also observed a school of approximately 50 shad, all exceeding 200 mm SL, in a Homestead canal. We presume that these shad were *D. cepedianum* because they exceeded the maximum size reported for *D. petenense* (Stevenson 1976; Burgess 1980f). Additional southern Florida specimens of *D. cepedianum* have been taken by Hogg (1976a) in Snapper Creek Canal and by Dineen (1974) in northern Everglades canals. These data extend its known range as given by Megrey (1980).

9. *Dorosoma petenense* (Günther) - threadfin shad (IV)
VS 28 Figure 17

During the study, we collected only one series of threadfin shad, from the open waters of a deep canal. All were juveniles from a single large school. *D. petenense* does not occur in the Everglades marsh or in the coastal rivers, and it has not been reported from large drainage canals in the northern Everglades (Dineen 1974). We are aware of only one other record from our study area, an east coast borrow pond (Mark Hudy pers. comm.). In the St. Lucie estuary, Gunter and Hall (1963a) also took only juveniles at low salinities. The paucity of shad in our samples may be due to their patchy distribution pattern, typical of schooling species. For that reason, we may have missed the threadfin and gizzard shads in some canals. The threadfin shad has a larger range than that shown by Burgess (1980f).

ENGRAULIDAE - anchovies

10. *Anchoa mitchilli* (Valenciennes) - bay anchovy (VI)
Not collected Figure 17

This widespread species was considered to be the most abundant fish in the brackish waters of Everglades National Park by Tabb and Manning (1961), who also collected it in fresh water. Odum (1971) found *A. mitchilli* in North River, but the salinity of the site was not reported. The bay anchovy has also been taken in fresh water in the St. Lucie River (Gunter and Hall 1965), from the Peace River (Wang and Raney 1971), and in the Indian River area (Gilmore 1977). We did not collect this species during our sampling.

ESOCIDAE - pikes

11. *Esox niger* Lesueur - chain pickerel (I)
VS 1, 2*, 7* Figure 18

The chain pickerel is a rare fish in extreme southern Florida. Briggs (1958) listed *E. niger* as ranging to the tip of the peninsula, but few records of the fish exist for Everglades National Park. We collected several specimens, all from the northern border of the study area in Tamiami Canal. We also observed this species in borrow pits and canals in Shark Valley and in L-67 Canal Extended. It appears that these canals mark the southern limit of the chain pickerel's range. Dineen (1968) stated that *E. niger* was common in canals in Everglades Water Conservation Area 2, but it had not become established in Water Conservation Area 3 because the species required a nearby deep-water marsh for spawning. Such deep-water marshes are uncommon south of Tamiami Canal. Heavy predation may affect its numbers at the northern border of our study area.

CYPRINIDAE - carps and minnows

12. *Notemigonus crysoleucas* (Mitchill) - golden shiner (I)
VS 1, 3, 4*, 5, 7, 10, 13, 17, 24, 26*, 27, 28, 29, 30, 31, 32, 33, 35, 36, 39 Figure 18

This important bait and forage species is the most abundant and widespread cyprinid in southern Florida. *N. crysoleucas* occurs in Lake Okeechobee (Ager 1971) and is common in the northern Everglades where it moves far into the marsh following wet season inundation (Dineen 1974). The golden shiner appears to be the southern Florida cyprinid best adapted to environmental conditions in the Everglades and Big Cypress Swamp. The preferred natural habitat appears to be alligator ponds, although we have occasionally collected juvenile shiners in marshes. This species is particularly numerous and attains its largest size in canals and rockpits, where it inhabits open, midwater areas. The golden shiner also occurs in mangrove-lined creeks and ponds in the headwaters region.

13. *Notropis maculatus* (Hay) - taillight shiner (I)
VS 35; CS 82, 161B Figure 19

In southern Florida, the taillight shiner ranges from Lake Okeechobee (Ager 1971) southward to the southern Everglades, where it and *N. petersoni*

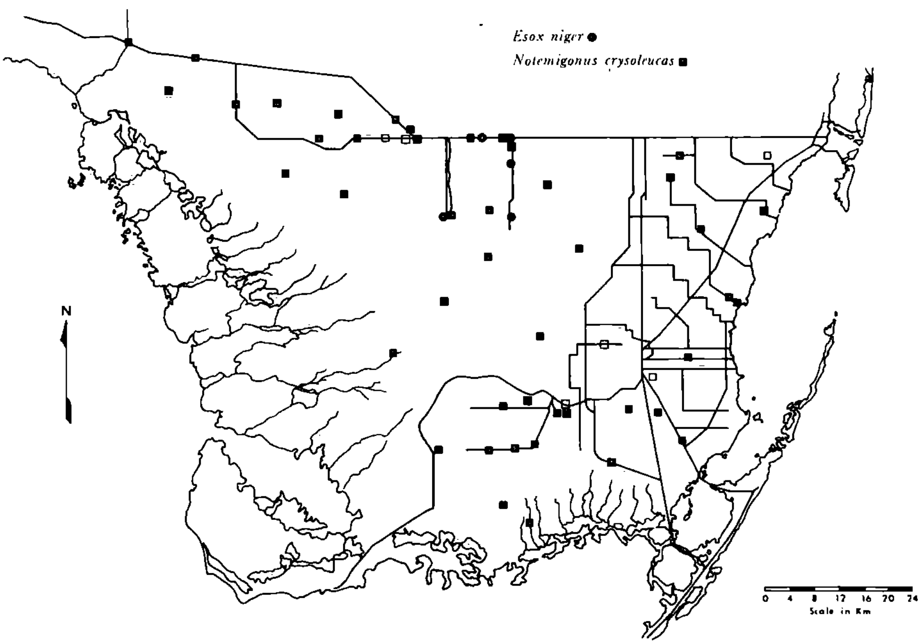

Figure 18.– Distribution of Esox niger and Notemigonus crysoleucas in fresh water in southern Florida. Open symbols signify sight records.

are the only two native species of *Notropis*. Both species are uncommon in our study area. The taillight shiner has been collected in only five locations in extreme southern Florida. Specimens were collected in an alligator pond in the Big Cypress Swamp (Kushlan 1974a) and were also taken in two out of six years of a study in the Everglades marshes (Kushlan 1980a). Specimens were collected in the Everglades marsh only during a prolonged high-water period (Kushlan 1980a) when conditions for the shiner may have been more suitable. We collected it in L-31W Canal, C-1 Canal, and in a mangrove-bordered pond near the headwaters of Taylor River. This last record from extreme southern Florida represents an extension of the range of *N. maculatus*, as provided by Kushlan and Lodge (1974) and Gilbert (1980b). To the west of our study area, Carter et al. (1973) collected specimens from canals in the Fakahatchee Strand. Large numbers of taillight shiners have been collected occasionally in northern Everglades canals (Dineen 1974).

Two explanations can be offered for the apparently discontinuous distribution of this species in southern Florida. The small population size of this shiner may enable it to escape detection during routine sampling, and the scarcity of slow-flowing canals, its preferred habitat (Kushlan and Lodge 1974), may limit its occurrence.

14. *Notropis petersoni* Fowler - coastal shiner (I)
VS 5*, 10, 25; CS 81, 82, 112 Figure 19

The coastal shiner is a widespread but uncommon fish in southern Florida. It has been recorded from Lake Okeechobee (Ager 1971) and the Caloosahatchee River (Gunter and Hall 1965) but has not been collected in the St. Lucie River (Gunter and Hall 1963a) or in the northern Everglades (Dineen 1974). *N. petersoni* was collected in only four of six years of a previous study in the southern Everglades (Kushlan 1980a), during which sizable collections of the coastal shiner were made. Kushlan and Lodge (1974) noted that, although it was the most numerous *Notropis* species in southern Florida, it varied in year-to-year abundance. This variation is well illustrated by the absence of *N. petersoni* in the samples from Shark River Slough taken during our study period, despite extensive collecting. We do not understand the reasons for this variation in numbers and distribution, but its periodic abundance must be related to irregularly favorable environmental conditions that allow the species to multiply and disperse rapidly.

We collected several large series of *N. petersoni* during the present study in Taylor Slough, from a habitat atypical of the Everglades, where water cascaded over a wooden structure to form a pool. A school of shiners gathered at the head of the pool in the current whenever the water flowed in the wet season. They were not present when water flow ceased during the following dry

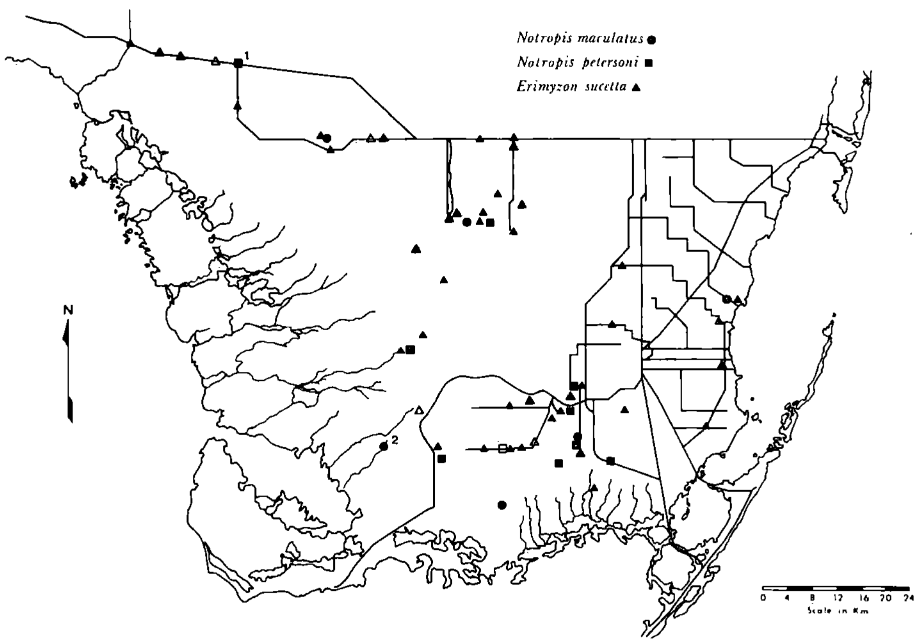

Figure 19.-- Distribution of Notropis maculatus, Notropis petersoni, and Erimyzon sucetta in fresh water in southern Florida. Open symbols signify sight records. 1 = Kushlan and Lodge (1974); 2 = Edward Rutherford (pers. comm.).

season. We also collected coastal shiners below a water control structure in L-31W Canal when water flowed swiftly over the structure. The records of coastal shiners in the southern Everglades represent range extensions for this species as given by Carr and Goin (1955), Stevenson (1976), and Swift (1980b).

CATOSTOMIDAE - suckers

15. *Erimyzon sucetta* (Lacepede) - lake chubsucker (I)
VS 1, 2, 5, 7, 8, 10, 25, 26, 28, 38, 39 Figure 19

The single species of catostomid in southern Florida is widespread but varies in abundance according to its habitat. *Erimyzon sucetta* occurs in all habitats in the southern Everglades and Big Cypress Swamp but is most common and attains its greatest size in canals and borrow pits. In the southern Everglades, adult chubsuckers normally inhabit the open waters of alligator ponds. We have taken adults in the marsh prairies primarily during spring when both sexes were in reproductive condition. It appears that adults move into the marshes to spawn. Juvenile chubsuckers are found in marsh prairies, sawgrass marshes, and canal edges, where they are especially abundant from April to July. However, we also collected juveniles at other times of year. In the northern Everglades, Dineen (1974) found juvenile *E. sucetta* nearly year-round, which indicates a lengthy spawning period at the southern terminus of its range.

The lake chubsucker usually occurs in small schools that move slowly about the bottom of ponds and canals grubbing for food. It is common to observe bluegills (*Lepomis macrochirus*) following the chubsuckers, presumably to capture prey disturbed by their actions.

Although we collected *E. sucetta* from all freshwater habitats throughout southern Florida, there are areas within this region where chubsuckers were quite uncommon. Despite much sampling in Shark River Slough, *E. sucetta* was common only in the northern part of the slough. We did not find it throughout much of the southern Big Cypress Swamp or in the East Everglades. It is our impression that *E. sucetta* is best adapted to stable, deep-water areas such as canals and may not be as successful in areas having shorter hydroperiods. The known range is larger than that shown by Wall and Gilbert (1980).

ICTALURIDAE - bullhead catfishes

16. *Ictalurus natalis* (Lesueur) - yellow bullhead (I)
VS 2, 3, 4, 6, 7, 8, 9, 10, 14, 15, 16, 17, 19, 23, 24, 25, 26, 29, 30, 31, 33, 38. Figure 20

This is the most common catfish in the southern Everglades. We collected it in marsh prairies, sawgrass marshes, alligator ponds, headwater streams, and cypress swamps. In the northern Everglades, Dineen (1974) found *I. natalis* to be more common in canals than in the Everglades marsh. In the southern Everglades, the reverse appears to be true.

The yellow bullhead was not common in headwater rivers where it appears to be replaced by two species of ariid catfishes. In those habitats, we normally took *I. natalis* among the mangrove roots or submerged vegetation at the edge of the stream, while the ariids always occurred near the bottom in mid-channel.

Like the Florida gar, the yellow bullhead exhibits seasonal movements among habitats in the southern Everglades. During high-water periods, the catfish disperse throughout the marsh system and are found in the sawgrass marshes and prairies. With the decline in water levels during the dry season, yellow bullheads concentrate in large numbers (up to several hundred per pond) in alligator ponds. *I. natalis* is better equipped than many Everglades fishes to survive the low oxygen conditions which accompany dry-down because its hemoglobin can efficiently load oxygen at low concentrations (Lodge 1974; Lagler et al. 1977). We often observed *I. natalis* swimming about alligator ponds during the dry season in compact, circular masses of individuals. These masses of catfish appear to exhibit synchronized movement (Pearson and Miller 1935). The function of this behavior is not understood, but it appears to be restricted to groups of fish confined in a limited space during the dry season and may somehow function in aiding respiration. Kushlan (1974a) observed a similar behavior in Big Cypress Swamp populations of *I. natalis* during the dry season and suggested that the movement might help to circulate oxygenated surface water into the water column where it could be utilized. The subspecies is probably *I. n. erebennus*.

17. *Ictalurus nebulosus* (Lesueur) - brown bullhead (I)
CS 5, 148, 164, 165 Figure 20

We found the brown bullhead in disturbed habitats such as canals but not in the Everglades marsh. *Ictalurus nebulosus* was never abundant in any habitat, and we did not collect it frequently. There appears to be a difference in habitat occurrence between the two bullhead species in southern Florida, the

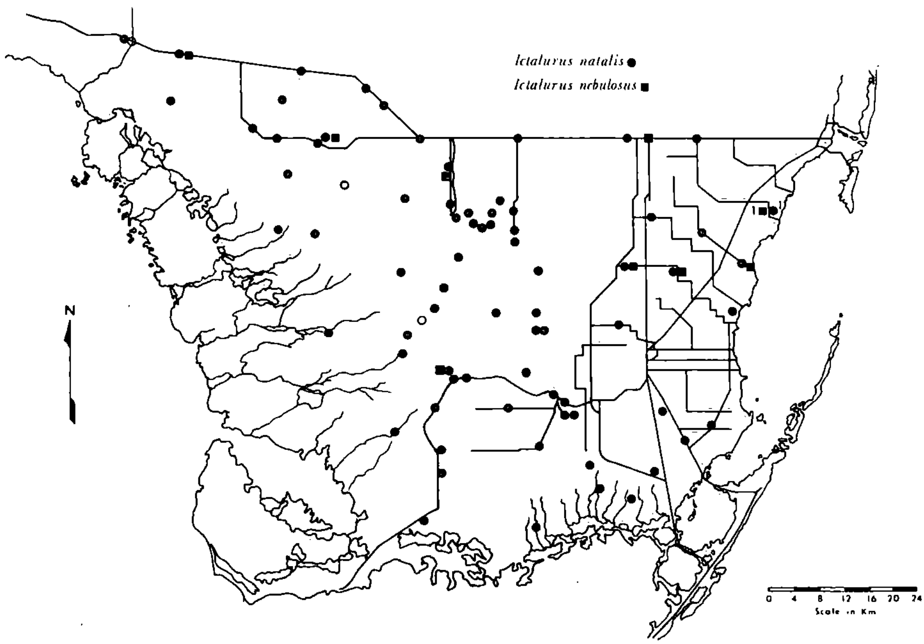

Figure 20.-- Distribution of Ictalurus natalis and Ictalurus nebulosus in fresh water in southern Florida. Open symbols signify sight records. 1 = Hogg (1974).

yellow bullhead being common in natural situations and the brown bullhead occurring in disturbed habitats. We collected both species in canals, and even there the yellow bullhead generally outnumbered the brown bullhead. Dineen (1974) did not report this distinction in the northern Everglades, instead stating that both bullheads occurred syntopically in canals and marshes. Kushlan and Lodge (1974) remarked that *I. nebulosus* appeared to be less abundant than *I. natalis* in southern Florida and that the former occurred mostly in open, muddy-bottomed habitats. Trautman (1957) found that *I. nebulosus* in Ohio was usually found in deeper, less-vegetated habitats than *I. natalis*. In southern Florida, canals best approximate such conditions. The subspecies is presumably *I. n. marmoratus*, although this species is in need of taxonomic review (C.R. Gilbert pers. comm.)

18. *Ictalurus punctatus* (Rafinesque) - channel catfish (I)
VS 1*, CS 82* Figure 21

The largest ictalurid in southern Florida occurs in Lake Okeechobee (Ager 1971) and ranges southward through the canal system of the northern Everglades (Dineen 1974). In our study area, *I. punctatus* is an uncommon fish despite repeated introductions. The Tamiami Canal, for example, is a Fish Management Area and has received plantings of channel catfish for angling purposes (Florida Game and Fresh Water Fish Commission brochure). *I. punctatus* has also escaped into the canal system near the main entrance of Everglades National Park from a nearby catfish farming operation. We have observed *I. punctatus* in these canals, and anglers sometimes report catching large specimens from these waters. We have also observed channel catfish in L-67 Canal Extended, which is continuous with the Tamiami Canal and the Conservation Area canals. We took no specimens from the Everglades marsh system, which indicates that this species does not enter marsh habitats. Dineen's (1974) findings in the northern Everglades concur with our evaluation of the habitat of this species. The channel catfish may be more widespread in the study area canals than our data indicate, but effective sampling of its deep-water habitat was difficult. Its range is larger than shown by Glodek (1980).

19. *Noturus gyrinus* (Mitchill) - tadpole madtom (I)
VS 1, 4, 10, 15 Figure 21

The smallest ictalurid in our study area occurred in a variety of habitats, from canal banks to mangrove swamps. It was most common in Everglades alligator ponds and mangrove stream edges among dense submerged vegetation, but even there it was rarely taken in large numbers. In the northern Everglades, Dineen (1974) found *N. gyrinus* to be uncommon,

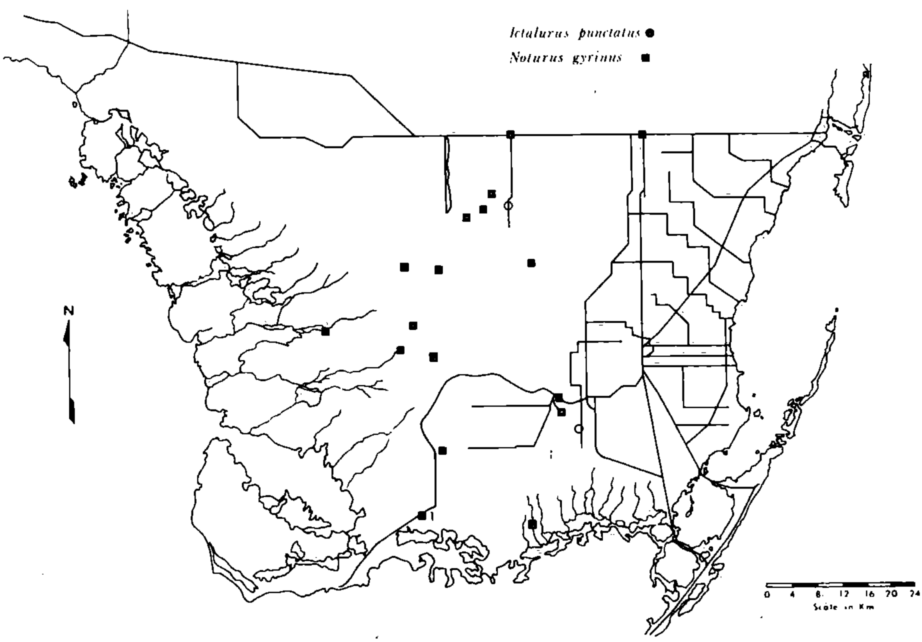

Figure 21.– Distribution of Ictalurus punctatus and Noturus gyrinus in fresh water in southern Florida. Open symbols signify sight records. 1 = Tabb and Manning (1961).

occurring primarily in deep marshes. Carter et al. (1973) did not report this species from the Fakahatchee Strand west of our study area. We did not collect specimens of *N. gyrinus* in the samples from the southern Big Cypress Swamp, and Kushlan (1974a) did not take it during his study of an alligator hole in the swamp. If *N. gyrinus* does occur in the Big Cypress Swamp, the population must be small.

Our sampling data suggest that *N. gyrinus* may be more successful in habitats with long hydroperiods. We collected most specimens in the Shark River Slough which had a sustained period without dry-down during our study. We found few or no *N. gyrinus* in the East Everglades and Big Cypress Swamp, both areas having shortened hydroperiods. As it is primarily an inhabitant of deeper marshes and canals, the absence of the tadpole madtom from large areas of southern Florida may be the result of reduced hydroperiod in many habitats.

CLARIIDAE - labyrinth catfishes

20. *Clarias batrachus* (Linnaeus) - walking catfish (II) - Exotic
VS 1*, 3, 4, 6, 7, 11*, 12, 18, 19, 23, 25, 26, 27, 32, 34, 39 — Figure 22

This most widely publicized exotic fish, *C. batrachus*, has been established in Florida for more than two decades. The original stock was imported from Bangkok, Thailand, and escaped from a north Broward County fish farm in 1965 or 1966 (Courtenay 1975). Entering the canal systems, the fish rapidly spread to adjacent areas of the state. Many of the original escapees were albino, but in successive generations, most of the population has reverted to the normal slate-gray coloration. The albino form is now uncommon in the wild.

Walking catfish presently range over much of central and south Florida. From the Kissimmee region, *C. batrachus* occurs south to Lake Okeechobee and the St. Lucie River (Courtenay 1975, 1978), and through the Everglades Water Conservation Areas (Courtenay and Robins 1973). In our study area, the walking catfish ranges from canals in the Big Cypress Swamp, across the Tamiami Canal, south through the East Everglades and rocky gladelands, and along the main Everglades National Park road to Flamingo. Recent samples from brackish-water bays and marshes, including those on Cape Sable, have included specimens of *C. batrachus*. This species also occurs in southern Dade County canals, though many were eliminated during a winter fish kill (Miami Herald, 26 December 1979). These data extend the known range of the catfish to the tip of the mainland. *C. batrachus* has thus far become well established only in disturbed situations, such as canals and borrow pits. We rarely

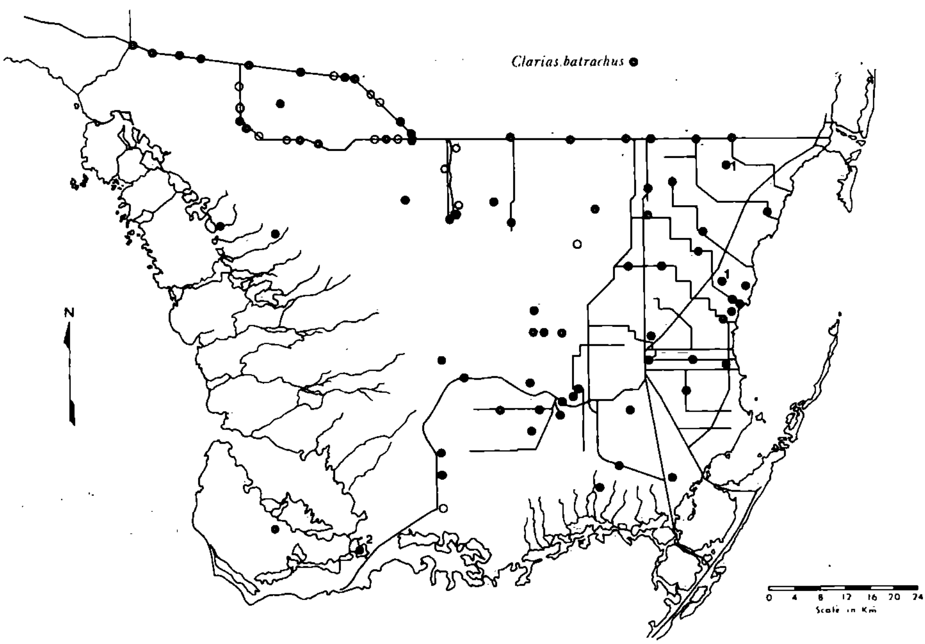

Figure 22.-- Distribution of Clarias batrachus in fresh water in southern Florida. Open symbols signify sight records. 1 = Mark Hudy (pers. comm.).

collected the catfish in natural freshwater habitats in the study area, despite intensive sampling programs. Only in the rocky gladelands, an area of shortened hydroperiod subject to repeated dry-downs, was the catfish common in a natural freshwater situation. The difficult aquatic conditions in this habitat may have given the catfish an advantage over native species there.

Courtenay and Miley (1975) expressed concern over the possible impact of walking catfish on native fishes. Because *Clarias* spawns during the wet season, they suggested that the population might greatly increase during an extended wet period. High water conditions existed in the Everglades from 1977 to 1981, but we have not seen a noticeable increase in walking catfish there. However, we have noted great increases in the abundance of *C. batrachus* in the Big Cypress Swamp, where the increases seem to be positively correlated to the duration and extent of flooding in the swamp.

The walking catfish has taken advantage of high-water periods to disperse across temporarily flooded pineland glades, extending its range southward through Everglades National Park (unpubl. data). Following heavy rains, catfish leave the canals to move overland into previously uncolonized waters. This mode of dispersal allows the species to invade new habitats and to rapidly extend its range.

The effects of a severe dry season on the ecology of *C. batrachus* are unknown at present. We agree with Courtenay (1975) that during a prolonged drought the walking catfish may adversely affect native fish populations that would already be under stress (Kushlan 1974a). *C. batrachus* can breathe air, enabling it to survive the low oxygen conditions accompanying a drought, and its aerial respiration is synchronous. This behavior, and the short time spent at the surface while respiring, may aid in reducing predation by wading birds (Loftus 1979). This combination of adaptations seems to provide *Clarias* with a great advantage over most native species. However, following the severe drought of 1981 when much of the Everglades marsh dried, there was no observable increase in the numbers or range of *C. batrachus* in the study area.

We have no current evidence that *Clarias* poses a threat to the integrity of the Everglades marsh ecosystem within Everglades National Park. Within our study area it is most numerous in canals, through which it has rapidly dispersed and in which it has survived cold spells. *C. batrachus* is now a permanent member of the freshwater ichthyofauna of southern Florida, but its conspicuous absence from most natural freshwater Everglades habitats suggests that competition with native species, or other ecological interactions, have thus far inhibited its colonization of those natural habitats.

ARIIDAE - sea catfishes

21. *Arius felis* (Linnaeus) - hardhead catfish (VI)
VS 16, 24 Figure 23

This euryhaline species occurs in a variety of habitats around southern Florida, but it is most abundant in salt and brackish waters. Hardhead catfish penetrate into the freshwater portions of the headwaters of coastal rivers in the southern Everglades but do not enter the marshes. We took *Arius felis* in gill nets in most of the rivers sampled. *A. felis* usually entered the gill nets after dark when they were actively foraging. The ranges of *A. felis* and *Bagre marinus* rarely overlapped the ranges of the three ictalurid species, all of which were uncommon in headwater streams. *A. felis* has been reported from fresh waters in southern Florida in the St. Lucie (Gunter and Hall 1963a) (0.15-0.23^{o}/oo) and Caloosahatchee rivers (Gunter and Hall 1965) and throughout North River at all seasons (Odum 1971).

22. *Bagre marinus* (Mitchill) - gafftopsail catfish (VI)
VS 16 Figure 23

We collected a single specimen of *Bagre marinus* in a gill net in the main channel of Broad River, the only record from fresh water during our study. It was collected in the company of *Arius felis* but did not approach it in abundance. Odum (1971) had previously collected *B. marinus* in fresh water in the North River, where it was out-numbered eight to one by *A. felis*. Additional freshwater records for *B. marinus* have come from the Caloosahatchee River (Gunter and Hall 1965). It appears that this euryhaline catfish is an uncommon inhabitant in southern Florida fresh water, where it occurs only in coastal rivers. However, it is apparently common in coastal fresh water in the Indian River region of central Florida (Gilmore 1977).

LORICARIIDAE - armored catfishes

23. *Hypostomus* sp. - suckermouth catfish (I) - Exotic
Not collected Figure 23

Many species of armored catfish have been imported into the United States from South America by the aquarium trade for use as scavengers and algae eaters. One or more species have escaped into southern Florida waters. We follow Robins et al. (1980) in calling armored catfish from Florida *Hypostomus* sp.

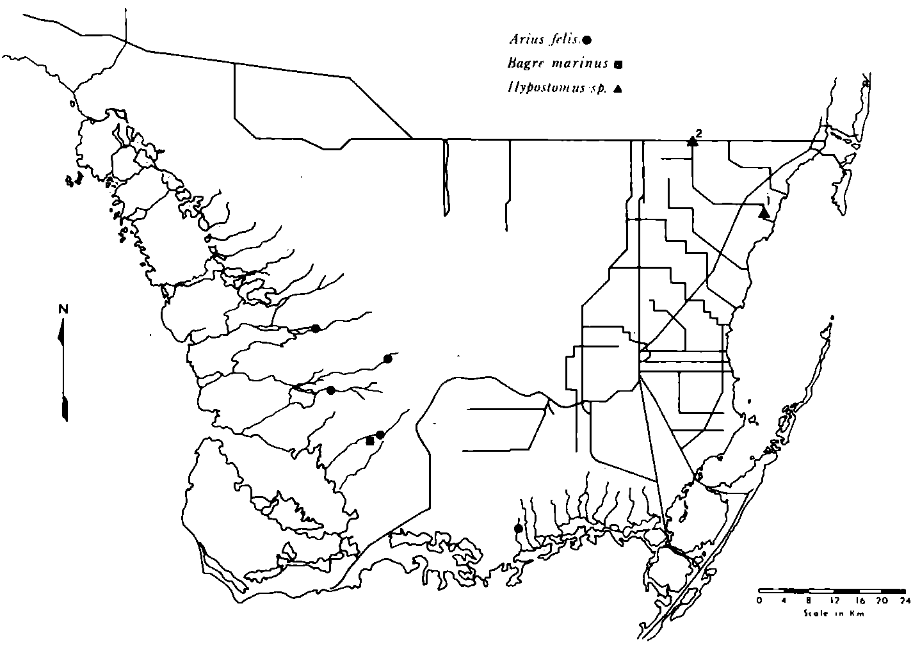

Figure 23.-- Distribution of Arius felis, Bagre marinus, and Hypostomus sp. in fresh water in southern Florida. 1 = Courtenay et al. (1974).

Hypostomus sp. was reported to be established in the Snapper Creek canal system (Courtenay et al. 1974) and in a west Miami rockpit (Rivas 1965). Additional specimens have been taken from canals near Conservation Area 3 (Courtenay et al. 1974). We did not collect any armored catfish in our study area, indicating that it has not significantly increased its numbers or distribution in southern Florida.

Paul Shafland (pers. comm.) suggests that some catfishes collected in our study area belong to the genus *Pterygoplichthys*, and that most past references to *Hypostomus* were based upon misidentifications of *Pterygoplichthys*. The generic identities of loricariid catfishes in southern Florida require further study.

BELONIDAE - needlefishes

24. *Strongylura marina* (Walbaum) - Atlantic needlefish (VI)
Not collected Figure 24

The Atlantic needlefish enters fresh water lakes and canals in southern Florida (Ager 1971; Dineen 1974) and is the North American belonid that most commonly enters fresh water (Burgess 1980h). It had previously been reported from fresh water in extreme southern Florida in canals (Kushlan and Lodge 1974) and in the North River (Odum 1971; Tabb et al. 1974). We observed dozens of needlefish in the coastal rivers during our study. It is possible that *S. marina* and *S. notata* may have occurred among the groups of needlefishes that we observed, but *S. timucu* was the only needlefish that we captured.

25. *Strongylura notata* (Poey) - redfin needlefish (VI)
Not collected Figure 24

The sole record of *S. notata* from fresh water in our study area was from the North River during 1966 (Tabb et al. 1974). The only previous record of this species in fresh water (0.25^{o}/oo) in southern Florida was of two specimens collected in the St. Lucie River (Gunter and Hall 1963a). However, Gilmore (1977) found *S. notata* to be abundant in freshwater tributaries of the Indian River area of central Florida. As mentioned in the previous account, we were unable to collect many of the needlefishes that we observed, so we may have missed this species. Although *Strongylura* species penetrate fresh water in southern Florida, they are restricted to the coastal canals, tidal rivers, and pools, and apparently do not enter the bordering marshes.

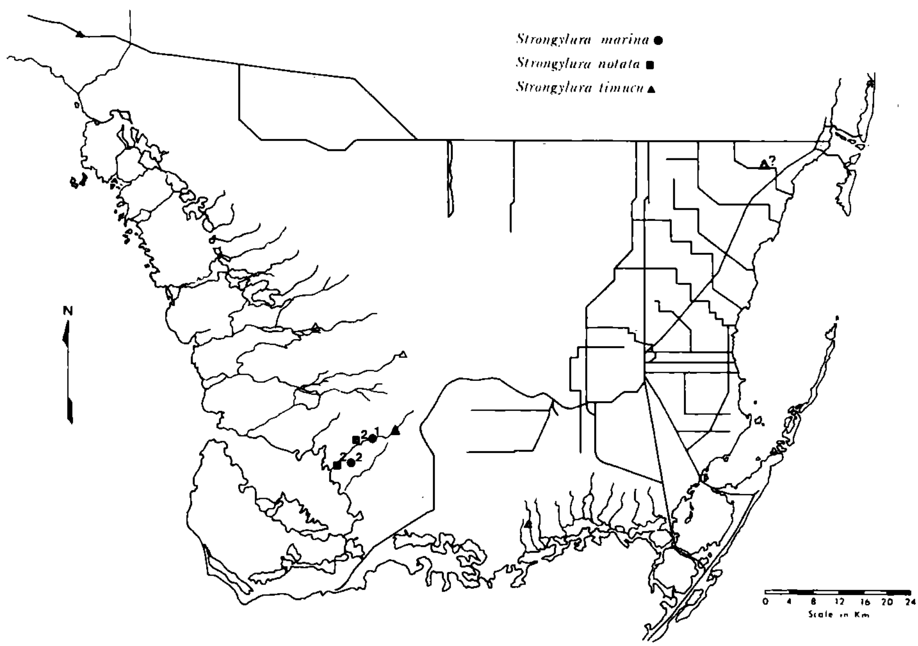

Figure 24.-- Distribution of Strongylura marina, Strongylura notata, and Strongylura timucu in fresh water in southern Florida. Open symbols signify sight records. 1 = Odum (1971); 2 = Tabb et al. (1974).

26. *Strongylura timucu* (Walbaum) - timucu (VI)
VS 16, 24 Figure 24

This common needlefish apparently enters fresh water in coastal canals and rivers around southern Florida. It has been collected in fresh water in southeastern Dade County canals (Belshe 1961), in the North River (Odum 1971), and in the northern Ten Thousand Islands region (Kushlan and Lodge 1974). We collected the timucu in gill nets and in rotenone samples in Taylor and North rivers. Needlefish in these rivers occurred either alone or in small groups near the water surface, although on occasion we observed groups of several dozen. Though we did not collect *S. timucu* in all river samples, our observations lead us to believe that it probably enters fresh water in most coastal areas of southern Florida.

CYPRINODONTIDAE - killifishes

27. *Adinia xenica* (Jordan and Gilbert) - diamond killifish (VI)
VS 3, 7*, 8, 16 Figure 25

This euryhaline killifish commonly occurs along the Gulf coast of Florida, where it tolerates salinities ranging from fresh to hypersaline (Springer and Woodburn 1960; Tabb and Manning 1961). In our study area, it was most abundant in brackish water (Tabb and Manning 1961; Odum 1971), but also occurred in fresh water in the mangrove zone (Tabb and Manning 1961: Odum 1971) and in the southern Everglades (Kushlan and Lodge 1974). Hastings and Yerger (1971) presented data on the life history and ecology of this species in Florida.

A. xenica is an uncommon fish in fresh water in the southern Everglades. Although we collected it along the length of the Shark River Slough from Tamiami Trail to the headwaters area, the number of specimens taken was never large. In collections made in the Shark River Slough, the numbers and distribution of this species were quite variable, and the species did not appear in repetitive samples for many months in a row. *A. xenica* apparently does not occur regularly to the north in the Everglades Water Conservation Areas, because neither we nor Dineen (1974) have ever collected it there despite extensive sampling.

In southern Florida, we collected *A. xenica* in a variety of freshwater habitats. In the Everglades it occurs in the densely vegetated marsh prairies and in road culverts connecting marsh habitats. *A. xenica* seemed to be most common in mangrove-lined pools and streams in the headwaters region. We collected our largest series of specimens from such habitats.

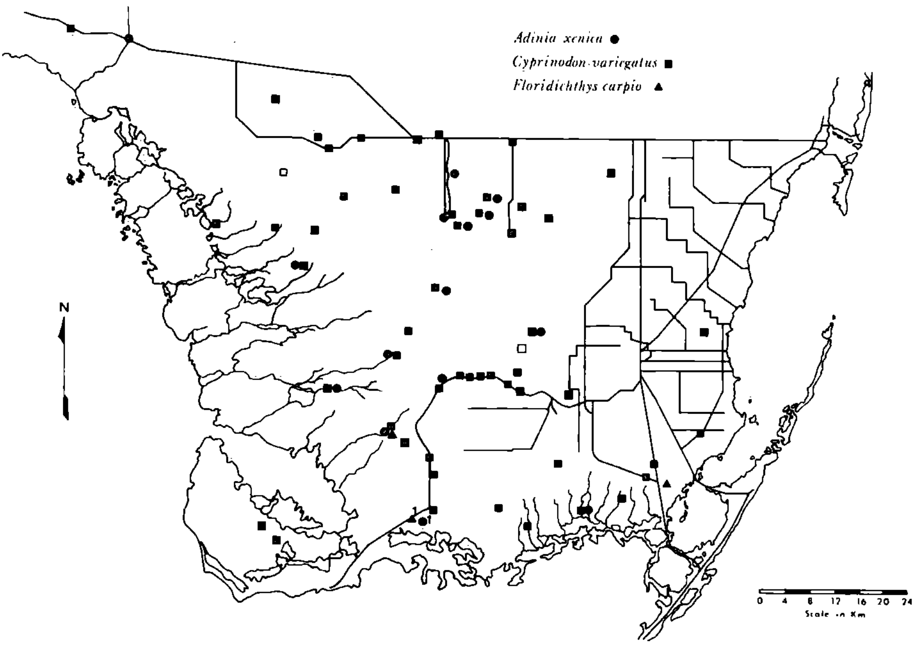

Figure 25.– Distribution of Adinia xenica, Cyprinodon variegatus, and Floridichthys carpio in fresh water in southern Florida. Open symbols signify sight records. 1 = Tabb and Manning (1961).

The diamond killifish is a species with a limited distribution in fresh water in southern Florida. Most commonly found in mangrove regions, it is also a permanent but uncommon member of the freshwater ichthyofauna of the southern Everglades. The factors that limit its numbers and distribution in southern Florida fresh waters are unclear.

28. *Cyprinodon variegatus* Lacepede - sheepshead minnow (VI)
VS 1, 2, 3, 6, 7, 8, 9, 10, 11, 13, 14, 16, 17, 19, 20, 22, 24, 31*, 34, 35 — Figure 25

The sheepshead minnow occurs along both coasts of Florida in brackish and fresh waters. It is a widespread and locally common member of the southern Everglades fish community in both Shark River Slough and Taylor Slough. *C. variegatus* also occurs in prairies in the Big Cypress Swamp and in the mangrove pools and marshes in the headwaters region. It is especially abundant in the shallow marshes bordering the headwaters of coastal rivers. Johnson (1974) provided a thorough diagnosis of this species.

In the southern Everglades, *C. variegatus* is most numerous in shallow areas, free of dense vegetation, with marl or rocky substrates. Marshes of the East Everglades, rocky gladelands, road culverts, and canal edges best characterize its habitat. The sheepshead minnow is uncommon in heavily vegetated marsh prairies and sawgrass marshes.

In the southern Everglades small groups of sheepshead minnows move slowly about the bottom, their pale body color blending well with the limestone or marl substrate. Like certain other killifishes, *C. variegatus* often buries itself in the substrate when threatened. This behavior, in addition to its coloration, probably aids in reducing predation.

Sexual differences are apparent in sheepshead minnows, and we often observed brilliantly colored males defending their nests during the long breeding season from January to October. A thorough description of the breeding biology and behavior of *C. variegatus* in southern Florida has been provided by Raney et al. (1953).

Odum (1971) discussed the fluctuation of fish populations in the North River and found that this species was greatly outnumbered by *Floridichthys carpio*. The opposite situation was described by Tabb et al. (1974) from the same river, several years earlier. In our sampling of North River, *C. variegatus* was very numerous in the freshwater sections, but we found few *F. carpio*. Apparently, *C. variegatus* varies in abundance from year to year in the headwaters region, and the same may be true in the Everglades and Big Cypress Swamp (Kushlan and Lodge 1974). The sheepshead minnow is uncommon in fresh water in the northern Everglades region, rarely occurring in samples from the Everglades Water Conservation Areas (Dineen 1974) or from Lake Okeechobee (Ager 1971). Christensen (1965) reported *C. v. hubbsi* from southern Florida as far south as the Loop Road (S.R. 94), but these specimens were reassigned to *C. v. variegatus* by Johnson (1974). Johnson (1974) did find evidence for a distinct south Florida race.

Martin (1972) discussed factors determining local distribution of *C. variegatus* in Texas. He collected it in areas characterized by shallow water, sparse stands of rooted vegetation, minimal wave action, and salinities greater than $10^{o}/oo$. It was frequently absent from similar situations at salinities less than $10^{o}/oo$. He concluded that the absence of *C. variegatus* in lower salinity waters was probably due to competitive exclusion by centrarchids and other primary freshwater fishes. The habitat he described was similar to that inhabited by this species in southern Florida fresh water. However, there it is normally sympatric with five species of *Lepomis, Micropterus salmoides, Ictalurus natalis*, and other primary species. In the southern Everglades, primary freshwater fishes do not appear to limit the establishment of *C. variegatus* in fresh water. Martin's (1972) conclusions have also been disputed by Christensen (1965) and Johnson (1974), both of whom found positive associations of centrarchids with *C. variegatus*. Johnson (1974) proposed that a combination of limiting factors, including physiological stress in fresh water, may limit the distribution of *C. variegatus* in Florida fresh water. Our observations tend to support his contention.

C. variegatus is a permanent and locally common member of the southern Florida freshwater fauna. It is most abundant in pools and marshes in the headwaters region, where it becomes concentrated during seasonal dry-downs and serves as a major prey for wading birds (Ogden et al. 1976).

29. *Floridichthys carpio* (Günther) - goldspotted killifish (VI)
VS 16 Figure 25

The goldspotted killifish is a common inhabitant of shallow brackish and saltwater bays along both coasts of southern Florida (Briggs 1958). It is uncommon in southern Florida fresh water, occurring only in pools and rivers in the mangrove zone. We collected a series of *F. carpio* in a rotenone sample from a mangrove-lined freshwater pool along the North River. *F. carpio* had been previously collected from fresh water in the North River area by Odum (1971) and Tabb et al. (1974). As discussed in the previous species account, the numbers of *F. carpio* seem to fluctuate dramatically in fresh water. Unlike *C. variegatus*, which it closely resembles, *F. carpio* does not enter the Everglades marsh system. Foster (1967) provided a summary of its coloration and breeding behavior in Florida.

30. *Fundulus chrysotus* (Günther) - golden topminnow (II)
VS 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 28, 29, 30, 31, 32, 33, 35 Figure 26

The golden topminnow is the most abundant and widespread species of *Fundulus* in fresh water in southern Florida. It occurs in the shallow marshes surrounding Lake Okeechobee (Ager 1971) and is numerous throughout the Everglades Water Conservation Areas (Dineen 1974). We collected *F. chrysotus* in all freshwater habitats in the southern Everglades and Big Cypress Swamp and found it to be one of the most numerous fishes in these areas. *F. chrysotus* is most abundant in heavily vegetated marsh prairies and in alligator ponds in the southern Everglades, but the largest specimens usually occur in canals and headwater streams. *F. chrysotus* inhabits the upper levels of the water column, usually alone or in small groups, but never in large schools like some killifishes. Though found primarily in fresh water, the golden topminnow does enter brackish water and exhibits a tolerance for high salinities. Miller (1955) reported no evidence for its occurrence in saline waters, but Kilby (1955) collected *F. chrysotus* at salinities of 15.0-24.7^{0}/oo along the Florida Gulf coast.

Kushlan (1973a) found differing responses to dry-down between *F. chrysotus* and *F. confluentus*, in which the former retreated to deeper waters such as alligator ponds while the latter species remained in the drying marsh. He suggested that these behavioral differences may be related to reproductive differences between the two species. *F. confluentus* lays resting eggs (Harrington 1959) and may have remained in the marsh to spawn, whereas *F. chrysotus* is not known to possess this capability. During our study, we collected fry of *F. chrysotus* from recently reflooded marshes in the company of fry of *F. confluentus*, suggesting that the golden topminnow may also be able to lay eggs capable of surviving a short dry-down.

Golden topminnows exhibit sexual dichromatism in the southern Everglades. All males are marked with red spots on the body and unpaired fins, in addition to the bars and golden spots mentioned by other authors (Brown 1956; Eddy and Underhill 1978). All females lack the red spots and bars. Occasional melanistic specimens of both sexes occurred in our samples but were not as common as reported by Dineen (1974) from northern Everglades collections. Foster (1967) provided a summary of the coloration, ethology, and life history of this species.

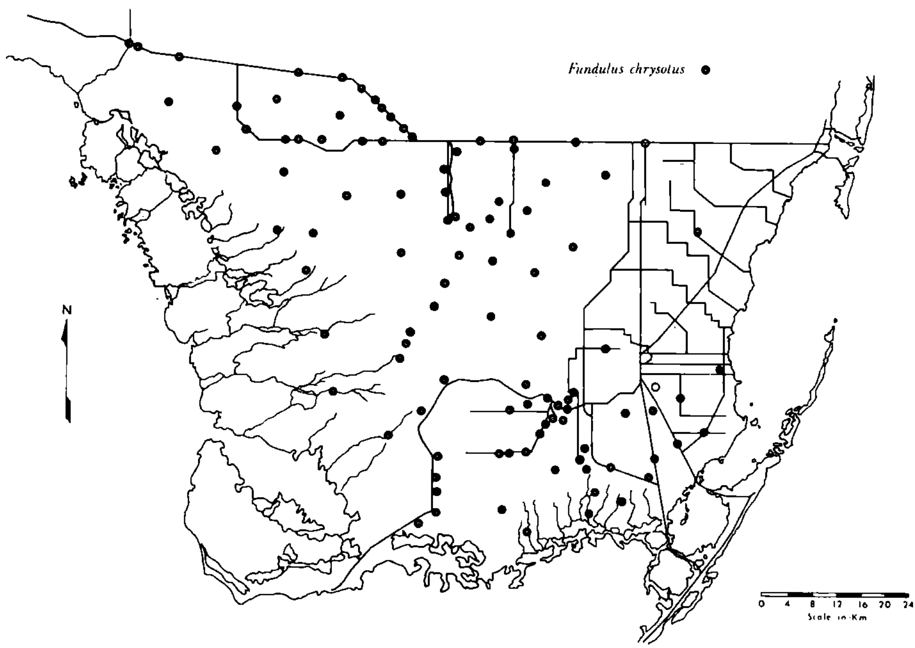

Figure 26.-- Distribution of Fundulus chrysotus in fresh water in southern Florida. Open symbols signify sight records.

31. *Fundulus confluentus* Goode and Bean - marsh killifish (VI)
VS 1, 2, 3, 4, 7, 8, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 26, 28, 31, 32, 33, 34 Figure 27

This euryhaline killifish is one of the most abundant brackish-water fishes in southern Florida (Tabb and Manning 1961) and is also widespread throughout the freshwater areas. *F. confluentus* ranges through the southern Everglades and Big Cypress Swamp. It is most abundant in the mangrove-lined creeks, pools, and marshes of the headwaters region. In the southern Everglades, the marsh killifish is the second most common *Fundulus*, but it never approaches *F. chrysotus* in abundance in fresh water. In the northern Everglades, *F. confluentus* occurs in very limited numbers (Dineen 1974). We collected the marsh killifish in a variety of freshwater habitats, including cypress swamps, marsh prairies, road culverts, and along canal banks. Like *Cyprinodon variegatus*, it is most numerous in shallow waters over a pale substrate. *F. confluentus* also exhibits burying behavior when threatened. Harrington (1959) showed that *F. confluentus* eggs were capable of surviving a lengthy dry-down, hatching soon after reimmersion in water. This mechanism enables the killifish to survive the droughts that occur seasonally throughout its southern Florida range. Similar mechanisms have evolved among many South American killifish that inhabit areas having short hydroperiods (Myers 1942). This capability may help to explain the abundance of the marsh killifish in the East Everglades, rocky gladelands, and headwater marshes, all of which are areas subject to frequent and prolonged dry-downs.

In southern Florida *F. confluentus* exhibits sexual dichromatism, which differs from descriptions by Eddy and Underhill (1978) and Stevenson (1976). Males are dark with narrow, pale bars on the flanks and light spots on the fins, instead of the series of dark, lateral bars described by Stevenson (1976). The unpaired fins of the males have yellowish-orange borders. Females possess black spots on the body and a black ocellus on the posterior rays of the dorsal fin, but they also exhibit a series of black lateral bars on a pale background. Neither of the abovementioned authors reported the lateral bars on the female. Brown (1957) and Foster (1967) examined material in which the markings agreed with our specimens. The subspecies is *F. c. confluentus*.

32. *Fundulus grandis* Baird and Girard - gulf killifish (VI)
VS 10, 11, 16, 24 Figure 27

The euryhaline gulf killifish is one of the largest species of *Fundulus* in southern Florida, where it is a common inhabitant of brackish and salt waters. It enters fresh water in southern Florida only in coastal regions. *F. grandis* had previously been collected from fresh water in our study area by Odum (1971) in

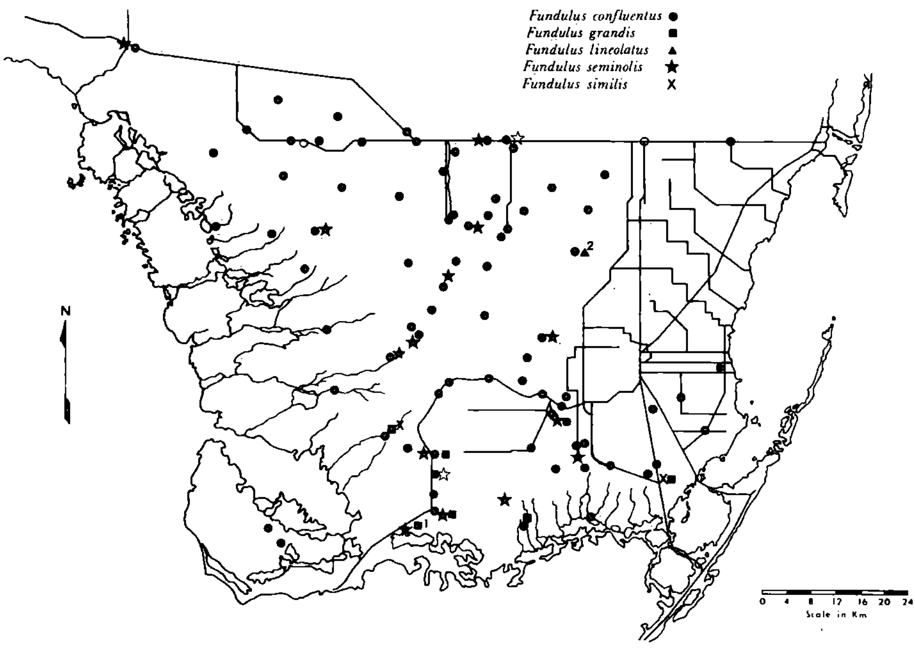

Figure 27.-- Distribution of Fundulus confluentus, Fundulus grandis, Fundulus lineolatus, Fundulus seminolis, and Fundulus similis in fresh water in southern Florida. Open symbols signify sight records. 1 = Tabb and Manning (1961); 2 = Relyea (1975).

the North River and from the area of Nine-mile Pond by Tabb and Manning (1961). We collected freshwater specimens of *F. grandis* in rotenone samples from pools along North and Taylor rivers, in a coastal marsh, and along the margin of a borrowpit.

Relyea (1975, 1983) stated that there seemed to be no records for this species along the extreme southwestern coast. Relyea's conclusion was probably the result of little collecting effort in that region, because the range of *F. grandis* in southern Florida does not appear to be disjunct. *F. grandis* is actually common in coastal streams and pools bordering the southern Everglades. It does not, however, occur in the Everglades freshwater marshes and most likely enters fresh water only in headwater creeks and coastal canals. This species has been found to produce eggs capable of withstanding desiccation (Harrington 1959), an adaptation that may help it to cope with seasonal dry-downs in coastal marshes. Our data fill in the distributional hiatus of the gulf killifish as mapped by Burgess and Shute (1980). The subspecific identity of our material is unclear because the study area forms the boundary between the ranges of *F. g. grandis* and *F. g. saguanus* as delineated by Relyea (1983).

33. *Fundulus seminolis* Girard - Seminole killifish (II)
VS 1*, 3, 10, 11, 14, 26*, 28, 35 — Figure 27

The only *Fundulus* endemic to Florida, *F. seminolis* is the largest killifish in the Everglades marsh. In southern Florida, it ranges from Lake Okeechobee (Ager 1971) and the Caloosahatchee River (Gunter and Hall 1965), southward through the canals of the Everglades Conservation Areas (Dineen 1974). Carter et al. (1973) collected *F. seminolis* to the west of our study area in canals in the Fakahatchee Strand. We collected specimens of Seminole killifish from canal edges in the Big Cypress Swamp and southern Everglades, along the margins of several rockpits, and in a sample from a marsh in Taylor Slough. It had previously been collected from culverts along the southern part of the main park road by Tabb and Manning (1961). Although reported from Shark River Slough by Kushlan and Lodge (1974), we did not collect *F. seminolis* there during the present study. From 1976 to 1982, we saw only one school of these fish near the headwaters region of the slough. In contrast, in 1969 and 1970, the Seminole killifish was taken frequently along the length of the slough (Kushlan 1980a), illustrating that the numbers and distribution of *F. seminolis* fluctuate over time.

In April 1983 following a two year period of record high water levels in Shark River Slough, we observed Seminole killifish in the upper portion of the slough for the first time. Collection data from the southern Everglades indicate that this species may inhabit Shark River Slough only during extended periods of high water levels.

F. seminolis is most abundant in shallow, open-water areas over light substrate, the habitat typically found along canal and rockpit margins. Its pale coloration makes it difficult to observe and probably provides protection against predation. *F. seminolis* is the only freshwater *Fundulus* in the Everglades region to travel in schools, a behavior that may be related to the open character of its habitat. DuRant et al. (1979) recently presented life history data for this species in central Florida. Our distributional data for *F. seminolis* extend the range given by Stevenson (1976) and Gilbert (1980c) to the limits of fresh water in southern Florida.

34. *Fundulus similis* (Baird and Girard) - longnose killifish (VI)
VS 16 Figure 27

Relyea (1983) placed *F. similis* in the synonomy of *F. majalis*; we continue to use the name *Fundulus similis* here to be consistent with Robins et al. (1980). *F. similis* is euryhaline and typically inhabits shallow estuaries, salt marshes, and lagoons (Briggs 1958; Relyea 1983). It rarely enters fresh water. We collected a single specimen of *F. similis* from a pool along the North River and took several specimens from fresh water in a tidal marsh along C-111 Canal. These represent the first freshwater records for this species in southern Florida. The only other freshwater record for *F. similis* of which we are aware is from the coast of east central Florida (Gilmore 1977). The individual from the North River fit the meristic and morphometric formula for *F. similis* but was atypically colored. It showed a pattern of dark bars along the flanks that were much wider than the interspaces, the opposite pattern of a normally colored specimen. Unfortunately this specimen has been lost. Additional adults were taken from fresh water near C-111 Canal. *F. similis* is apparently capable of surviving in fresh water for short periods, but it cannot be considered to be a common member of southern Florida's freshwater fauna. It is much more numerous and widespread in coastal waters where it occurs over a wide range of salinity (Martin and Finucane 1967). Relyea (1975, 1978, 1983) found no specimen records for the southwestern coast of our study area, but this species does occur throughout that region in estuarine habitats. The taxonomic status of the southern Florida population remains unclear and may prove to be at least subspecifically distinct (Relyea 1978; C.R. Robins pers. comm.).

35. *Jordanella floridae* (Goode and Bean) - flagfish (II)
VS 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 29,31, 32, 33, 34, 35, 36 — Figure 28

The second species of killifish endemic to Florida (Gilbert and Burgess 1980b), the flagfish is widespread and locally abundant in southern Florida fresh water. *J. floridae* inhabits the shallows of Lake Okeechobee (Ager 1971) and ranges southward through the Everglades Water Conservation Areas (Dineen 1974) into the Fakahatchee Strand (Carter et al. 1973), the Big Cypress Swamp, and southern Everglades (Kushlan and Lodge 1974). The flagfish enters brackish water in the headwaters region where we collected it in salinities in excess of 12.0^{o}/oo. It had been previously collected in brackish water in our study area by Tabb and Manning (1961) who remarked on the extreme fluctuations in its numbers.

J. floridae is present in all freshwater habitats within our study area. We found it to be especially common in the Big Cypress Swamp during low water, at which time the fish become concentrated in road culverts and ponds. In some culverts we observed crowded masses of thousands of *J. floridae* jammed together. The reasons for this crowding behavior were not clear, especially in light of the presence of nearby, continuous aquatic habitats where ample space was available.

In the southern Everglades, we collected few flagfish in marsh prairies with dense, submerged vegetation. They are more common in sparsely vegetated marshes with loose peat or marl substrates into which they can bury when threatened. In these open marshes, we often observed flagfish in small groups moving along the bottom taking in mouthfuls of sediment. In canals and alligator ponds, we collected *J. floridae* only along the vegetated margins. Flagfish in all habitats are strictly bottom dwellers.

During the spring, we observed nesting flagfish in open marsh prairies in southern Everglades. The larger, more colorful males excavate small depressions in the soft substrate and attempt to attract females to the nest while defending a territory of up to 25 cm in diameter. In one small area of marsh, we counted several dozen nests in May 1978. Foster (1967) summarized the nesting biology of *J. floridae* and its behavior in aquaria.

Eddy and Underhill (1978) erroneously reported that *J. floridae* occurred in coastal marshes from Florida to Yucatan. The flagfish was reported from Yucatan by Barbour and Cole (1906), but this record was based upon an incorrect identification. Hubbs (1936) erected a new genus, *Garmanella*, for the Yucatan fish, which does slightly resemble *J. floridae* and may be closely related (C.R. Gilbert pers. comm.)

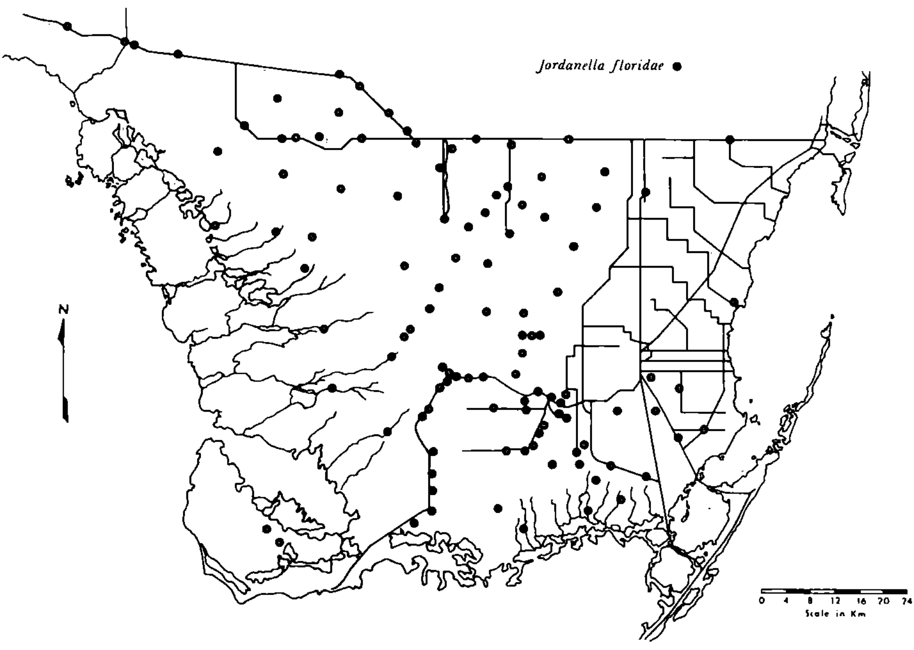

Figure 28.– Distribution of Jordanella floridae in fresh water in southern Florida.

36. *Lucania goodei* Jordan - bluefin killifish (II)
VS 1, 2, 3, 4, 5, 6,7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21,22, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 36, 37, 38 Figure 29

L. goodei is one of the four most numerous fishes in the southern Everglades, rivaled in abundance only by *Gambusia affinis*, *Heterandria formosa*, and *Poecilia latipinna*. Bluefin killifish are numerous in the littoral zone of Lake Okeechobee (Ager 1971) and are abundant in all freshwater habitats in the northern Everglades (Dineen 1974), the Fakahatchee Strand (Carter et al. 1973), the Big Cypress Swamp, and the southern Everglades (Kushlan and Lodge 1974).

In the southern Everglades, *L. goodei* is most abundant in densely vegetated marsh prairies that have surface periphyton mats and peat substrates. It is less common in open-water habitats, such as canals and alligator ponds, where we collected it only along vegetated margins. In all freshwater habitats, *L. goodei* always inhabits dense submerged vegetation which it seems to require for cover. The bluefin killifish occurs in mangrove regions of southern Florida primarily during periods of freshwater runoff (Tabb and Manning 1961; Odum 1971), but it also tolerates brackish water. Kilby (1955) collected *L. goodei* in brackish water along the Florida Gulf Coast, and we caught specimens in the mangrove zone at a salinity of 12.5^{o}/oo. Although *L. goodei* occurs within the area of the headwaters of coastal rivers, it is uncommon and appears to be replaced there by its congener, *Lucania parva*.

Unpaired fin coloration in male *L. goodei* is variable. Both the dorsal and anal fins of a male fish can have the same color, either red or blue, or the dorsal and anal fins may be different in color, with one red and the other blue.

37. *Lucania parva* (Baird) - rainwater killifish (IV)
VS 11, 14, 15, 16, 19, 22, 24, 34 Figure 29

The rainwater killifish inhabits a variety of salt and brackish-water habitats throughout its range (Duggins 1980b) and is locally common in fresh water in areas of northern Florida (Arndt 1971; Burgess et al. 1977). Relyea (1975, 1983) reported the absence of Atlantic coastal records from central Florida to the upper Florida keys, but we have taken many specimens throughout Biscayne Bay north to Miami. Florida mainland populations extend around the tip of the peninsula and are continuous with the Florida keys population. That gene flow exists among Florida populations is supported by the finding of only minor genetic distances in electrophoretic data from different populations (Duggins et al. 1983).

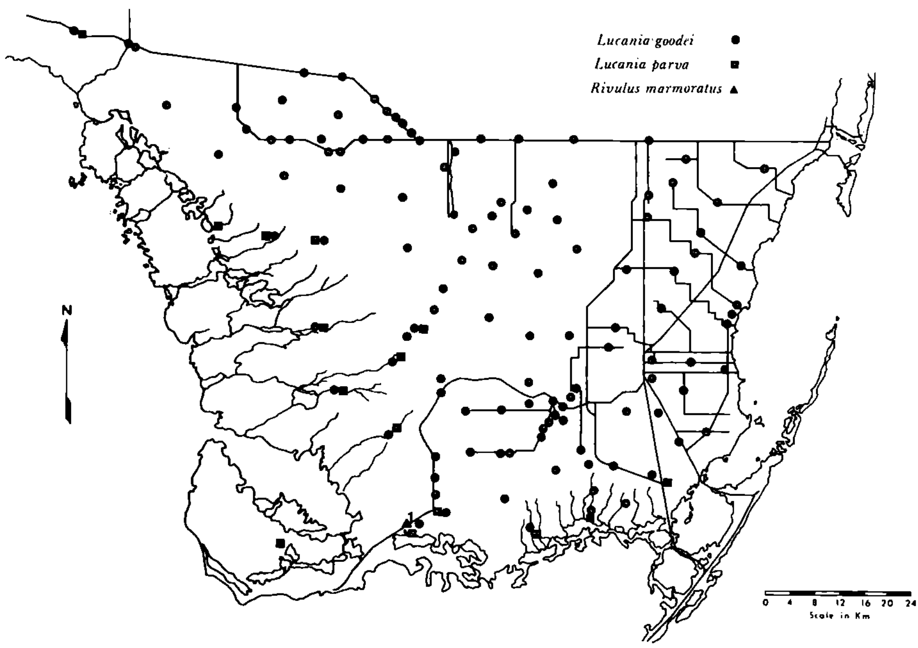

Figure 29.-- Distribution of Lucania goodei, Lucania parva, and Rivulus marmoratus in fresh water in southern Florida. 1 = Tabb and Manning (1961).

In southern Florida, *L. parva* had previously been taken in fresh water in the Caloosahatchee River (Gunter and Hall 1965), in the North River (Odum 1971), and from a southeastern Dade County canal (Belshe 1961). We collected *L. parva* in fresh water from every creek, river, and pond sampled in the headwaters region. We also collected freshwater specimens in coastal canals in southeastern Dade county.

Odum (1971) found that *L. parva* was one of the most numerous small carnivores in the North River. It occurred in pools and along the banks where plant cover provided protection. *L. parva* was very common in the headwaters region during our sampling, greatly outnumbering *Lucania goodei* and most other killifishes in that area. We found it along the margins of rivers and creeks among mangrove prop roots and in submerged vegetation. In fresh water, *L. parva* is restricted to the coastal regions. The rainwater killifish rarely enters the southern Eveglades marshes, where it is replaced by *Lucania goodei*. We collected only three small specimens of *L. parva* in the fresh water Shark River Slough marshes during five years of sampling.

38. *Rivulus marmoratus* Poey - rivulus (IV)
Not collected — Figure 29

R. marmoratus is primarily a coastal brackish and saltwater species, first reported from Florida in 1958 (Harrington and Rivas 1958). It had previously been known only from Cuba. *R. marmoratus* has since been collected only from estuarine mangrove habitats and mosquito ditches along both coasts of southern Florida (Hastings 1969, 1975) and from the Bahamas and the Lesser Antilles (Snelson 1978; Gilbert and Burgess 1980d). Several authors have reported *R. marmoratus* from our study area, but two (Belshe 1961; Odum 1971) did not report the salinities in which the specimens were collected. Although it appears to be rare, *Rivulus* does enter the diet of wading birds in southern Florida (Ogden et al. 1976; Frohring and Kushlan unpubl. data). The only verified freshwater record for *R. marmoratus* in southern Florida was by Tabb and Manning (1961). They also collected it in brackish-water habitats. We did not collect *R. marmoratus* during our sampling in the estuarine zone. We conclude that it is very rare in fresh water in southern Florida and does not enter the Everglades marsh.

POECILIIDAE - livebearers

39. *Belonesox belizanus* Kner - pike killifish (II) - Exotic
VS 29, 39 Figure 30

This piscivorous livebearer from Central America was introduced into southeastern Dade County canals in the 1950's (Belshe 1961). It had become established near Black Creek by 1957 and has since spread north to Coral Gables (Courtenay et al. 1974) and south to the mangrove marshes around Canal C-111. We collected several large series of *B. belizanus* from fresh water in the coastal canals of Dade County, but we have never found it more than 10-12 km inland from the coast. Some factor appears to restrict *B. belizanus* to coastal regions in southern Florida. The pike killifish is very tolerant of saline conditions and has been collected from mangrove pools with salinities in excess of $35^{o}/oo$ (Robins and Getter In Robins et al. 1980; Gary Balogh pers. comm). This tolerance has probably aided its dispersal around southeastern Dade County by enabling it to use saline pathways.

Belshe (1961) found that *B. belizanus* was most abundant in deep, narrow canals having dense marginal vegetation. This habitat is abundantly represented by small farm ditches and mosquito ditches near the coast. We collected the largest numbers of pike killifish in such habitats. *B. belizanus* is locally common in the larger drainage canals where the wide, deep channels are kept free of aquatic vegetation. There the pike killifish occurs only in vegetation along the canal margins. Dense aquatic vegetation provides protective cover and, in turn, affords cover from which it can ambush small prey fishes. When stalking small fishes, the pike killifish remains motionless until the prey is near, then arches its body and springs at the prey, which is swallowed either head or tail first. Belshe (1961) found it to be a voracious predator of small fishes in southeastern Dade County and reported that there was fear that malarial epidemics might occur if the pike killifish significantly reduced the number of small, mosquito-eating fishes. These fears have not been realized, though we have observed very low populations of small fishes, including the usually abundant *Gambusia affinis*, in ditches where *B. belizanus* is common. It seems likely that, considering the diet, habitat, and salinity tolerance of *B. belizanus*, it will continue to increase its range along the southeast coast. Whether it will colonize inland aquatic habitats is uncertain at this time.

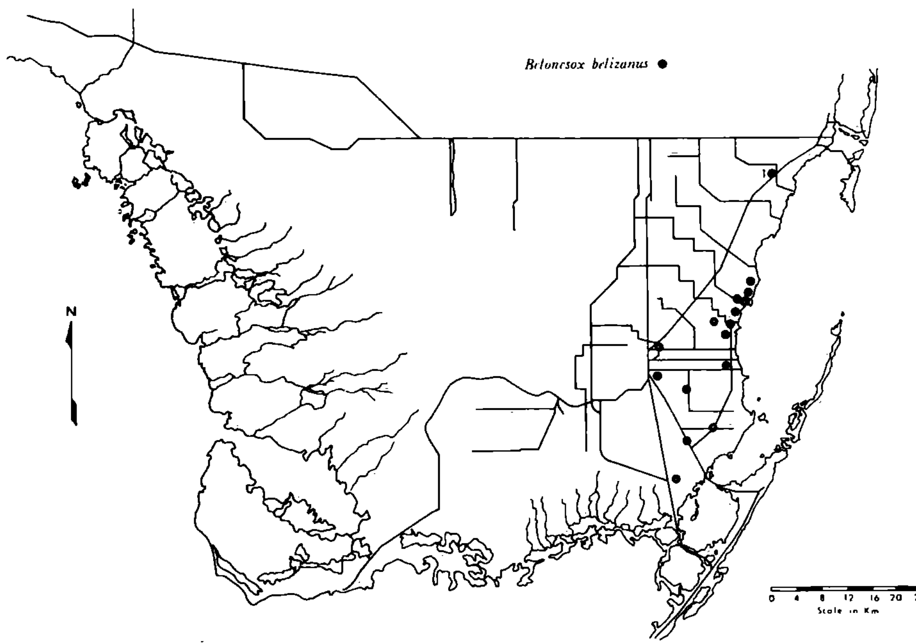

Figure 30.-- Distribution of Belonesox belizanus in fresh water in southern Florida. 1 = Courtenay et al. (1974).

40. *Gambusia affinis* (Baird and Girard) - mosquitofish (II)
VS 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39 — Figure 31

The mosquitofish is the most abundant and ubiquitous fish in southern Florida fresh water (Kushlan and Lodge 1974). It occurs in large numbers in Lake Okeechobee (Ager 1971) and ranges south through the Everglades Conservation Areas (Dineen 1974), the Big Cypress Swamp, and southern Everglades. It is also common in canals along the eastern coastal ridge. We took *G. affinis* in nearly all the collection sites and from every freshwater habitat type within our study area. The mosquitofish is also widespread and numerous in brackish water (Tabb and Manning 1961; Odum 1971) and may enter waters in southern Florida that are more saline than those inhabited elsewhere in its range (Gunter and Hall 1963a). We have frequently collected and observed *G. affinis* in salt water along the shallow coastal areas and mangrove keys of Florida Bay and Biscayne Bay. In the Indian River area, this species has been collected at 80°/oo (R.G. Gilmore pers. comm.).

In the southern Everglades, we found *G. affinis* in alligator ponds, marshes, and canal margins. Although it is common in the densely vegetated marsh prairies, the mosquitofish is more numerous in sparsely vegetated marsh prairies without dense periphyton cover at the surface. In aquarium studies of habitat choice (Casterlin and Reynolds 1977), *G. affinis* preferred habitat characteristics similar to those we observed in natural situations, except the fish chose darker rather than lighter colored substrates. Maglio and Rosen (1969) found that water temperature was more important than substrate color in determining the distribution of *G. affinis* in a pond, but that there was a relationship between reproductive state of females and their choice of substrate color. In the southern Everglades, we commonly took *G. affinis* over both pale and dark-colored substrates in canals and marsh prairies, indicating that substrate color may not be an important parameter for habitat selection by *G. affinis* in our area.

The mosquitofish is the most abundant species in canals, swamps, alligator ponds, and in sloughs in the Big Cypress Swamp (Carlson and Duever 1977). It is also numerous in the freshwater pools and streams at the headwaters of coastal rivers.

G. affinis is primarily a surface-dwelling fish, small groups moving constantly about the open surface waters. *G. affinis* is particularly attracted to surface disturbances and will quickly converge on the site of a disturbance, probably in search of food. In the Everglades, this behavior is peculiar to the mosquitofish, and it is taken advantage of by wading birds that disturb the water surface to attract fish within striking distance (Kushlan 1973b). We have

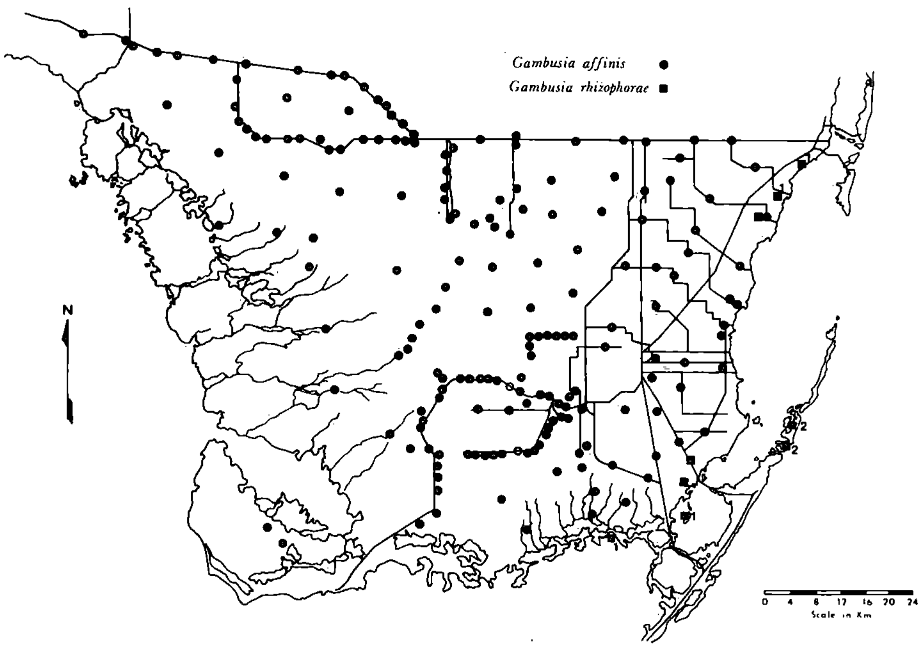

Figure 31.-- Distribution of Gambusia affinis and Gambusia rhizophorae in fresh water in southern Florida. 1 = Rivas (1969). Marine sites are indicated by 2.

often observed *G. affinis* clustering around alligators, whose movements may stir up prey for the fish. The mosquitofish also peck at the alligators, probably to dislodge flecks of dead skin or parasites.

Individual *G. affinis* differ in maximum size and coloration in different habitats within our study area. Mosquitofish in the Everglades marsh do not reach the larger maximum sizes of *G. affinis* from fresh water in coastal canals. Mosquitofish from coastal canals are also darker in coloration and have a darker suborbital bar. As with many poeciliids, female mosquitofish grow considerably larger than the males (Turner 1941). Coloration of the sexes is similar, although a small percentage of males are partially melanistic (Regan 1961). Coastal populations of mosquitofish seem to have relatively higher proportions of melanistic males than inland populations (pers. observ.).

An aggressive nature, catholic diet, small size, and ability to survive in foul water (Lewis 1970; Kushlan 1974a) all combine with a long reproductive season to make *G. affinis* the most successful fish in southern Florida fresh water. The well-defined subspecies in peninsular Florida is *G. a. holbrooki*.

41. *Gambusia rhizophorae* Rivas - mangrove gambusia (IV)
CS 151a Figure 31

In his description of *G. rhizophorae*, Rivas (1969) listed the type locality as Paradise Key, Everglades National Park, but added that the species appears to be restricted to estuarine areas and mangrove swamps. Paradise Key, in Taylor Slough, is occupied by a tropical hardwood hammock (Royal Palm Hammock) surrounded by fresh water. Freshwater records for *G. rhizophorae* from Florida prior to our study were non-existent (Getter 1976; Gilbert 1978a), although records did exist for Cuban fresh waters (Getter 1982). Kushlan and Lodge (1974) thought that Rivas' (1969) collection data were erroneous; we concur. Rivas (pers. comm.) has informed us that he did not personally collect the type specimens, and that he now also believes that the collection data included with the type specimens were probably in error. We collected the first known freshwater specimens of *G. rhizophorae* at Parrot Jungle, a south Miami tourist attraction, from an artificially maintained stream leading to a brackish-water canal. Small groups were present in the stream at the time of sampling. We did not collect *G. rhizophorae* at any other freshwater site during this study and conclude that it is uncommon in fresh water in south Florida. In aquaria, this species can survive and reproduce in fresh water indefinitely and it reproduces in fresh water in Cuba (Getter 1976, 1982, pers. observ.), so that its natural occurrence in southern Florida fresh water must be limited by factors other than salinity. Getter (1982) presented evidence that the distribution of *G. rhizophorae* in southern Florida is restricted by its intolerance of cool, winter water temperatures. Perhaps, the artificial Parrot Jungle stream maintains higher water temperatures than nearby canals.

Incidental to collections made in fresh water in the study area, we also collected *G. rhizophorae* at several new saltwater locales in the upper Florida Keys. The specimens were taken from shallow, protected waters around *Rhizophora mangle* roots at Elliott, Old Rhodes, and Totten Keys in Biscayne National Park (Fig. 31). The mangrove gambusia is probably present in suitable habitat throughout Biscayne National Park and portions of northeastern Florida Bay in Everglades National Park where, as a Species of Special Concern in Florida (Gilbert 1978a), it is afforded protection from collection and habitat loss.

42. *Heterandria formosa* Agassiz - least killifish (II)
VS 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38 — Figure 32

One of the most abundant fishes in the southern Everglades, *H. formosa* occurs throughout southern Florida. It ranges from Lake Okeechobee (Ager 1971) through the Everglades Water Conservation Areas (Dineen 1974), into the Fakahatchee Strand (Carter et al. 1973), the Big Cypress Swamp, southern Everglades, and eastern coastal ridge. The least killifish also inhabits the margins of freshwater pools and streams in the headwaters of coastal rivers. It enters brackish-water habitats in this region but is never numerous there (Tabb and Manning 1961; Odum 1971).

We collected the least killifish in all the habitats samples, including cypress swamps, canal margins, sawgrass marshes, and alligator ponds. In all habitats, *H. formosa* is always associated with dense vegetation. *H. formosa* is most numerous in the marsh prairies of the southern Everglades, where it inhabits dense beds of *Utricularia* spp. under the surface periphyton mat. Only occasionally is it found in more open areas, usually in mixed schools with *Gambusia affinis*. Because of its size, it requires protective cover against predation by most cohabiting fishes. The least killifish seems to be well adapted to dry season conditions in the Everglades marsh. Its small size enables it to remain alive in puddles of water in the drying marsh. Female *H. formosa* attain greater maximum sizes than do males, which are among the world's smallest vertebrates at maturity (Breder and Rosen 1966).

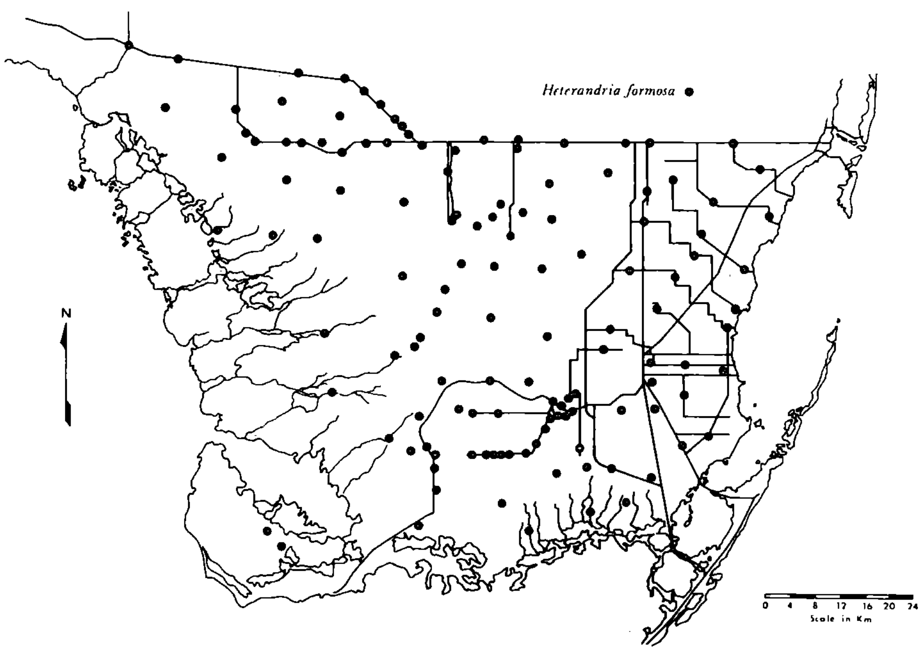

Figure 32.-- Distribution of Heterandria formosa in fresh water in southern Florida.

43. *Poecilia latipinna* (Lesueur) - sailfin molly (VI)
VS 1, 2, 3, 4, 6, 7, 8, 9, 10, 13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 26, 28, 29, 31, 32, 33, 34, 35, 36, 37, 38, 39 — Figure 33

The sailfin molly is another widely distributed southern Florida fish, attaining greatest abundance in brackish water. In fresh water, the sailfin molly ranges from the marshes surrounding Lake Okeechobee (Ager 1971) southward into the Fakahatchee Strand (Carter et al. 1973), the Big Cypress Swamp, southern Everglades, and eastern coastal canals. *P. latipinna* is very numerous in the mangrove-lined streams and pools of the headwaters and in most coastal canals.

P. latipinna is quite common in the southern Everglades marsh, where we collected it in all aquatic habitats. The sailfin molly is most numerous in sparsely vegetated marsh prairies with periphyton-covered marl substrates. The pale body color of the sailfin molly blends well with the substrate in this habitat. Mollies inhabit all levels of the water column, traveling about in small to moderately sized groups while grazing on algal-covered plant stems and bottom materials.

Freshwater specimens of *P. latipinna* attain their largest sizes in canals and alligator ponds. Smaller individuals normally inhabit the Everglades marshes. Sailfin mollies from inland freshwater habitats rarely attain the larger maximum sizes of mollies from brackish-water areas. This habitat-related size difference in sailfin mollies has been noted in other parts of its range (Swift et al. 1977) and may result from a combination of environmental, social, and genetic interactions (Snelson 1982).

The sailfin molly is sexually dimorphic and dichromatic. Large males possess high, long dorsal fins marked with black streaks, and caudal fins edged in blue and black. Males spread both these fins during sexual and agonistic displays. In the southern Everglades marsh, it appears that some males never develop the bright colors and large fins of males from other habitats, possibly because they generally do not grow as large. We collected several melanistic sailfin mollies of both sexes during our sampling, but melanism seems to be less frequent in the freshwater populations than in the brackish-water populations in southern Florida (pers. observ.).

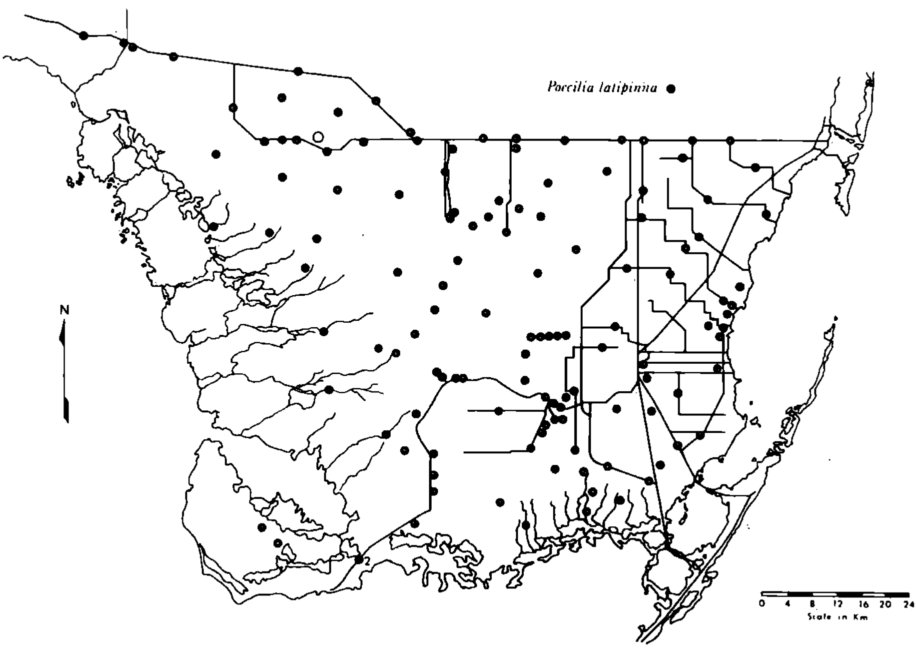

Figure 33.-- Distribution of Poecilia latipinna in fresh water in southern Florida.

ATHERINIDAE - silversides

44. *Labidesthes sicculus* (Cope) - brook silverside (IV)
VS 1, 2, 5, 7*, 8*, 10, 11, 13, 21, 22, 24, 26, 27, 28, 32, 35, 37, 38 — Figure 34

L. sicculus is primarily restricted to fresh water in southern Florida, where it ranges from Lake Okeechobee (Ager 1971), through the Everglades Water Conservation Areas (Dineen 1974), into the Big Cypress Swamp, the southern Everglades, and eastern coastal canals. We collected *L. sicculus* in all freshwater habitats in the southern Everglades except sawgrass marshes. In the Big Cypress Swamp, *L. sicculus* occurs in alligator ponds and deep cypress sloughs. We collected very few specimens in Shark River Slough, although specimens were regularly taken there from 1966 to 1972 (Kushlan 1980a). *L. sicculus* is most common in open-water habitats, such as canals, alligator ponds, and borrow pits, where it travels about in small to moderately sized groups. We were often able to record the presence of *L. sicculus* at a collection site because of its habit of leaping from the water. This behavior is probably an avoidance response to aquatic predators.

The ranges of the brook silverside and inland silverside (*Menidia beryllina*) overlap only in the freshwater streams of the headwater region and in certain coastal canals. *L. sicculus* is primarily a freshwater silverside occurring inland of the brackish-water zone; *Menidia beryllina* is abundant in brackish areas, entering fresh water only in coastal regions. Because *L. sicculus* ranges to the limits of fresh water on the peninsula, its range is larger than that presented by Lee (1980c). The subspecies is *L. s. vanhyningi*, a well-defined race that ranges well outside of Florida (Lee 1980c).

45. *Menidia beryllina* (Cope) - inland silverside (V)
VS 15, 16, 19, 22, 24, 34 — Figure 34

The inland silverside is a euryhaline species that ranges in fresh water from Lake Okeechobee (Ager 1971), the St. Lucie (Gunter and Hall 1963a) ($0.14^{o}/oo$) and Caloosahatchee rivers (Gunter and Hall 1965) southward along both coasts in mangrove areas (Raney et al. 1953) and canals (Hogg 1976a) to the southern tip of the peninsula. An exceedingly abundant fish in brackish water, *M. beryllina* is also numerous in freshwater habitats along the headwaters of coastal streams in southern Florida. Large schools of *M. beryllina* inhabit the surface waters of streams, pools, and river margins in the headwaters, and we found it at nearly every collection site there. Odum (1971) found *M. beryllina* to be the most abundant fish in the North River system, and

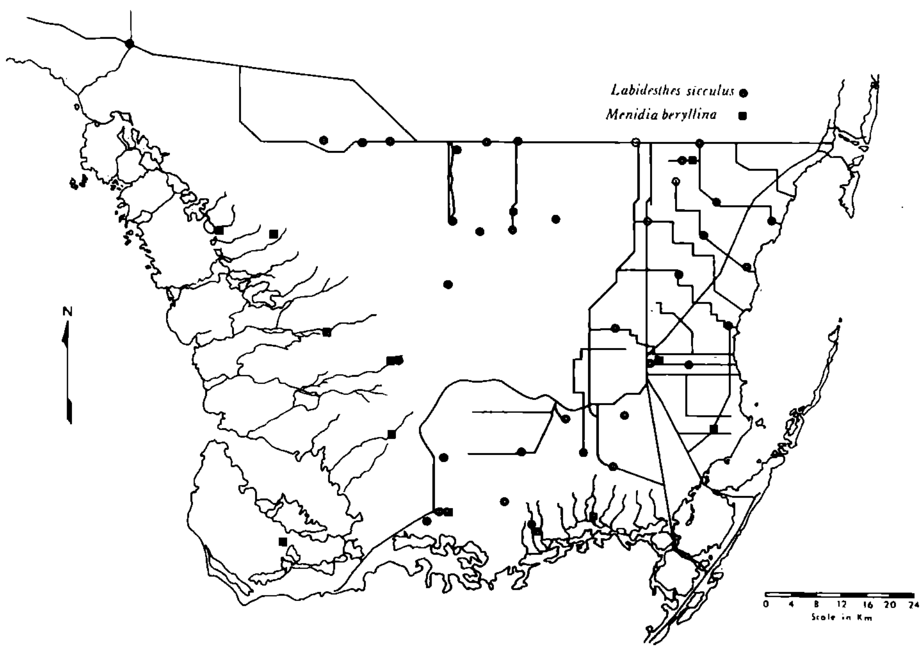

Figure 34.-- Distribution of Labidesthes sicculus and Menidia beryllina in fresh water in southern Florida. Open symbols signify sight records.

the same is probably true for other river systems in southern Florida. We do not believe that Atlantic and Gulf populations are disjunct, as was proposed by Relyea (1983).

Although *M. beryllina* inhabits small streams that enter the southern Everglades marsh, we never collected it in the marsh. In southern Florida, this silverside appears able to penetrate into fresh water only in coastal areas, where it is restricted to canals and riverine habitats. Three recent taxonomic studies of *Menidia* (Johnson 1975; Duggins 1980a; Chernoff et al. 1981) have clarified the identities of *Menidia beryllina* and *M. peninsulae*. No subspecific designation has been provided for southern Florida populations of *M. beryllina*.

CENTROPOMIDAE - snooks

46. *Centropomus ensiferus* Poey - swordspine snook (VI)
Not collected Figure 35

C. ensiferus is apparently uncommon in North American fresh water, where it is limited to extreme southern Florida (Burgess 1980b). Four specimens collected from freshwater canals in Miami (Rivas 1962) represent the only known records of this snook from our study area. *C. ensiferus* is the smallest snook and has the most restricted occurrence of any *Centropomus* in Florida (Rivas 1962; Burgess 1980b). We did not collect it during our sampling of canals and rivers.

47. *Centropomus parallelus* Poey - fat snook (VI)
Not collected Figure 35

The fat snook ranges from Lake Okeechobee to the southern tip of Florida in fresh water (Rivas 1962; Burgess 1980c), but most freshwater habitats within this range are probably unsuitable for it. The majority of freshwater records come from canals along the southeast coast (Rivas 1962; Burgess 1980c). We did not collect *C. parallelus* during our sampling, but it seems possible that it may enter fresh water in the coastal rivers that drain the Everglades.

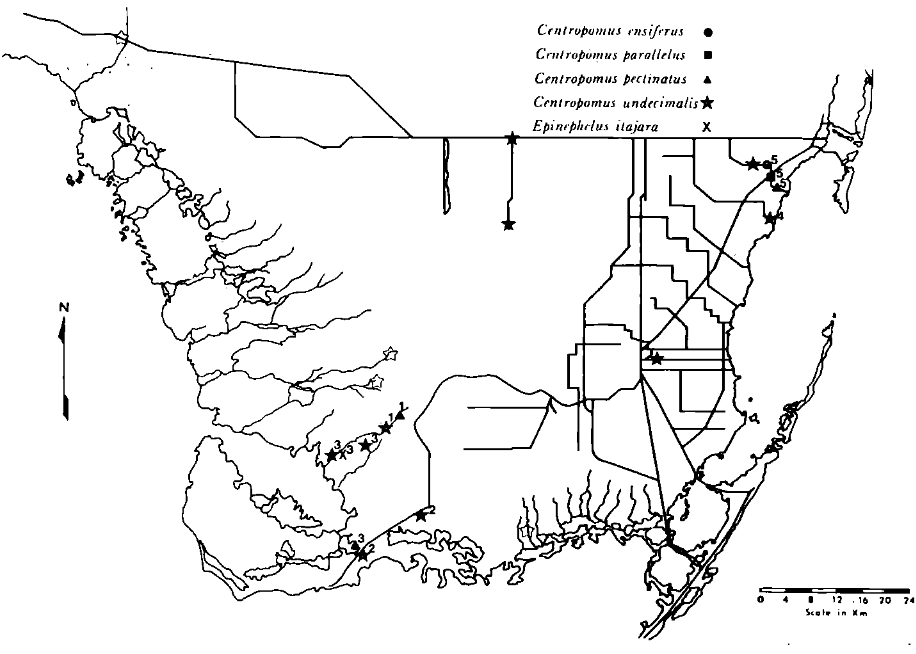

Figure 35.-- Distribution of Centropomus ensiferus, Centropomus parallelus, Centropomus pectinatus, Centropomus undecimalis, and Epinephelus itajara in fresh water in southern Florida. Open symbols signify sight records. 1 = Odum (1974); 2 = Tabb and Manning (1961); 3 = Tabb et al. (1974); 4 = Hogg (1974); 5 = Rivas (1962).

48. *Centropomus pectinatus* Poey - tarpon snook (VI)
Not collected — Figure 35

This species ranges southward in Florida from the Indian River region on the Atlantic coast and the Fort Myers area on the Gulf coast (Burgess 1980d). Freshwater specimens of tarpon snook in southern Florida have been collected in the Caloosahatchee River and in several Miami canals (Rivas 1962). It has also been taken in fresh water in North River (Tabb et al. 1974). We did not collect *C. pectinatus*, but it probably occurs in small numbers in coastal freshwater canals and rivers in our study area. The tarpon snook appears to be more common in freshwater habitats in the Indian River region of east central Florida (Gilmore 1977).

49. *Centropomus undecimalis* Bloch - snook (VI)
VS 1, 2*, 22*, 24*, 26*, 27; CS 154 — Figure 35

The snook is the most numerous and widespread of the four species of *Centropomus* in southern Florida (Burgess 1980e). Snook have been collected in fresh water in Lake Okeechobee (Ager 1971), in the St. Lucie (Gunter and Hall 1963a) and Caloosahatchee rivers (Gunter and Hall 1965), and in the canals of the Everglades Water Conservation Areas (Dineen 1974), the Big Cypress Swamp, and the southern Everglades (Kushlan and Lodge 1974). *C. undecimalis* also enters fresh water in coastal canals (Rivas 1962) and in the rivers and pools of the headwaters region (Tabb and Manning 1961). Both adult and juvenile snook occur in the freshwater areas of coastal rivers in Evergaldes National Park (Odum 1971; Tabb et al. 1974).

Snook enter the canal system of the Everglades and Big Cypress areas by following the same routes as tarpon. *C. undecimalis* occurs in several canals in this part of our study area, but at least one canal, L-67 Canal Extended, lost its population in the freeze of 19-20 January 1977. Five large snook died a few days after this freeze, and many months passed before any snook were seen or caught in that canal. Snook are especially sensitive to low temperatures, and mortality caused by winter cold spells is not uncommon in southern Florida (Marshall 1958; Dineen 1974).

Most of our distribution records for snook (Fig. 35) are based on sight observations in coastal rivers and canals. *C. undecimalis* is a large, unmistakable *Centropomus* that is easy to observe with a spotlight during night sampling but is difficult to capture. Snook are more widespread in fresh water than our data indicate, but their relatively low numbers and difficulty of capture resulted in few specimens.

SERRANIDAE - sea basses

50. *Epinephelus itajara* (Lichtenstein) - jewfish (VI)
Not collected Figure 35

The largest serranid in southern Florida spends its juvenile stages in shallow, coastal waters where it tolerates a variety of salinities. In the Shark River, McPherson (1970) collected specimens at salinities ranging from 3.2^{o}/oo to 15.0^{o}/oo. In these rivers, juvenile jewfish also stray into fresh water. In 1966, a specimen measuring 191 mm was taken in fresh water in North River (Tabb et al. 1974), the first freshwater record for this species. We did not collect jewfish during our sampling, but it may be more common in the freshwater portions of the rivers than the collection records indicate.

CENTRARCHIDAE - sunfishes

51. *Elassoma evergladei* Jordan - Everglades pygmy sunfish (I)
VS 2, 4, 10, 15, 30, 31, 35 Figure 36

E. evergladei is one of the smallest centrarchids, reaching a maximum length of about 30 mm TL. The Everglades pygmy sunfish ranges widely throughout southern Florida from Lake Okeechobee (Ager 1971) and the Everglades Water Conservation Areas (Dineen 1974), through the Big Cypress Swamp, and into the southern Everglades (Kushlan and Lodge 1974). It occurs in a variety of habitats throughout its range, but in southern Florida we always collected it in dense aquatic vegetation. In the sloughs of the southern Everglades and Big Cypress Swamp, *E. evergladei* is most common in thick beds of *Utricularia* and *Najas* and also in dense sawgrass strands. In canals, Kushlan and Lodge (1974) frequently collected it among water hyacinth roots. Although Dineen (1974) collected *E. evergladei* in shallow marshes of 8-25 cm in depth, we found it most often in deeper sloughs and ponds, where dense vegetation was present. The Everglades pygmy sunfish is absent from the more developed parts of the study area (Fig. 36). In northern Florida, Swift et al. (1977) found that *E. evergladei* occurred primarily in stained, soft waters and was rare in clear, unstained, hard waters. In the study area, *E. evergladei* occurs in a variety of water and habitat conditions but is most numerous in the clear, alkaline waters of the southern Everglades. Our collection data extended the known range of this species as shown by Böhlke and Rohde (1980).

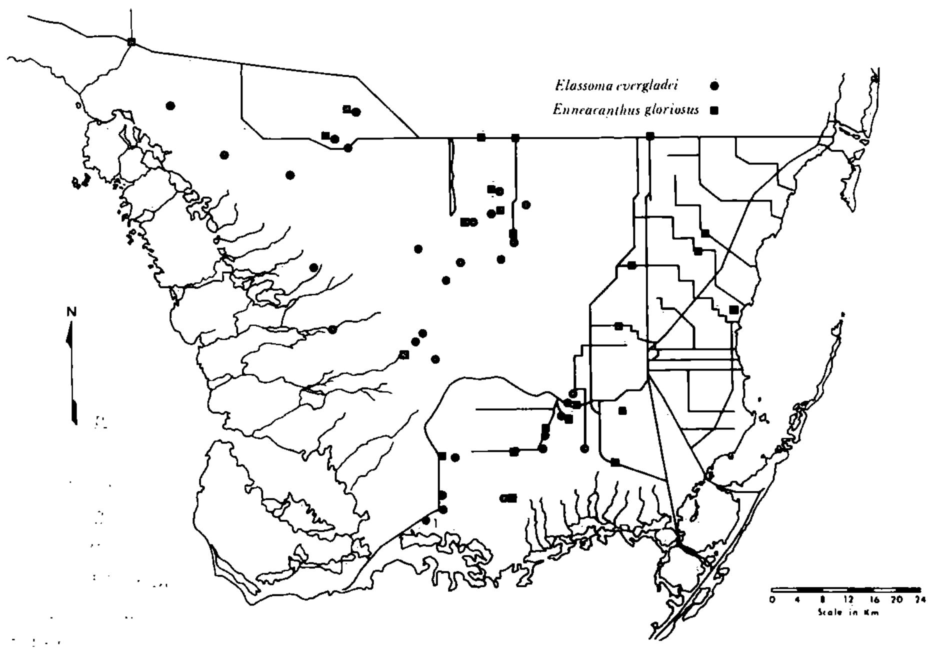

Figure 36.-- Distribution of Elassoma evergladei and Enneacanthus gloriosus in fresh water in southern Florida. 1 = Tabb and Manning (1961).

The Everglades pygmy sunfish is abundant near the headwaters of coastal rivers in Everglades National Park, where it occurs in heavily vegetated marshes and stream margins. In dry-season samples from this area, we found large numbers in isolated puddles in the drying marshes, indicating that it may be able to survive in these shallow marshes until reflooding occurs.

Male Everglades pygmy sunfish attain a slightly larger size than females in southern Florida. During much of the year, the male retains his spawning colors of a black body marked with blue streaks. This fact suggests an extended breeding season in southern Florida, although the peak of breeding appears to be in late winter and spring. Recent studies have investigated aspects of the reproductive behavior of *E. evergladei* (Mettee 1974) and the effects of population density on community dynamics (Rubenstein 1977) in aquaria.

52. *Enneacanthus gloriosus* (Holbrook) - bluespotted sunfish (I)
VS 1, 2, 4, 5, 10, 22, 26, 28, 32, 35, 38 Figure 36

The bluespotted sunfish is another small centrarchid that is widespread throughout the southern Everglades and Big Cypress Swamp. *E. gloriosus* ranges through the Everglades Water Conservation Areas (Dineen 1974), Lake Okeechobee (Ager 1971), and the St. Lucie (Gunter and Hall 1963a) and Caloosahatchee rivers (Gunter and Hall 1965). In our study area, we collected *E. gloriosus* in marshes, cypress sloughs, and alligator ponds in association with thickets of submerged plants. The bluespotted sunfish also occurs in heavily vegetated canals and road culverts, but it is less common in canals of the urbanized east coast (Kushlan and Lodge 1974). We collected the first specimens of *E. gloriosus* from the headwaters region of southern Florida (Fig. 36), in beds of *Najas* in the feeder creeks. Tabb and Manning (1961) and Odum (1971) did not collect *E. gloriosus* at their study sites in that region.

The bluespotted sunfish, although widespread in southern Florida, is only locally common and rarely as abundant as sympatric *Elassoma evergladei*. It is much more common in the northern Everglades, as evidenced by the collection of 1021 fish in a 1-acre marsh sample (Dineen 1974). In our sampling of the Everglades Water Conservation Areas (unpublished data), we also found the bluespotted sunfish to be more common than in the southern Everglades marsh. Water levels there are artificially maintained at higher levels for longer periods than in the southern Everglades. Within our study area, the largest numbers of *E. gloriosus* occur in canal and alligator ponds that offer more stable water conditions than the surrounding wetlands. It appears that *E. gloriosus* is poorly adapted to the fluctuating water levels and occasional dry-downs of the southern Everglades and is more successful in habitats having longer hydroperiods. This species has a more extensive Florida range than that shown by Lee and Gilbert (1980).

53. *Lepomis gulosus* (Cuvier) - warmouth (I)
VS 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 37, 38, 39 Figure 37

The warmouth is widespread throughout southern Florida, where it is one of the most abundant centrarchids. Its range extends from the littoral zone of Lake Okeechobee (Ager 1971), through the canals and marshes of the northern Everglades (Dineen 1974), southward into the Big Cypress Swamp, the southern Everglades, and the eastern coastal canals (Kushlan and Lodge 1974). In the Big Cypress Swamp, *L. gulosus* is a common inhabitant of alligator ponds and cypress sloughs. In the southern Everglades, we found the warmouth to be common in marsh prairies and sawgrass marshes during the wet season, retreating to alligator ponds as the waters recede in the dry season. *L gulosus* is one of the best-adapted centrarchids to the fluctuating water levels of the Everglades. It seems to be the sunfish most tolerant of the low oxygen conditions associated with the dry season and survives after all other centrarchids have died (Kushlan 1974a). Unlike the bluegill (*Lepomis macrochirus*) and redear sunfish (*Lepomis microlophus*), which inhabit more open waters, *L. gulosus* is often abundant in densely vegetated marshes. In the shallow littoral zones of ponds and canals, *L. gulosus* inhabits cavities in the limestone margins. The warmouth is a top-level predator in the southern Everglades marsh, where most bass (*Micropterus salmoides*) and gar are excluded by the shallow waters, fluctuating water levels, and thick vegetation.

The warmouth is quite common in the pools and creeks of the headwaters region where it occurs in moderately brackish waters. However, Kilby (1955) considered *L. gulosus* to be practically restricted to fresh water, never having collected it in salinities above $1.8^{o}/oo$. We collected specimens at a salinity of $12.5^{o}/oo$, higher than the upper limit reported by Brockman (1974).

54. *Lepomis macrochirus* Rafinesque - bluegill (I)
VS 1, 2, 3, 4*, 5, 7, 8*, 10, 11, 19, 22, 23, 25, 26, 27, 28, 29, 32, 37, 38, 39 Figure 38

The bluegill is one of the most abundant centrarchids in the southern Florida canal system, where it is an important food and sport fish. It is the most numerous centrarchid in Lake Okeechobee (Ager 1971) and ranges southward through the canals of the Everglades Water Conservation Areas (Dineen 1974), the Big Cypress Swamp, the southern Everglades, and eastern coastal canals (Kushlan and Lodge 1974). The bluegill is very common in canals and borrow pits that are kept free of dense aquatic vegetation. In older

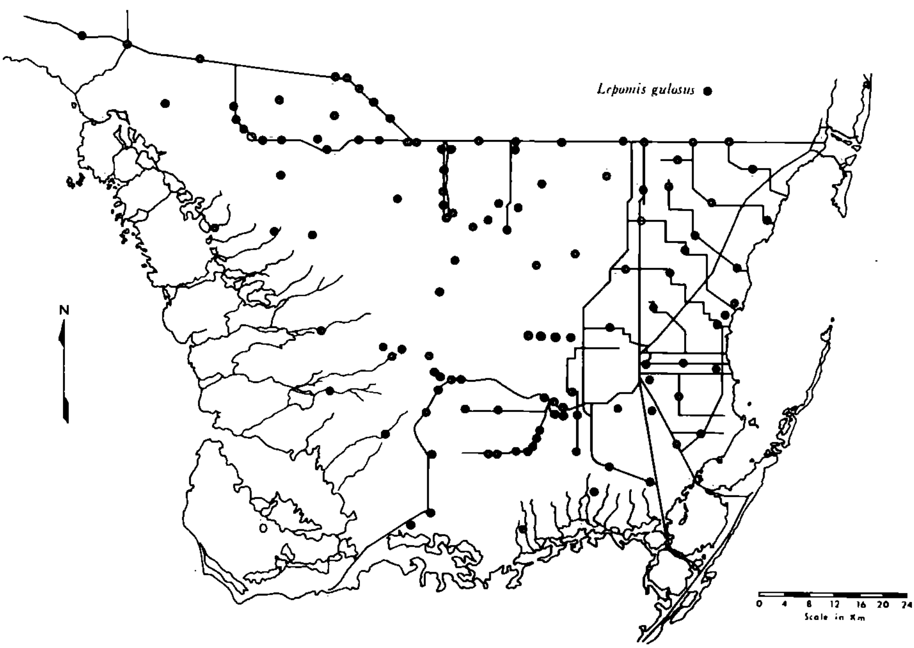

Figure 37.-- Distribution of Lepomis gulosus in fresh water in southern Florida.

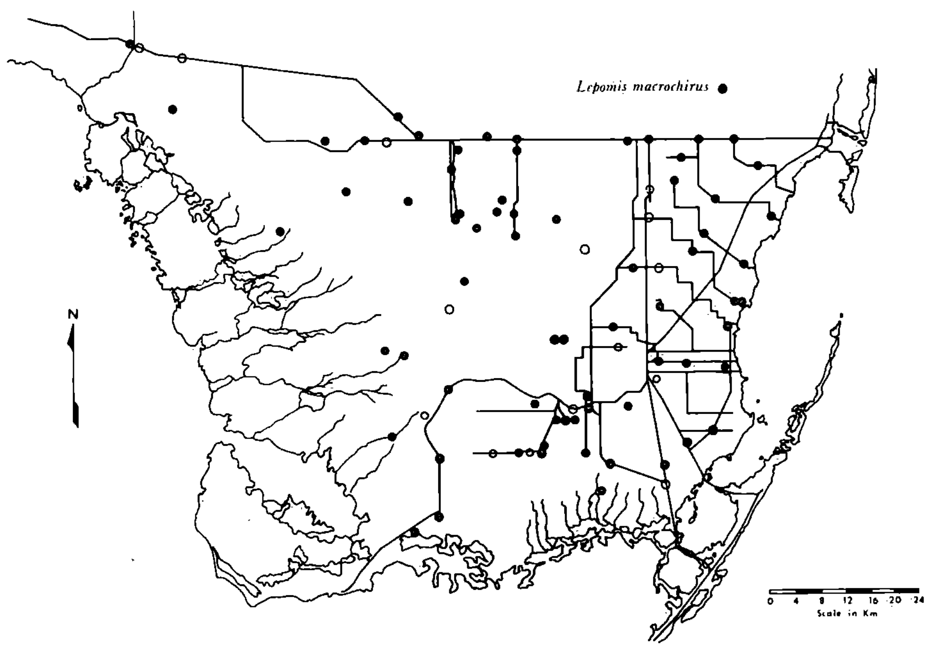

Figure 38.-- Distribution of Lepomis macrochirus in fresh water in southern Florida. Open symbols signify sight records. 1 = Odum (1974).

weed-choked canals, adult bluegill occur only in the open-water areas maintained by alligators. Immature specimens occur in the surrounding beds of vegetation. These observations of habitat partitioning by different age-classes agree with those made on the northern subspecies by Werner et al. (1977) and Casterlin and Reynolds (1978).

In the southern Everglades and Big Cypress Swamp, we collected adult bluegills mainly in alligator ponds and deeper sloughs, the only habitats free of dense vegetation. In marshes, we collected only small specimens, and these only occasionally. Dineen (1974) found that *L. macrochirus* was never abundant in northern Everglades marshes and that the bluegills from the marshes were smaller than those living in canals. In our study area, the bluegill also occurs in pools and creeks in the headwaters region, where we observed it nesting in moderately brackish water. *L. macrochirus* is sensitive to low oxygen conditions associated with the dry season and is one of the first species to die during a fish kill (Kushlan 1974a). We believe it is this lack of adaptation to seasonal water fluctuations that is responsible for the absence of bluegills from large sections of natural habitat in the study area.

During our study of ponds at the Anhinga Trail (CS 112), we repeatedly saw largemouth bass soliciting bluegills for cleaning. This behavior was first described by Sulak (1975) from the same location. We have observed groups of bluegills following alligators as they move through the water and have also seen them follow closely behind foraging groups of *Erimyzon sucetta* near the bottom. We assume that the bluegills are feeding on prey disturbed by the movements of these animals.

The subspecies in southern Florida has been called *L. m. purpurescens*, but recent evidence indicates that the subspecific name refers to a more northerly population, and that the Florida subspecies is currently unnamed (Felley 1980).

55. *Lepomis marginatus* (Holbrook) - dollar sunfish (I)
VS 1, 2, 3, 4, 7, 8, 10, 11, 13, 14, 15, 16, 17, 19, Figure 39
20, 21, 22, 23, 24, 25, 26, 28, 29, 30, 32, 33, 34, 35

The dollar sunfish occurs in the littoral zone of Lake Okeechobee (Ager 1971), in the marshes and weedy canal margins of the northern Everglades (Dineen 1974), and throughout the Big Cypress Swamp and the southern Everglades. Although Martin (1963) had established its presence there, Kushlan and Lodge (1974) were uncertain of its occurrence south of Tamiami Trail, primarily because of its similarity to other small *Lepomis* species. Its status has been clarified during the present study. We have found that *L. marginatus* is one of the most abundant centrarchids in the southern Everglades marsh. The dollar sunfish occurs in nearly all aquatic habitats in southern Florida, always in association with dense submerged vegetation, and is

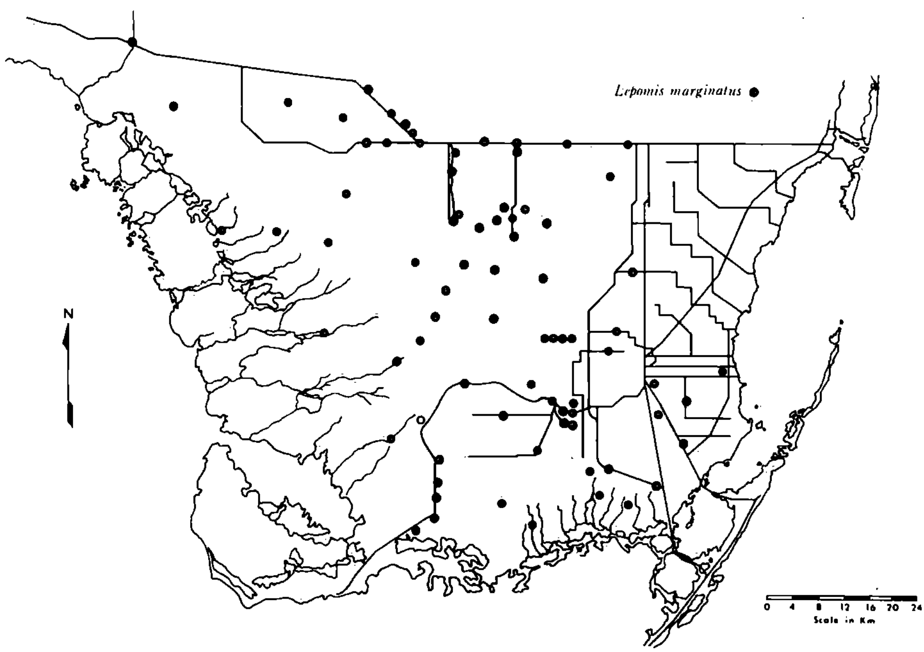

Figure 39.-- Distribution of Lepomis marginatus in fresh water in southern Florida. Open symbols signify sight records.

most numerous in sawgrass marshes and marsh prairies in the southern Everglades. This sunfish is also common in cypress sloughs and alligator ponds in the Big Cypress Swamp. *L. marginatus* is virtually absent from east coast drainage canals (Fig. 39) but does occur in small creeks in the headwaters region.

The dollar sunfish is the smallest *Lepomis* in southern Florida and, because of its small size, requires dense vegetation for protective cover. It appears to be one of the better adapted centrarchids to marsh conditions in southern Florida as evidenced by its abundance in a wide range of habitats. Our collections clarify the southern Florida range of this species as given by Carr and Goin (1955), Briggs (1958), Kushlan and Lodge (1974), and Bauer (1980).

56. *Lepomis microlophus* (Günther) - redear sunfish (I)
VS 1, 2, 3, 4*, 5, 6, 7, 8*, 11, 13, 19, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 32, 34, 35, 37, 38, 39 — Figure 40

The redear sunfish is a common centrarchid in canals and rockpits, where it is a valued food and game fish. In the eastern coastal canals, numbers of this species often surpass those of *L. macrochirus* with which it shares similar habitats. *L. microlophus* ranges from Lake Okeechobee (Ager 1971) southward through the Everglades Water Conservation Areas (Dineen 1974), into the Big Cypress Swamp, the southern Everglades, and eastern coastal ridge. This is the largest *Lepomis* in southern Florida, and it attains its greatest size in canals and rockpits.

In the southern Everglades and the Big Cypress Swamp, *L. microlophus* occurs primarily in alligator ponds and deeper sloughs (Kushlan and Lodge 1974). As with *Lepomis macrochirus*, larger redear sunfish occur in deeper, less-vegetated waters, while only juveniles inhabit the shallow, weedy marshes. The redear sunfish is the least common species of *Lepomis* in the southern Everglades, but in the northern Everglades, Dineen (1974) found it to be the dominant centrarchid in the marshes. Apparently *L. microlophus* requires a more stable, deeper-water environment than is available in the southern Everglades. Habitat preferences of *L. microlophus* seem to vary with location in Florida. Swift et al. (1977) collected it in larger lakes and streams in northern Florida but not in small, swampy watercourses, while Kilby (1955) found it to prefer vegetated habitats along the west central Gulf Coast of Florida. In Lake Okeechobee during the winter, adult redear sunfish exhibit a habitat shift from shallow, bulrush marshes (*Scirpus* sp.) to deeper, open waters (Ager 1971). It appears that this species can adapt to a range of habitats, and that its rarity in natural habitats in southern Florida may be due primarily to the effects of seasonal water level fluctations.

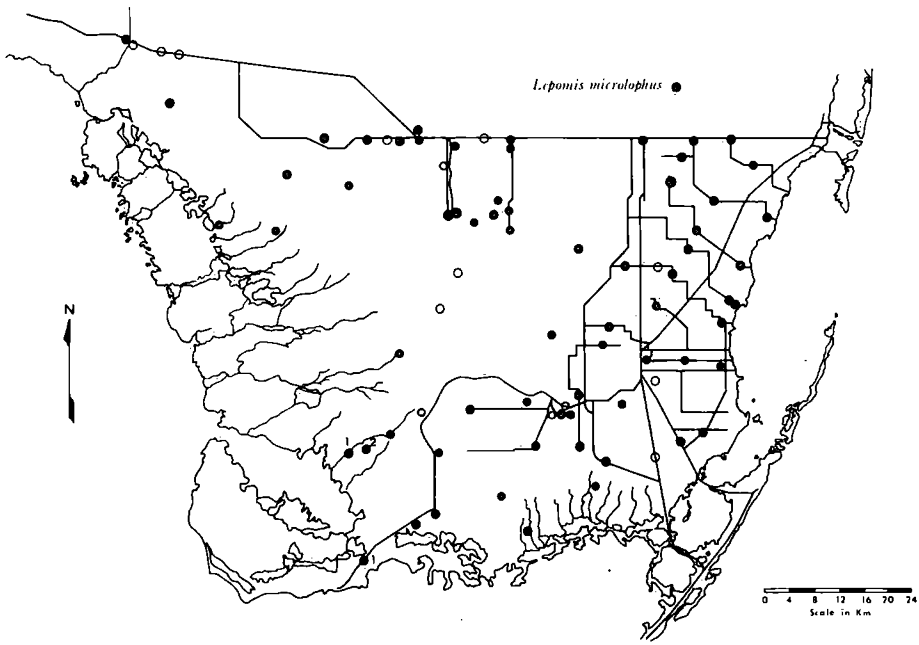

Figure 40.-- Distribution of Lepomis microlophus in fresh water in southern Florida. Open symbols signify sight records. 1 = Tabb et al. (1974); 2 = Tabb and Manning (1961).

Redear sunfish have been collected in tidewater areas in northern Florida (Swift et al. 1977) and in the headwaters region of our study area (Tabb and Manning 1961). We often collected *L. microlophus* in coastal rivers and pools in both fresh and brackish water, up to 11.0^{o}/oo.

57. *Lepomis punctatus* (Valenciennes) - spotted sunfish (I)
VS 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 14, 15, 16, 17, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 32, 33, 34, 35, 36, 37, 38, 39 — Figure 41

The spotted sunfish is probably the most ubiquitous and abundant centrarchid in southern Florida. It occurs in the littoral zone of Lake Okeechobee (Ager 1971), ranges south through the Everglades Water Conservation Areas (Dineen 1974), and is present throughout the Big Cypress Swamp, the southern Everglades, and eastern coastal ridge (Kushlan and Lodge 1974). In the southern Everglades, it is one of the most numerous centrarchids in alligator ponds and marshes. Dineen (1974) considered *L. punctatus* to be the least numerous sunfish in the northern Everglades. However, we frequently collected it there during our study of fish standing crop from 1979 to 1981 (unpubl. data). Its abundance and wide distribution in our study area indicate that it is better adapted to conditions in the southern Everglades than most centrarchids. This fact, plus the absence of the larger species of centrarchids from much of the southern Everglades, may account for its relative abundance there in contrast to the northern Everglades.

We collected *L. punctatus* in alligator ponds, cypress sloughs, and prairies in the Big Cypress Swamp, and in canals and rockpits throughout our study area. The spotted sunfish is common in pools and creeks in the headwaters, where we collected specimens in moderately brackish water at 12.5^{o}/oo salinity. Kilby (1955) reported a salinty range of 0.0^{o}/oo to 11.8^{o}/oo along the Florida Gulf coast, but Brockman (1974) found no *L. punctatus* in salinities exceeding 4.9^{o}/oo in a southwestern Florida coastal canal.

We observed that adult *L. punctatus* inhabited the open waters of alligator ponds and canals in our study area, while the juveniles occurred in the dense, submerged vegetation of the marshes and canal margins. Only rarely did we collect large *L. punctatus* in the marsh prairies. Kilby (1955) always found the spotted sunfish in association with dense aquatic vegetation in marshes of the Gulf Coast.

In southern Florida, spotted sunfish have the longest nesting season of any *Lepomis* species, lasting from March to November. Juvenile *L. punctatus* can be found in the Everglades marsh throughout the year. Male *L. punctatus* are usually larger and more vividly marked than females, and they exhibit black

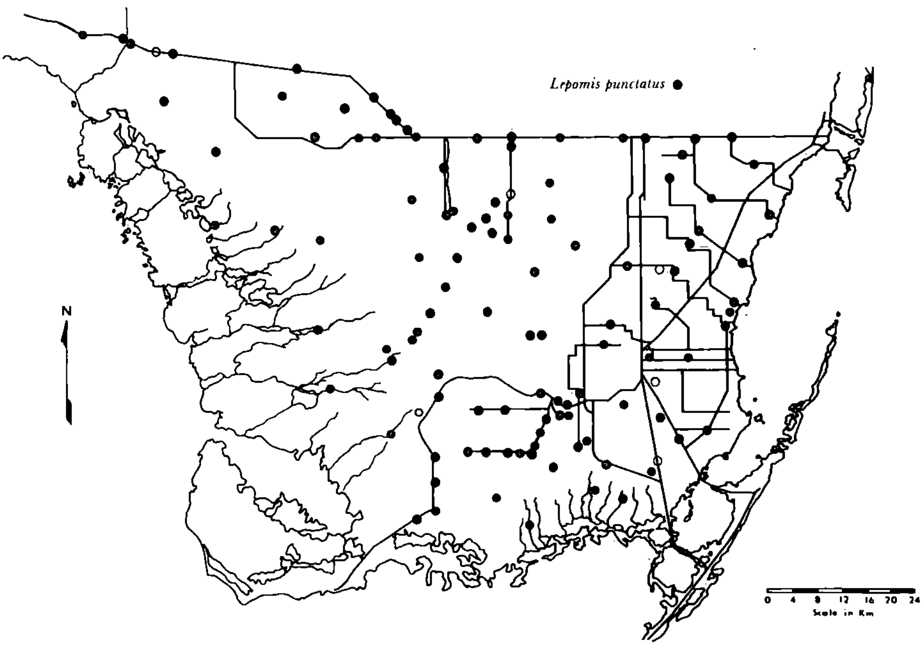

Figure 41.– Distribution of Lepomis punctatus in fresh water in southern Florida. Open symbols signify sight records.

pelvic fins when reproductively active. The subspecies for peninsular Florida is *L. p. punctatus*.

58. *Micropterus salmoides* Lacepede - largemouth bass (I)
VS 1, 2, 4*, 5, 6, 7, 8*, 10, 11, 13, 15, 16, 21*, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 35, 37, 38, 39 — Figure 42

This important sport and food fish is found throughout southern Florida, where it is the largest centrarchid. Bass are abundant in Lake Okeechobee and adjacent waters (Ager 1971) and are common in the canals and deep marshes of the northern Everglades (Dineen 1974). The bass ranges from the Big Cypress Swamp through the southern Everglades, to the canals of the eastern coastal ridge (Kushlan and Lodge 1974). In southern Florida, *M. salmoides* is most numerous and attains its largest size in the canal system. Adults inhabit the deep, open waters of canals while the juveniles find shelter around beds of submerged vegetation.

In the southern Everglades and Big Cypress Swamp, bass are uncommon and occur mainly in alligator ponds, airboat trails, and deep marshes. We occasionally collected juveniles in marsh prairies, but this was very rare. In the northern Everglades, *M. salmoides* frequently inhabits shallow, seasonally flooded marshes (Dineen 1974), but we did not find this to be the case in the southern Everglades.

M. salmoides is abundant in headwater creeks and rivers, and in the "moats" surrounding mangrove stands and bayheads in that region. The bass survives and reproduces in slightly brackish water in these coastal areas, as it does in other areas of Florida. Swift et al. (1977) collected bass in salinities ranging to 15.6^{o}/oo in northern Florida, and Kilby (1955) found *M. salmoides* at 11.8^{o}/oo along the Florida Gulf Coast.

The largemouth bass is one of the important fish predators in freshwater ecosystems in Florida. The major prey species are small fishes and crayfish. It is not well adapted to conditions in the southern Everglades, being very sensitive to the low oxygen conditions that occur in the dry season. *M. salmoides* is one of the first fishes to die during a natural fish kill (Kushlan 1974a), and this has limited its persistence in the southern Everglades marsh system. The Florida subspecies is *M. s. floridanus* (Bailey and Hubbs 1949; Philipp et al. 1983).

59. *Pomoxis nigromaculatus* (Lesueur) - black crappie (I)
VS 37; CS 43, 160 — Figure 43

The black crappie is an abundant gamefish in Lake Okeechobee. It inhabits the pelagic zone and moves into the shallows only during the spawning

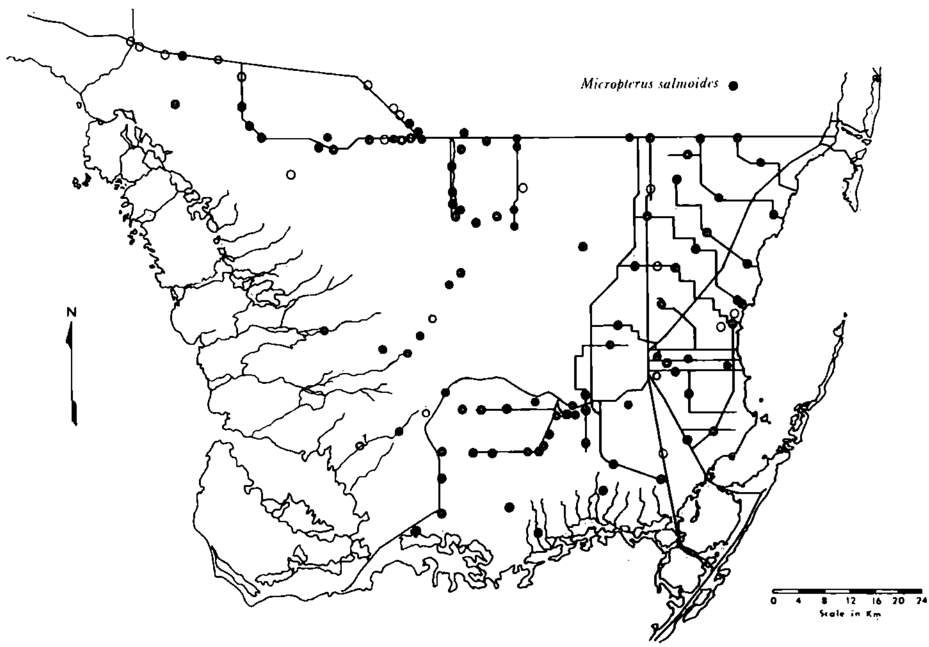

Figure 42.-- Distribution of Micropterus salmoides in fresh water in southern Florida. Open symbols signify sight records. 1 = Odum (1971).

season (Ager 1971). Its range extends southward into the northern Everglades, where small numbers of fish inhabit canals and rarely enter the marshes (Dineen 1974). *P. nigromaculatus* is very rare in extreme southern Florida. We have only three records from our study area, all taken from canals within a few kilometers of the Tamiami Canal. These represent the only known records for this species south of the Tamiami Trail. Carr and Goin (1955), Stevenson (1976), and Lee (1980d) reported that its range included the entire state of Florida, but this is incorrect. Kushlan and Lodge (1974) suggested that the crappie may have moved southward into extreme southern Florida during historic times, probably using the canal system to extend its range. Lack of suitable habitat or unfavorable water regimes probably account for its scarcity in the southern Everglades.

PERCIDAE - perches

60. *Etheostoma fusiforme* (Girard) - swamp darter (I)
VS 1, 10, 16, 28, 31, 32, 37 Figure 43

The swamp darter is the only percid found in the Everglades. This bottom-dwelling species is common along the margins of Lake Okeechobee and adjacent canals (Ager 1971). It is fairly common along canal banks in the northern Everglades but rarely enters the marsh system (Dineen 1974). In our study area, *E. fusiforme* is widespread but only locally common. It appears to be absent from large areas of southern Everglades marsh, and we took it there only in a few alligator ponds. We also collected *E. fusiforme* in a rotenone sample in a creek in the headwaters region. It is most numerous along the rocky margins of canals and rockpits in southern Florida, showing a preference for the limestone rubble substrates available in those disturbed habitats. Its range in southern Florda is more extensive than that described by Kuene and Barbour (1983) and Norden (1980).

The swamp darter has been collected to the west of the Big Cypress Swamp by Carter et al. (1974), but we have only one sight record from the swamp. We think it is probably more widespread there, but because the habits and habitat of *E. fusiforme* make it difficult to collect without the use of rotenone or electricity, we might have missed it during routine sampling. This difficulty, in addition to its usually low numbers, is probably the reason for its absence from Big Cypress Swamp samples. The subspecies is *E. f. barratti*, a very well-defined subspecies that had been considered a valid species in the past (Carr and Goin 1955; Collette 1962). Further study may result in re-elevation to full species status (B. B. Collette, pers. comm. to C. R. Gilbert).

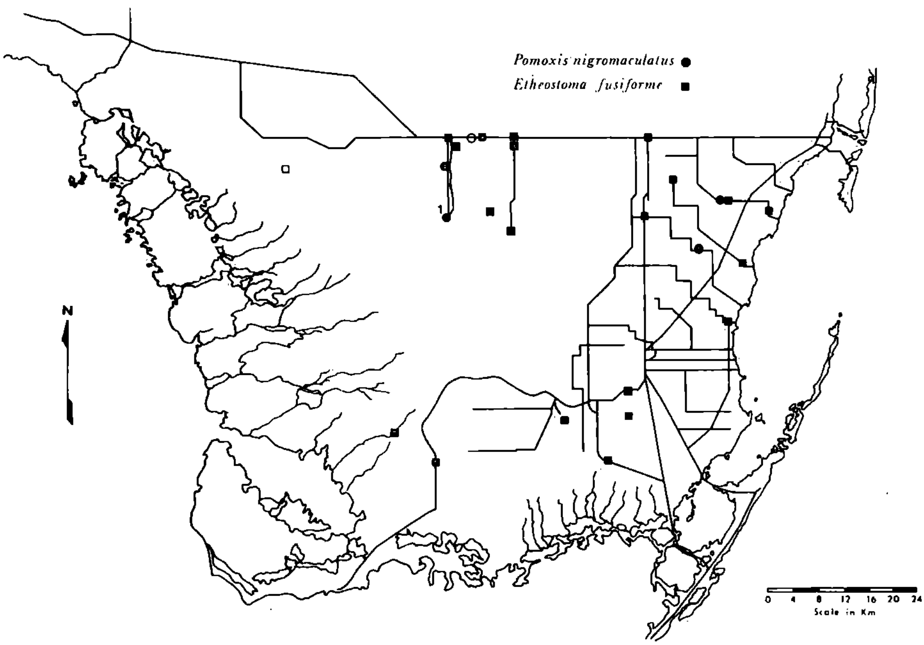

Figure 43.-- Distribution of Pomoxis nigromaculatus and Etheostoma fusiforme in fresh water in southern Florida. Open symbols signify sight records. 1 = Thomas Lodge (pers. comm.).

CARANGIDAE - jacks

61. *Caranx hippos* (Linnaeus) - crevalle jack (VI)
VS 24*; CS 154*, 172 Figure 44

C. hippos is abundant in the brackish and marine environments of northern Florida Bay and connecting waters (Tabb and Manning 1961). It occasionally enters fresh water in the coastal rivers and canals that drain the southern Everglades. Odum (1971) stated that *C. hippos* was common in most habitats in the North River system, including small headwater creeks. We observed jacks in fresh water in Taylor River, collected a specimen in the Coral Gables Waterway, and found a dead specimen in C-103 Canal in Homestead, thereby adding additional freshwater records to those of Ross (1980a). *C. hippos* is known to enter fresh water in other areas of southern and central Florida, including the St. Lucie River (Gunter and Hall 1963a) and the Indian River region (Gilmore 1977). Despite its common occurrence in Florida fresh waters, it was not listed as entering fresh water in the most recent A.F.S. checklist (Robins et al. 1980).

62. *Oligoplites saurus* (Schneider) - leatherjacket (VI)
Not collected Figure 44

One specimen of this carangid, measuring 250 mm, was taken in fresh water from North River in 1966 (Tabb et al. 1974). This is the only freshwater record of *O. saurus* in our study area. Additional freshwater specimens from southern and central Florida have been taken in the St. Lucie River (Gunter and Hall 1963a) (0.25^{o}/oo) and the Indian River region (Gilmore 1977). The leatherjacket is not listed from fresh water in the A.F.S. checklist (Robins et al. 1980).

LUTJANIDAE - snappers

63. *Lutjanus griseus* (Linnaeus) - gray snapper (VI)
VS 24*, 27*; CS 154 Figure 44

L. griseus is the most abundant snapper in the marine and brackish waters surrounding our study area (Tabb and Manning 1961). The only lutjanid taken

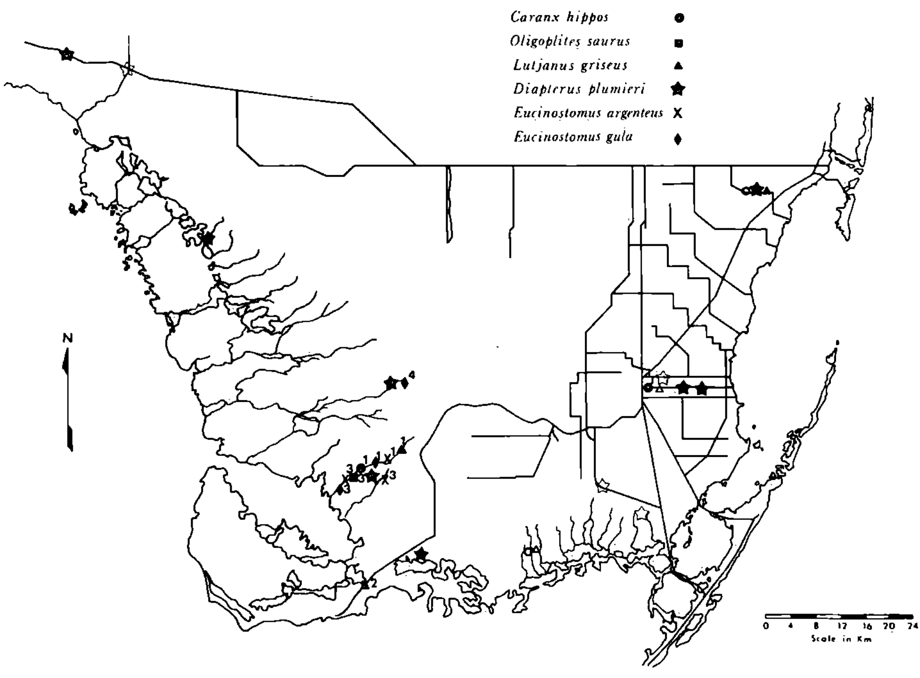

Figure 44.-- Distribution of Caranx hippos, Oligoplites saurus, Lutjanus griseus, Diapterus plumieri, Eucinostomus argenteus, and Eucinostomus gula in fresh water in southern Florida. Open symbols signify sight records. 1 = Odum (1971); 2 = Tabb and Manning (1961); 3 = Tabb et al. (1974); 4 = Kushlan and Lodge (1974).

in fresh water during our sampling, *L. griseus* commonly enters fresh water in coastal rivers and canals. Most gray snappers found in these coastal areas are juveniles (Tabb and Manning 1961) that enter the rivers and canals in winter and congregate in deep holes. *L. griseus* is much easier to see than to capture in the clear coastal waters. Specimens in fresh water from our study area were taken by Tabb and Manning (1961) in rivers north of Whitewater Bay, and by Odum (1971) and Tabb et al. (1974) in North River. *L. griseus* probably occurs in most river systems in southern Florida, and in large drainage canals along the east coast where salinity structures do not preclude access. These new freshwater records supplement those given by Ross (1980c).

GERREIDAE - mojarras

64. *Diapterus plumieri* (Cuvier) - striped mojarra (VI)
VS 16, 22*, 26*, 27, 34; CS 154 Figure 44

This is the common freshwater mojarra in our study area. It occurs in most coastal rivers and some canals, often many kilometers from salt water. *D. plumieri* is often numerous in freshwater habitats, and we collected it in nearly every river system sampled. Tabb and Manning (1961) and Odum (1971) also found large numbers of *D. plumieri* in fresh water in the Everglades estuary. Another study in Everglades National Park (Waldinger 1968) concluded that this species favors a brackish to freshwater environment.

In all habitats, striped mojarras occur at or near the bottom. Small groups of fish can be seen to constantly probe in the substrate for food items. This mojarra is normally much easier to observe than to capture in rivers and canals. All of our specimens from fresh water were either large juveniles or adults. The adults apparently spawn in fresh water and the young pass through their early life stages at sea (C. R. Robins, pers. comm.). These collections add additional freshwater records to those of Ross (1980b).

65. *Eucinostomus argenteus* Baird - spotfin mojarra (VI)
Not collected Figure 44

The spotfin mojarra is the most abundant mojarra in high salinity waters in southern Florida (Tabb and Manning 1961) but was frequently collected in fresh water in the North River by Odum (1971) and Tabb et al (1974). Though Tabb and Manning (1961) and Waldinger (1968) considered *E. argenteus* to be an inhabitant of high salinity waters, others have collected it primarily in brackish, estuarine waters (Kilby 1955; Springer and Woodburn 1960). *E.*

argenteus had previously been taken from fresh water in the St. Lucie (Gunter and Hall 1963b) (0.16^{o}/00) and Caloosahatchee rivers (Gunter and Hall 1965), and from the Indian River region (Gilmore 1977). We collected no specimens of *E. argenteus* in our sampling and must assume that both this species and *Eucinostomus gula* only occur sporadically in fresh water in our study area.

66. *Eucinostomus gula* (Quoy and Gaimard) - silver jenny (VI)
Not collected Figure 44

The silver jenny is a common inhabitant of brackish and saltwater habitats in southern Florida (Tabb and Manning 1961) but is uncommon in fresh water. *E. gula* has been collected in fresh water from the Caloosahatchee River (Gunter and Hall 1965) (0.09^{o}/oo), the Indian River area (Gilmore 1977), and from our study area in the Rookery Branch section of Shark River (Kushlan and Lodge 1974) and in North River (Odum 1971; Tabb et al. 1974). We did not collect *E. gula* in fresh water during this study.

Several studies have shown that *E. gula* varies in relative abundance with *E. argenteus* based upon habitat type and salinity. Both Kilby (1955) and Springer and Woodburn (1960) found that *E. gula* was more abundant than *E. argenteus* at high salinities along the Florida Gulf Coast. Conversely, Tabb and Manning (1961) found *E. gula* to be less numerous than *E. argenteus* in high salinity waters in southern Florida. In brackish water, Odum (1971) collected *E. gula* in similar numbers and from the same habitats as *E. argenteus* in North River. The reasons for these differences in relative abundance are unclear.

SPARIDAE - porgies

67. *Archosargus probatocephalus* (Walbaum) - sheepshead (VI)
VS 15, 22 Figure 45

The occurrence of this large porgy in coastal fresh waters in Florida is well documented (Herald and Strickland 1949; Gunter and Hall 1963a [0.26^{o}/oo]; Tagatz 1968; Burgess 1980a). Odum (1971) collected sheepshead in fresh water in North River, where it was the second most abundant gamefish. We obtained large specimens of sheepshead in rotenone samples in feeder streams along Broad River and in gill nets at Rookery Branch. *A. probatocephalus* probably occurs in most coastal rivers in southern Florida. We did not collect this species in the freshwater areas of coastal canals because access to most is precluded by salinity dams. It probably inhabits those few canals without such barriers.

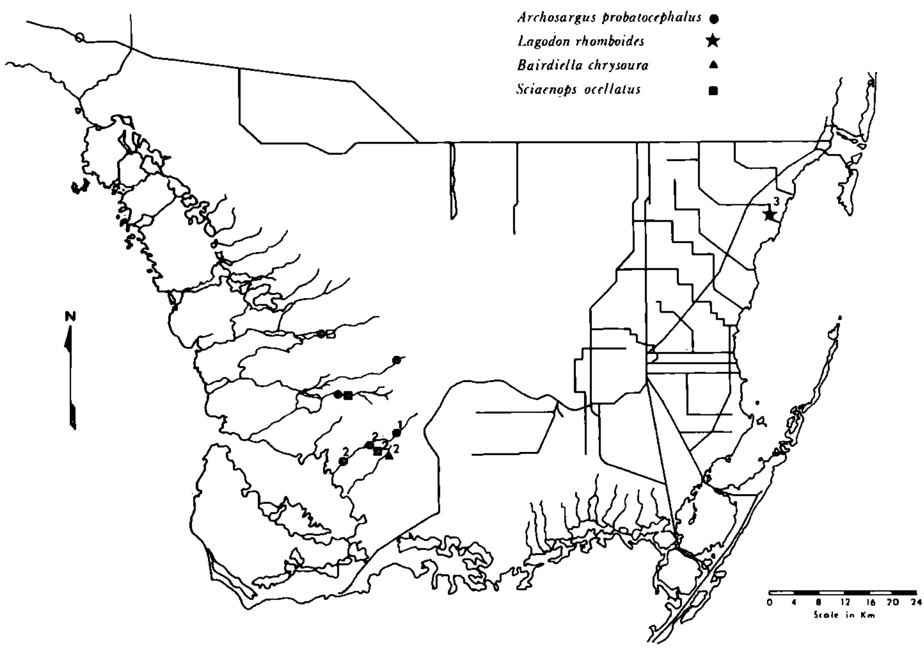

Figure 45.-- Distribution of Archosargus probatocephalus, Lagodon rhomboides, Bairdiella chrysoura, and Sciaenops ocellatus in fresh water in southern Florida. 1 = Odum (1971); 2 = Tabb et al. (1974); 3 = Hogg (1974).

68. *Lagodon rhomboides* (Linnaeus) - pinfish (VI)
Not collected Figure 45

L. rhomboides is exceedingly numerous on the grass flats of Florida Bay (Tabb and Manning 1961) and Biscayne Bay. The single freshwater record of pinfish in our study area was taken by Hogg (1976a) in Snapper Creek Canal. The pinfish has also been taken in southern Florida in fresh water in the St. Lucie (Gunter and Hall 1963a) (0.15^{o}/oo) and Caloosahatchee rivers (Gunter and Hall 1965), and also from the Indian River area (Gilmore 1977). Elsewhere in Florida, Tagatz (1968) collected it in fresh water in the St. John's River. We did not collect *L. rhomboides*, but it is likely that it occasionally enters fresh water in coastal streams and canals in our study area.

SCIAENIDAE - drums

69. *Bairdiella chrysoura* (Lacepede) - Silver perch (VI)
Not collected Figure 45

The single record of *B. chrysoura* from fresh water in our study area is a 110 mm fish taken in a creek between North and Roberts rivers in 1966 (Tabb et al. 1974). Other freshwater specimens from outside of our study area have been taken in the St. Lucie River (Gunter and Hall 1963a) (0.17^{o}/oo), the Indian River region (Gilmore 1977), in the St. John's River (Tagatz 1968), and Charlotte Harbor (Wang and Raney 1971). We did not collect *B. chrysoura* during our sampling.

70. *Sciaenops ocellatus* (Linnaeus) - red drum (VI)
VS 15*; CS 140 Figure 45

We collected two specimens of red drum by angling at night in the Rookery Branch of the Shark River. We also observed this species in fresh water in Broad River. Juvenile *S. ocellatus* use the brackish-water areas in the mangrove zone of the Everglades estuary as a nursery (Odum 1971). Both the young and adults commonly ascend Everglades coastal rivers into fresh water. Specimens ranging from 230 mm to 430 mm were taken in fresh water near Robert's River in 1966 (Tabb et al. 1974). The red drum is likely to occur in most rivers along the coast of southern Florida. Other freshwater records for the red drum in Florida are from Cedar Key (Kilby 1955) and the Caloosahatchee River (Gunter and Hall 1965).

CICHLIDAE - cichlids[1]

71. *Astronotus ocellatus* (Agassiz) - Oscar (II) - Exotic
VS 1, 37*; CS 112*, 149*, 152, 158* Figure 46

This large predatory cichlid, a popular aquarium fish, was originally imported from South America by the aquarium trade. It is now established over a large area of eastern Dade County, following its escape from at least two points of origin (Hogg 1976b). It has been aided in its dispersal by anglers who have transported the fish to new locations (Courtenay et al. 1974). The oscar is only locally common within its southern Florida range, occurring primarily in canals and rockpits in Dade, Broward, and Palm Beach counties. Hogg (1976a) found that *A. ocellatus* inhabited deeper areas of Dade County canals than did other cichlid species, and that its population densities were low. The present range of *A. ocellatus* in our study area appears to extend to Black Creek on the south and to Krome Avenue (U.S. Highway 27) on the west, although there is evidence of establishment in canals in the eastern Big Cypress Swamp. The southern Florida range is expanding as evidenced by our collection of an adult from the Tamiami Canal at its junction with L-67 Canal, and by occasional sightings of specimens in other Dade County waters, such as at the Anhinga Trail in Everglades National Park.

72. *Cichlasoma bimaculatum* (Linnaeus) - black acara (II) - Exotic
VS 3, 4, 7*, 10, 12, 17, 18, 26, 29, 37, 38, 39 Figure 46

Of South American origin, *C. bimaculatum* has been established in southern Florida longer than other cichlid species and presently has the widest distribution of any cichlid in extreme southern Florida. It ranges from the canals and sloughs of the Big Cypress Swamp (Kushlan 1972), eastward through the canals of the Everglades Water Conservation Areas (Dineen 1974) and southern Everglades, into canals and rockpits along the eastern coastal ridge. The first specimens of this fish in Florida were identified as *Aequidens portalegrensis* (Hensel) by Rivas (1965) and followed by Bailey et al. (1970) and Kushlan (1972). These two fishes are differentiated by their anal spine count,

[1] While this paper was in press, the first U.S. collections of Cichlasoma urophthalmus were made in the Taylor Slough drainage of Everglades National Park. Several juveniles were taken in 1983 at $0^{o}/oo$, followed by the May 1984 collections of nesting adults near Joe Bay at $26^{o}/oo$. Establishment appears certain.

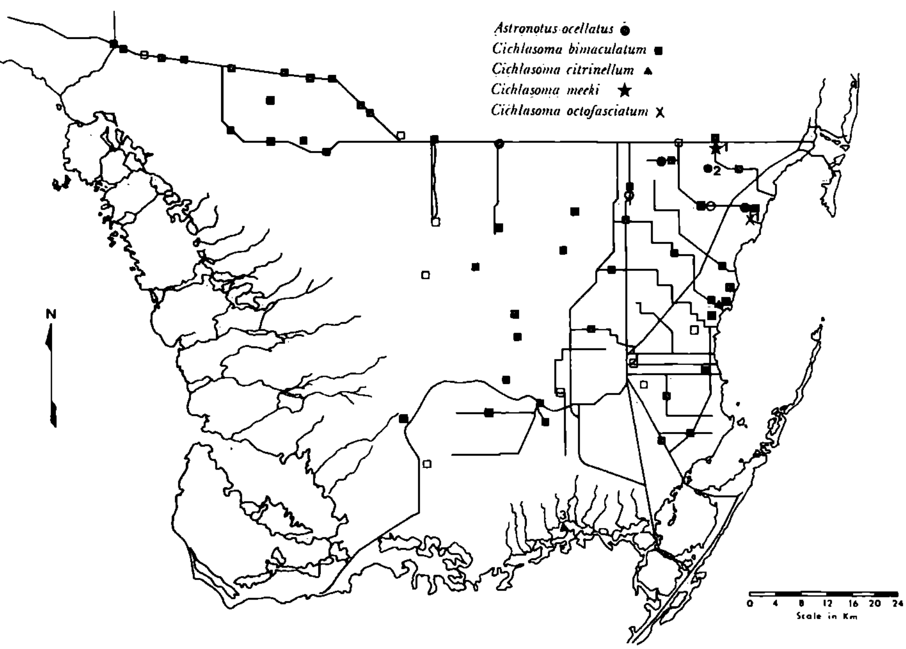

Figure 46.-- Distribution of Astronotus ocellatus, Cichlasoma bimaculatum, Cichlasoma citrinellum, Cichlasoma meeki, and Cichlasoma octofasciatum in fresh water in southern Florida. Open symbols signify sight records. 1 = Hogg (1974); 2 = Mark Hudy (pers. comm.); 3 = Hogg (1974).

and a recent study indicates that they may be conspecific and only subspecifically distinct (Kullander 1983).

Hogg (1976a) and Courtenay and Hensley (1979a) stated that *C. bimaculatum* was abundant in northern Dade County, but that it was unable to colonize southeastern Dade County canals, possibly because of unfavorable water conditions. However, we have collected the black acara from several canals in the Homestead area, which represents a range extension of 10 km to 16 km. Water conditions do not seem to be limiting because the black acara is quite common in several southeastern Dade County locales.

Throughout its southern Florida range, *C. bimaculatum* is much more common in disturbed habitats, especially canals, than in natural habitats. We collected the largest numbers of this species in the Big Cypress Swamp portion of the Tamiami Canal and in ditches along the eastern coastal ridge. In Everglades National Park, we found the black acara in road culverts along the main road as far south as Sweet Bay Pond. It is well established in the park only in the rocky gladelands between Taylor and Shark Sloughs. We collected or observed specimens from natural habitats in Shark Slough on just three occasions, each record consisting of only a few individuals.

The black acara would seem to be well equipped to survive in the fresh waters of southern Florida. It is a prolific and frequent spawner, an omnivorous feeder (Hogg 1976a), and more resistant to drought conditions than most native species. Breeding occurs mainly from spring to fall, although we have collected fry in early January, at a time when most native centrarchids are not spawning. In typically steep-banked canals, the aggressive acara appears to compete directly with centrarchids for limited nesting space. Though it does provide some food and sport, the black acara is not as highly regarded by anglers as the native centrarchids. *C. bimaculatum* is securely established in southern Florida and has become a locally dominant member of some canal faunas within a relatively short time. However, during the present study, we have seen an apparent displacement of this fish by *Tilapia mariae* in canals in which *C. bimaculatum* was once the most abundant exotic. *C. bimaculatum* is much less numerous in eastern Dade County than it was several years ago (this study; Courtenay and Hensley 1979a). When it is sympatric with *T. mariae*, it is usually much less abundant and inhabits shallower, marginal areas of canals than when it is the only cichlid present.

73. *Cichlasoma citrinellum* (Günther) - midas cichlid (II) - Exotic
VS 39 Figure 46

While electrofishing in Black Creek Canal (C-1) in August 1980, we collected an adult male midas cichlid measuring 142 mm SL. The identification of this specimen was confirmed by C. R. Gilbert (pers. comm.). This was one of the first records of this fish in United States waters. It was collected along the shallow, rocky margin of the canal with *Tilapia mariae*, *Cichlasoma bimaculatum*, and several species of centrarchids. This specimen has been deposited at the Florida State Museum (UF 31651). Anderson et al. (1984) took numerous specimens on nests in Black Creek, which confirms its establishment. The midas cichlid is sold in local pet stores, so it seems likely that this introduction resulted from aquarium or fish farm releases. *C. citrinellum* is native to the Atlantic slope of Nicaragua, including the Great Lakes of Nicaragua (Miller 1966).

74. *Cichlasoma meeki* (Brind) - firemouth (II) - Exotic
Not collected — Figure 46

This attractive aquarium fish, which is native to the Yucatan peninsula (Hubbs 1936), apparently escaped from Miami area fish farms into the canal system. It was first recorded from southern Florida waters by Courtenay et al. (1974) in Dade and Palm Beach counties. It was reported to be established in small canals just south of the Tamiami Canal in Miami where its numbers and range increased rapidly (Hogg 1976a). We did not collect *C. meeki* in the vicinity of Tamiami Canal, although we did find several other cichlid species there. If the firemouth occurs within our study area, it is either very localized or its numbers and range have decreased since Hogg's (1976b) study.

75. *Cichlasoma octofasciatum* (Regan) - Jack Dempsey (II) - Exotic
Not collected — Figure 46

Another aquarium species native to Yucatan (Hubbs 1936), *C. octofasciatum* was reported to be established in Snapper Creek Canal (C-2) into which it escaped from tropical fish farms (Hogg 1976a). The Jack Dempsey does not appear to have extended its range in recent years, and it seems that the population was never large. Courtenay and Hensley (1979a) remarked that it was not abundant in Snapper Creek Canal. We did not collect *C. octofasciatum* during our sampling, and if it is still present within our study area, its range and numbers must be quite small. P. L. Shafland (pers. comm.) has never collected this species in our study area.

76. *Hemichromis bimaculatus* Gill - jewelfish (II) - Exotic
CS 153, 154 — Figure 47

The jewelfish is an aquarium escapee, native to West Africa, that was established in the Miami area prior to 1965 (Rivas 1965). The specific identity of the aquarium escapee is now unclear following a revision of the genus by Loiselle (1979), but we have retained the nomenclature of Robins et al. (1980).

Hogg (1976a) reported that *H. bimaculatus* was common north of the Tamiami Trail in Miami and seemed to be expanding its range. In 1980, we collected this species in both the Tamiami Canal and Coral Gables Waterway where it was abundant. A small species at maturity, *H. bimaculatus* always inhabits the shallow, littoral areas of these canals. Both adults and juveniles occur in marginal vegetation and in cavities along the canal banks. At the time of sampling (October 1980), we observed pairs of jewelfish nesting very close to the spawning beds of *Tilapia mariae* and *Cichlasoma bimaculatum*. The aggressively defensive nature of this cichlid may explain its successful nesting in the company of larger cichlids as well as its recent range expansion to the south.

77. *Tilapia aurea* (Steindachner) - blue tilapia (II) - Exotic
CS 80b, 81*, 82*, 112 Figure 47

T. aurea was originally introduced into central Florida lakes by the Florida Game and Fresh Water Fish Commission as a biological control for aquatic weeds (Courtenay and Robins 1973). The stock for United States introductions apparently originated in Israel (Courtenay and Hensley 1979a). In two decades, it has become the most numerous and wide-ranging cichlid in the state. During a recent survey of exotic fishes, specimens of *T. aurea* were collected in parts of Dade County but it was not widespread there (Harris 1978).

We have identified and observed adult *T. aurea* since 1978 at the Anhinga Trail in Everglades National Park, L-31W Canal on the eastern border of the park, and in a rockpit at the Homestead airport. In 1982-83, the species spread throughout Taylor Slough where it is now breeding. The blue tilapia population in extreme southern Florida could have immigrated there through the canal system from other areas but, based upon its limited distribution, it is more likely that this population is the result of localized introductions. The Taylor Slough population probably originated from a fish-farming operation next to the park. Trewavas (1984) placed this species in the genus *Oreochromis*.

78. *Tilapia mariae* (Boulenger) - spotted tilapia (II) - Exotic
VS 1*, 37, 39 Figure 47

This cichlid is presently one of the most numerous and rapidly dispersing exotic fishes in extreme southern Florida. A native of west Africa (Whitehead 1962), *T. mariae* appears to have had two points of introduction into Dade County waters (Hogg 1974). The present range of *T. mariae* now encompasses all of eastern Dade County west to Krome Avenue (State Highway 27). In

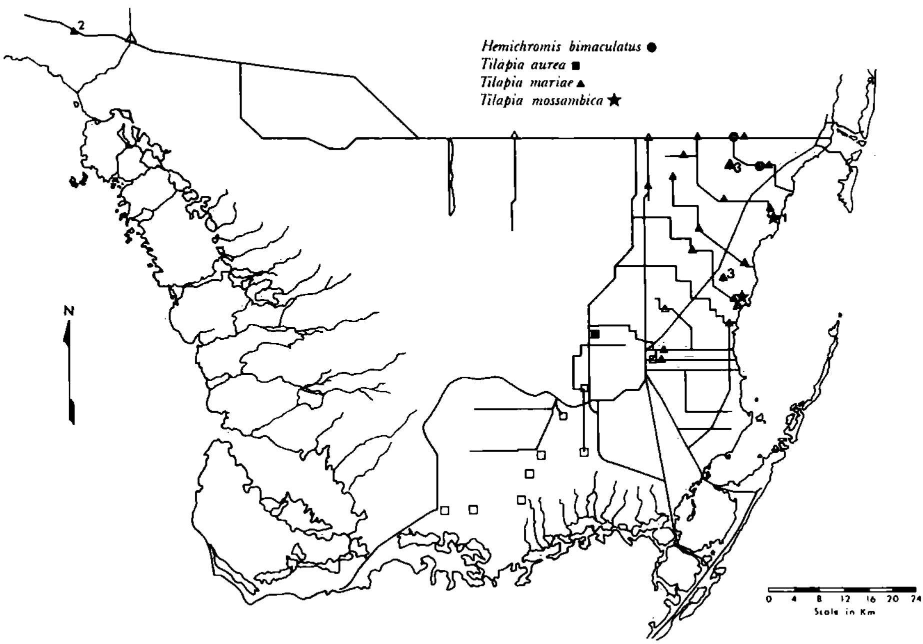

Figure 47.-- Distribution of Hemichromis bimaculatus, Tilapia aurea, Tilapia mariae, and Tilapia mossambica in fresh water in southern Florida. Open symbols signify sight records. 1 = Hogg (1974); 2 = Courtenay and Hensley (1979); 3 = Mark Hudy (pers. comm.).

1979, we observed a nesting pair even farther west at the junction of the Tamiami and L-67 Canals. Courtenay and Hensley (1979b) reported specimens from a Collier County pond, and in early 1983, we observed large numbers of spotted tilapia, including nesting adults, in Turner River Canal, Collier County. We have collected *T. mariae* just north of our study area in L-30 Canal and farther north (Kushlan, in prep.), but we have not yet found it in the nearby East Everglades region. Like the black acara, *T. mariae* is another species of cichlid that has been able to colonize canals in the Homestead area. These distribution data represent a 10-16 km extension south of the range given by Hogg (1976a).

T. mariae is often extremely abundant wherever it occurs. Hundreds of black-barred juveniles, which had originally been described as *Tilapia meeki* (Whitehead 1962), are usually visible in shallow water along the canal banks, while the spotted adults inhabit the deeper mid-portions. The breeding season begins in spring in our study area and extends into the fall (unpubl. data). Both parents aggressively defend the nest and free-swimming fry against intruders. We have collected *T. mariae* in brackish water but are uncertain of its upper salinity limit.

The successful colonization of southern Florida waters by *T. mariae*, its fecundity, and rapid dispersal suggest that it will be the next exotic fish to invade Everglades National Park. We know very little about its potential impact on the Everglades ecosystem or its ability to survive in the marshes. Further study is needed to determine its probable effects upon Everglades ecology.

79. *Tilapia mossambica* (Peters) - Mozambique tilapia (II) - Exotic
VS 39 Figure 47

T. mossambica has been introduced into many tropical countries as a food fish for pond culture. In a number of countries, it has escaped into natural waters where it has rapidly become a major component of the freshwater biota (Bardach et al. 1972; Loftus 1975). In the United States, *T. mossambica* has been in the aquarium trade for decades and is of special interest to hobbyists because of its mouthbrooding behavior. Its introduction into southern Florida canals was the result of releases from aquaria and escapes from tropical fish farms.

T. mossambica has been established just to the north of our study area since 1972 (Courtenay et al. 1974). Hogg (1976a) reported sighting indiviudals near Snapper Creek Canal (C-2) but was uncertain of its establishment. We collected juvenile and adult *T. mossambica* in Black Creek Canal (C-1) and in small canals nearby. We observed males in breeding coloration in these areas, observed courtship behavior, and have collected numerous juveniles. These collections represent a range extension for this species since 1974. We did not find *T. mossambica* south of the Black Creek area, but in view of its performance in other countries, further dispersal through southern Florida seems likely. This species was recently reassigned to the genus *Oreochromis* (Trewavas 1984).

MUGILIDAE - mullets

80. *Agonostomus monticola* (Bancroft) - mountain mullet (VI)
CS 151b Figure 48

Kushlan and Lodge (1974) did not include *A. monticola* in their list of southern Florida freshwater fishes, stating that it apparently did not occur here. However, on a number of occasions from 1977 to 1980, we observed juvenile mountain mullet in a small waterway in the Parrot Jungle, a Miami tourist attraction (Loftus et al. 1984). We collected a single specimen there in January 1981 and saw several others. The specimen measured 63.0 mm SL and shared this stream with many native and exotic species. In June 1982 we collected one adult and three juveniles at the same location. Additional adults and many juveniles were present in the stream on that date (Loftus et al. 1984). These fish were not introduced into the attraction (N. DeLeon pers. comm.), and, because this small waterway is connected to Snapper Creek Canal, we believe that they entered from that canal. Although *A. monticola* has been collected in several freshwater locales in coastal areas along the Florida Atlantic and Gulf Coasts (Gilbert 1978b; Rhode 1980), there have been just two collections other than ours from the study area (Tabb et al. 1974; Randy Metzger pers. comm.). Collections of larvae in the Gulf Stream off the Florida coast (Anderson 1957) and of juveniles in Biscayne Bay (C. R. Robins pers. comm.) show that a source of recruitment exists for southern Florida. Its rarity in southern Florida can be explained by the absence of natural high-gradient streams, its usual habitat in tropical America and the West Indies (W. F. Loftus pers. observ.). The artificial stream in Parrot Jungle probably approximates this preferred habitat better than any other natural situation in southern Florida. The increase in the number of mountain mullet, including the presence of adults, at Parrot Jungle, raises the possibility that this may be the first reproducing population within the United States.

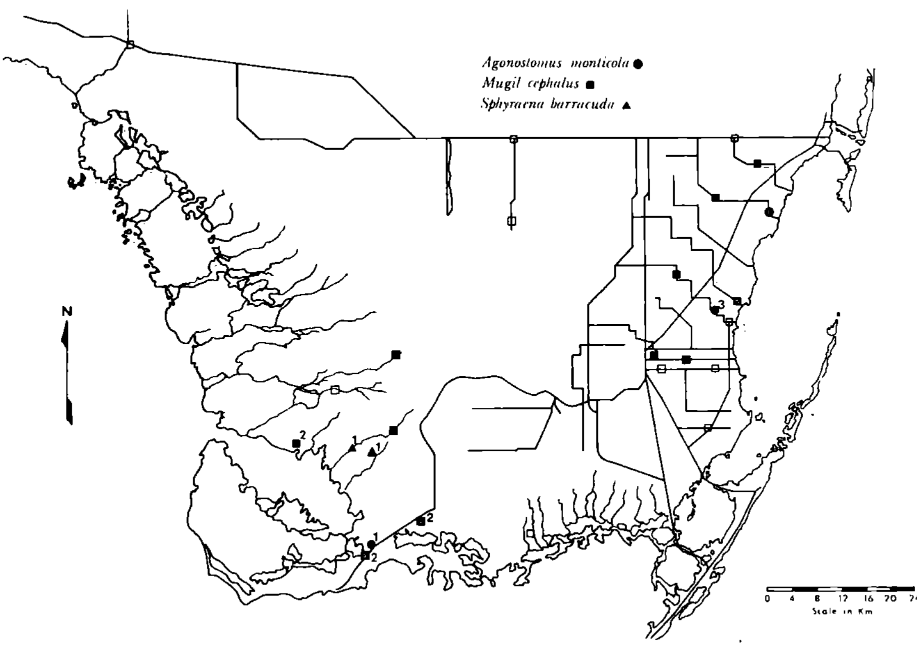

Figure 48.– Distribution of Agonostomus monticola, Mugil cephalus, and Sphyraena barracuda in fresh water in southern Florida. Open symbols signify sight records. 1 = Tabb et al. (1974); 2 = Tabb and Manning (1961); 3 = Randy Metzger (pers. comm.).

81. *Mugil cephalus* Linnaeus - striped mullet (VI)
VS 1*, 2*, 16, 22, 24*, 26*, 27, 37, 39 Figure 48

The striped mullet occurs in southern Florida fresh waters from Lake Okeechobee (Ager 1971) and the St. Lucie (Gunter and Hall 1963a) and Caloosahatchee rivers (Gunter and Hall 1965), southward into the canals and rivers of the Big Cypress Swamp and southern Everglades (Kushlan and Lodge 1974). This mullet ascends Everglades river systems into the smallest headwaters creeks, sometimes penetrating 15-25 km inland. Although these creeks are fed by the sawgrass marshes, the striped mullet never enters the marshes. It is restricted to the deeper, open waters of the creeks. We observed or collected striped mullet in every river system sampled. Most of our specimens were taken by electrofishing, and all specimens collected were adults. Tabb and Manning (1961) and Odum (1971) have previously collected it in fresh water in the Everglades estuary. The striped mullet occurs in small to moderately sized schools in freshwater habitats, and their presence at several collection sites was revealed by their characteristic leaping. Most freshwater canals with connections to salt water in southern Florida have striped mullet populations. The mullet use the canal system to move far inland into the Everglades and Big Cypress regions, but they are restricted to canal habitats there.

SPHYRAENIDAE - barracudas

82. *Sphyraena barracuda* (Walbaum) - great barracuda (VI)
Not collected Figure 48

Several specimens, ranging from 280 mm to 320 mm in length, were taken from fresh water in North River in 1966 (Tabb et al. 1974). This is the only known collection record for *S. barracuda* from fresh water in our study area. We have frequently seen juvenile barracuda in low salinity waters in coastal canals, but we did not collect specimens in fresh water during our sampling. C. R. Robins (pers. comm.) informed us that he has seen *S. barracuda* in fresh water at the University of Miami Campus in Coral Gables.

ELEOTRIDAE - sleepers

83. *Dormitator maculatus* (Bloch) - fat sleeper (III)
CS 151b* Figure 49

This brackish-water species has been taken in fresh water in the Everglades estuary by Tabb and Manning (1961) and Tabb et al. (1967). It has also been taken in Snapper Creek Canal (Hogg 1976a) and in other Dade County coastal canals (Belshe 1961). Along the Gulf Coast, Dawson (1969) stated that D. maculatus is most abundant in brackish-water habitats, but that it does enter coastal fresh water. The fat sleeper does not seem to be numerous in extreme southern Florida fresh waters. We did not collect specimens within our study area, but we did observe several large individuals in an artificial stream at Parrot Jungle. We also took two specimens in a freshwater canal in north Miami, several km north of the study area (Kushlan, in prep.).

84. *Eleotris pisonis* (Gmelin) - spinycheek sleeper (III)
Not collected — Figure 49

E. pisonis is a euryhaline species that ranges along the southern coast of Florida in estuarine habitats. It is known to enter fresh water along the east coast in the Indian River area (Gilmore 1977) and in Palm Beach County (Kushlan and Lodge 1974). The spinycheek sleeper had been collected in coastal ditches in our study area by Belshe (1961), but the salinity was not reported. The only confirmed freshwater record for extreme southern Florida was taken by Darcy (1978) in the Coral Gables Waterway. We did not collect it in our sampling.

85. *Gobiomorus dormitor* Lacepede - bigmouth sleeper (III)
VS 37; CS 149 — Figure 49

G. dormitor is another brackish-water species that enters fresh water in Florida (Lindquist 1980). The bigmouth sleeper is a large predator that normally lies motionless on the bottom while waiting for prey. We collected two large specimens in a freshwater canal near Miami, and took a third adult in Snapper Creek Canal. We also observed a small, juvenile *G. dormitor* in the Parrot Jungle stream. C. R. Robins (pers. comm.) informed us of a number of sightings in the Miami area and Everglades canals. This species may be more common in freshwater canals in extreme southern Florida than our collections indicate. *G. dormitor* has frequently been collected elsewhere in fresh water in southern and east central Florida (Kushlan and Lodge 1974; Gilmore 1977).

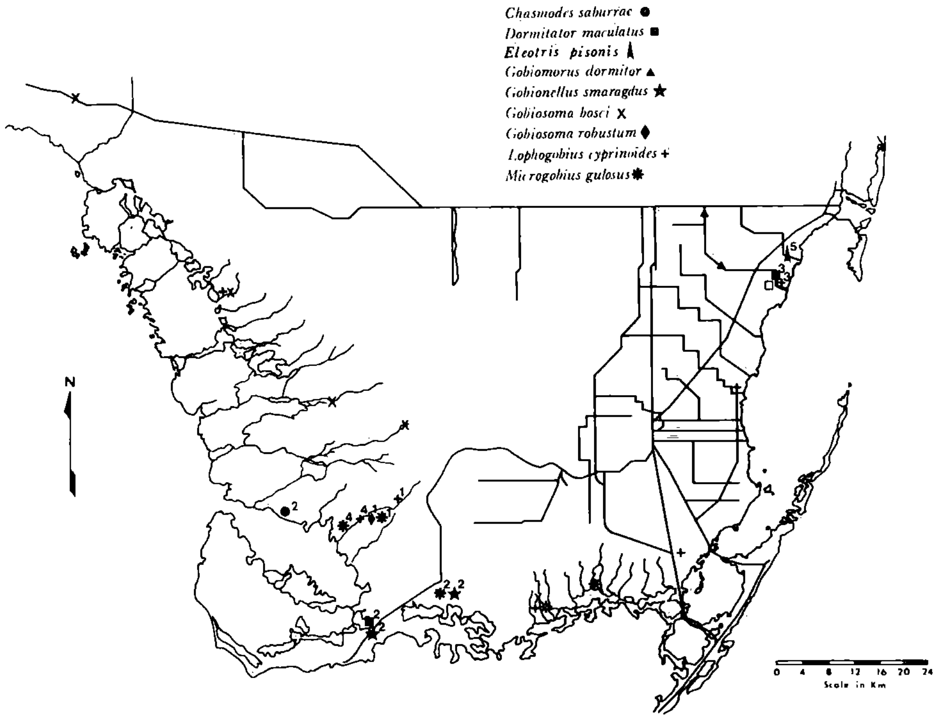

Figure 49.-- Distribution of Chasmodes saburrae, Dormitator maculatus, Eleotris pisonis, Gobiomorus dormitor, Gobionellus smaragdus, Gobiosoma bosci, Gobiosoma robustum, Lophogobius cyprinoides, and Microgobius gulosus in fresh water in southern Florida. 1 = Odum (1971); 2 = Tabb and Manning (1961); 3 = Hogg (1974); 4 = Tabb et al. (1974); 5 = Darcy (1978).

GOBIIDAE - gobies

86. *Gobionellus smaragdus* (Valenciennes) - emerald goby (VI)
Not collected Figure 49

The only freshwater specimens of this goby in southern Florida were collected by Tabb and Manning (1961) in the mangrove region of Everglades National Park. They collected it in a sample with *Noturus gyrinus* and *Micropterus salmoides*. Tabb and Manning (1961) also collected the emerald goby in brackish estuarine waters and in Florida Bay, and they considered it to be euryhaline. We know of no other freshwater records for *G. smaragdus*, and we did not collect it during our sampling.

87. *Gobiosoma bosci* (Lacepede) - naked goby (VI)
VS 15, 24, 34 Figure 49

The naked goby inhabits low salinity waters, usually less than 22^{o}/oo (Dawson 1969), and enters fresh waters along both the Atlantic and Gulf Coasts. In southern Florida, *G. bosci* has been collected in fresh water in the Caloosahatchee River (Gunter and Hall 1965) and in Lake Okeechobee (Ogilvie 1969). We collected *G. bosci* in fresh water in the headwaters region of several coastal rivers. It was locally common in the shallows over muddy or rocky substrates. Neither Tabb and Manning (1961) nor Odum (1971) collected *G. bosci* in the Everglades estuary. Instead, Odum (1971) collected *Gobiosoma robustum* in the same locales and habitats in which we took *G. bosci.*

88. *Gobiosoma robustum* Ginsburg - code goby (VI)
Not collected Figure 49

G. robustum is usually found only in moderate to high salinity waters from 22^{o}/oo to 32^{o}/oo (Dawson 1969; Springer and Woodburn 1960), although it has been collected at 2.1^{o}/oo (Wang and Raney 1971). We include it here on the basis of freshwater collections made by Odum (1971) in the North River, where he found it to be the most common goby. Tabb and Manning (1961) did not take *G. robustum* in fresh water, although they considered it to be the most abundant goby in the saline waters of the Everglades estuary. We did not collect this goby in fresh water. We have not checked Odum's (1971) specimens, but we feel that there may have been a misidentification of this species. *G. bosci* is the common *Gobiosoma* in fresh water in extreme southern Florida.

89. *Lophogobius cyprinoides* (Pallas) - crested goby (VI)
VS 24, 34: CS 166 Figure 49

The crested goby is common in inshore, brackish habitats in southern Florida and enters fresh water in rivers and canals near the coast. Tabb and Manning (1961) collected it in freshwater rivers emptying into Whitewater Bay, and they considered it to be a euryhaline species. It was the second most abundant goby in the North River and maintained the highest biomass of any goby (Odum 1971). On the east coast, Hogg (1976a) collected *L. cyprinoides* in Snapper Creek Canal in fresh water.

We collected the crested goby in several headwater rivers and coastal canals, usually in quiet water over leaf-littered bottoms. It is typically a sedentary species with dull coloration that blends well with the bottom. The gobies occupy small burrows in the bottom, often with only a part of the body exposed. The larger males actively defend territories and move about more than do smaller individuals. *L. cyprinoides* is locally common in coastal fresh waters and seems likely to occur in many rivers and canals with connections to salt water. Aspects of its biology and ecology in southern Florida were studied by Darcy (1978).

90. *Microgobius gulosus* (Girard) - clown goby (VI)
VS 24; CS 146 Figure 49

M. gulosus is another euryhaline species that enters fresh water in the Everglades estuary. Along the Gulf Coast, it occurs in muddy estuarine habitats as well as in areas protected by aquatic vegetation (Dawson 1969). Similarly, it inhabits areas of aquatic vegetation in the littoral zone of Lake Okeechobee (Ager 1971). Tabb and Manning (1961) found it to be the second most abundant goby in brackish water in southern Florida. They also collected it in fresh water in pools and canals and over a wide variety of bottom types in mangrove swamps. *M. gulosus* has also been taken in fresh water in North River (Odum 1971; Tabb et al. 1974). We found the clown goby to be common in coastal freshwater rivers and pools, especially over muddy bottoms. These data indicate that *M. gulosus* is probably present in fresh water throughout the Everglades estuary. We did not collect this species in coastal canals.

SOLEIDAE - soles

91. *Achirus lineatus* (Linnaeus) - lined sole (III)
Not collected Figure 50

The most abundant flatfish in Florida Bay and surrounding coastal waters (Tabb and Manning 1961), *A. lineatus* has been collected in fresh water on several occasions in the Everglades estuary. During 1966-1972, several specimens were collected in a headwater stream at Rookery Branch (Kushlan and Lodge 1974). Tabb and Manning (1961) found the lined sole in fresh water in mangrove swamps near Whitewater Bay, and it was also collected in fresh water in North River (Odum 1971; Tabb et al. 1974). Juveniles occur more frequently in fresh water than do the adults which move into Florida Bay (Tabb and Manning 1961).

Though it occurs in fresh water in the headwaters region of Everglades National Park, as well as in the St. Lucie (Gunter and Hall 1963a) (0.18 ^{o}/oo) and Caloosahatchee rivers (Gunter and Hall 1965) (0.14 ^{o}/oo), *A. lineatus* is never as common in southern Florida fresh water as the hogchoker, *Trinectes maculatus*. We did not collect it during our sampling.

92. *Trinectes maculatus* (Bloch and Schneider) - hogchoker (III)
VS 15, 34* Figure 50

We collected the hogchoker in fresh water throughout the Everglades estuary where it was locally common. It normally inhabits slowly flowing streams and pools over muddy, leaf-littered bottoms, with which its coloration blends well. In fresh water, *T. maculatus* is restricted to the streams and canals of the headwaters region and does not enter the marsh habitat. It is known from fresh water from Lake Okeechobee (Ager 1971) and the Caloosahatchee River (Gunter and Hall 1965) and was previously collected in southern Florida fresh water by Tabb and Manning (1961), Odum (1971), and Tabb et al. (1974). Many specimens were collected in the headwater streams of Rookery Branch from 1965 to 1972 (Kushlan 1980a), and we have since taken many additional specimens from that area. None of these fish exceeded 80 mm SL, supporting the findings of Springer and Woodburn (1961) and Gunter and Hall (1963a) that larger specimens inhabit more saline waters. Dovel et al. (1969) have provided definitive treatment of the salinity-size relationship of this species.

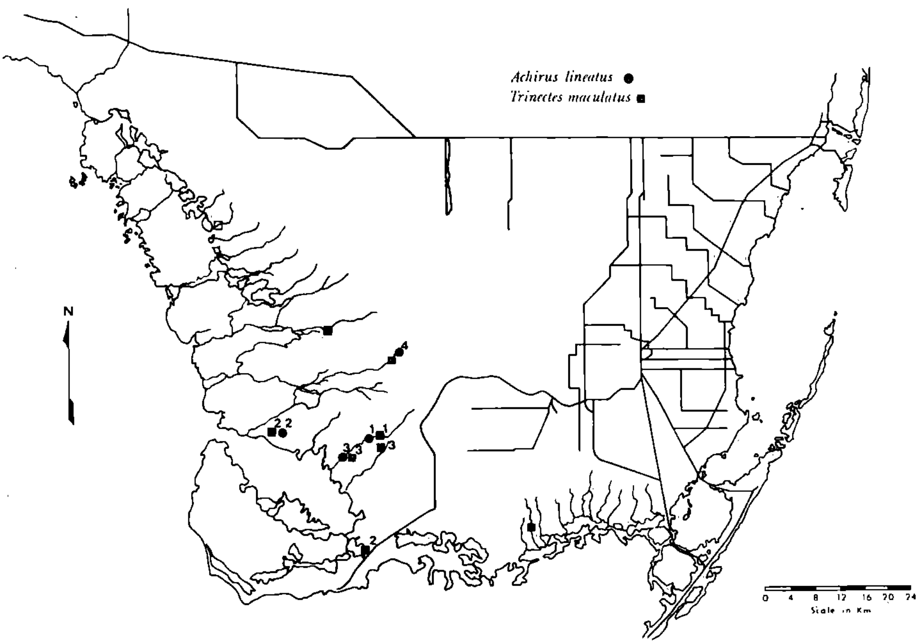

Figure 50.-- Distribution of Achirus lineatus and Trinectes maculatus in fresh water in southern Florida. 1 = Odum (1971); 2 = Tabb and Manning (1961); 3 = Tabb et al. (1974); 4 = Kushlan and Lodge (1974).

SPECIES OF DOUBTFUL OCCURRENCE OR PERSISTENCE

LEPISOSTEIDAE - gars

1. *Lepisosteus osseus* (Linnaeus) - longnose gar (II)

Carr and Goin (1955), Briggs (1958), and Stevenson (1976) gave the range of *L. osseus* as the entire state of Florida. We did not collect or observe this fish during our sampling, nor had the species been collected from extreme southern Florida previously. The southernmost record for *L. osseus* was reported by Dineen (1974) from Everglades Conservation Area 2A where it was very rare. The longnose gar does not occur in extreme southern Florida.

CLUPEIDAE - herrings

2. *Brevoortia smithi* Hildebrand - yellowfin menhaden (VI)

Kushlan and Lodge (1974) reported the freshwater occurrence of *B. smithi* in Everglades National Park, but its freshwater occurrence in our study area is doubtful (C. R. Robins pers. comm.). Freshwater specimens have never been reported in the literature for extreme southern Florida (Tabb and Manning 1961; Odum 1971; Tabb et al. 1974). The only freshwater record from Florida of which we are aware comes from the Indian River region (R. G. Gilmore pers. comm.). Gunter (1956) included *B. smithi* on a list of euryhaline species based on Carr and Goin's (1955) report, but the source for their record is not clear. *B. smithi* does not appear to have been collected in fresh water throughout the remainder of its range (Dahlberg 1970; Lee et al. 1980; Robins et al. 1980).

3. *Brevoortia tyrannus* (Latrobe) - Atlantic menhaden (VI)

This menhaden was reported from southern Florida fresh water by Kushlan and Lodge (1974). Dahlberg's (1970) work on the genus *Brevoortia* has shown that *B. tyrannus* does not extend into southern Florida but is replaced by *B. patronus*, the Gulf menhaden. In addition, a hybrid of *B. smithi* and *B. patronus* occurs in marine areas of southern Florida (Dahlberg 1970). *B. partonus* has been collected in fresh water along the Gulf Coast (Gunter 1956), but we have found no freshwater collection records for southern Florida (Tabb and Manning 1961; Odum 1971; Tabb et al. 1974).

CHARACIDAE - characins

4. *Colossoma* spp. - pacus

The South American pacus are among the largest characids in the world. On several occasions, large specimens have been caught by fishermen in Miami area canals (P. L. Shafland pers. comm.). C. R. Robins (pers. comm.) recently informed us of a pacu specimen (either *C. brachypomum* or *C. oculus*) taken by a fisherman in a Coral Gables canal. This fisherman reported catching additional pacus from the same locale in the past. The reproductive status and ultimate persistence of pacus in southern Florida waters is presently unknown. The occasional specimen taken might merely be the result of a release by an aquarist into the canal system.

CYPRINIDAE - carps and minnows

5. *Notropis chalybaeus* (Cope) - ironcolor shiner (I)

Stevenson (1976) stated that the range of this minnow extended to the southern tip of Florida. We did not collect *N. chalybaeus* in our study area, nor has it been reported from this area by other workers (Dineen 1974; Kushlan and Lodge 1974). Its occurrence in extreme southern Florida is doubtful, and we believe that its southern limit is near Lake Okeechobee (Swift 1980a).

6. *Notropis emiliae* (Hay) - pugnose minnow (I)

Stevenson (1976) and Carr and Goin (1955) gave the range of the pugnose minnow as the entire Florida peninsula. We did not collect *N. emiliae* during our sampling, and we know of no records for this species south of Lake Okeechobee (Gilbert 1980a; Kushlan and Lodge 1974). The Florida peninsula subspecies, *N. e. peninsularis*, is very well defined. In their description, Gilbert and Bailey (1972) listed its range as peninsular Florida, south to Lake Okeechobee. Based on our sampling, we do not believe that it occurs in extreme southern Florida.

APHREDODERIDAE - pirate perches

7. *Aphredoderus sayanus* (Gilliams) - pirate perch (I)

The pirate perch ranges southward in Florida to Lake Okeechobee (Lee 1980) and the northern Everglades Water Conservation Areas (Dineen 1974). It is apparently very rare in the northern Everglades (Dineen 1974). Based on a single specimen collected near Florida City in 1930 (Kilby and Caldwell 1955), Carr and Goin (1955), and Briggs (1958) stated that the range of *A. sayanus* included the entire state. Kushlan and Lodge (1974) suggested that this record was in error. C. R. Gilbert (pers. comm.) informed us that the true range of *A. sayanus* parallels the range of *Esox americanus* very closely and so would not be expected in extreme southern Florida. We did not collect the pirate perch in our sampling, nor has it been collected by other workers in the study area. Based upon the lack of additional specimens from our study area, we conclude that the collection locale of the "Florida City" specimen was erroneous.

CYPRINODONTIDAE - killifishes

8. *Fundulus cingulatus* Valenciennes - banded topminnow (II)

The banded topminnow has been recorded from southern Florida on the basis of two specimens from an unspecified location in the Tamiami Canal (Brown 1956). This record had been cited in subsequent papers on Florida fishes as documentation that the range of *F. cingulatus* extends into extreme southern Florida (Kushlan and Lodge 1974; Relyea 1975; Stevenson 1976). Foster (1967) reexamined Brown's specimens and found them to be misidentified specimens of *Fundulus chrysotus*. We can find no other record of *F. cingulatus* south of Lake Trafford in Collier County (L. R. Rivas pers. comm.), and it was not recorded south of Lake Okeechobee by Gilbert and Burgess (1980a). It has not been collected in the northern Everglades (Dineen 1974), in the Fakahatchee Strand (Carter et al. 1973), or in the Everglades portion of the Tamiami Canal (Hunt 1953). We did not collect *F. cingulatus* in our study area, and we doubt that its range extends into extreme southern Florida.

9. *Fundulus lineolatus* (Agassiz) - lined topminnow (II)

Three specimens of *F. lineolatus* were collected at Chekika State Park in Dade County in 1968 by Relyea (1975). The specimens were catalogued as *F. notti lineolatus*. Dr. Relyea allowed us to examine these specimens and we agree with their identification as *F. lineolatus*. With the exception of this record, the southern limit of the range of this species is usually considered to be Palm Beach County (Rivas 1966; Wiley 1980a). No specimens other than those of Relyea (1975) have been collected in extreme southern Florida (Dineen 1974; Kushlan and Lodge 1974; present study). Crowder (1974) included *F. notti* on a list of south Florida fishes but provided no reference or collection data to support the record. Chekika State Park is a popular fishing and recreation area, and we and L. R. Rivas (pers. comm.) believe that the specimens Relyea caught had probably been introduced into this lake. We did not collect *F. lineolatus* during our 1977 sampling of Lake Chekika and doubt that it has successfully established itself in our study area.

10. *Leptolucania ommata* (Jordan) - pygmy killifish (II)

Relyea (1975) stated that *Leptolucania ommata* ranged throughout the Florida peninsula in fresh water. We have found no records for this species south of central Florida (Briggs 1955; Gilbert and Burgess 1980c) and doubt its occurrence in southern Florida. Relyea (pers. comm.) agrees that he misstated the range of *L. ommata* in his 1975 paper.

BLENNIDAE - combtooth blennies

11. *Chasmodes saburrae* Jordan and Gilbert - Florida blenny (VI)
Not collected Figure 49

C. saburrae was collected by Tabb and Manning (1961) at 0^{o}/oo salinity in the Everglades estuary near Whitewater Bay. They stated that it was the common brackish-water blenny in that area, occurring on oyster bars in clean water where salinities normally ranged from 10^{o}/oo to 27^{o}/oo. The Florida blenny cannot be considered a true member of the freshwater ichthyofauna, because it would be exposed to fresh water only during heavy runoff in the wet season. We did not collect this species, nor are we familiar with other freshwater records. Williams (1983) noted no freshwater records in his systematic revison of the genus.

HYBRIDS

In general, natural hybridization between closely related freshwater fish species is not uncommon. The process appears to be increasing because of human modification of aquatic environments and fish distribution (Lagler et al. 1977). We found little evidence of hybridization in southern Florida freshwater fishes. In our collections of thousands of fishes, we found only two hybrids, both centrarchids. Both were taken in borrow ponds in which the parental stocks were forced to nest in close proximity because suitable spawning habitat was limited. Such nest site competition is often responsible for the occurrence of sunfish hybridization (Lagler et al. 1977). One specimen, a relatively rare hybrid of *Lepomis macrochirus* x *Lepomis punctatus*, was identified by R. M.

Bailey and has been deposited at the University of Michigan Museum of Zoology (UMMZ 209310). The second hybrid, apparently *Lepomis macrochirus* x *Lepomis microlophus*, was observed but not captured. Only one other instance of hybridization, a *Lepomis microlophus* x *Lepomis gulosus* cross, has been reported from extreme southern Florida (Martin 1963). We detected no hybridization among members of the common families Poeciliidae, Cyprinodontidae, or Ictaluridae, and we conclude that hybridization is rare in southern Florida fresh water. Furthermore, centrarchid hybrids are rare in all known collections of Florida freshwater fishes (C. R. Gilbert pers. comm.). One of the few published records of hybrid sunfishes in Florida described a natural hybrid population that probably resulted from the lack of suitable nesting sites for one of the parent species (Birdsong and Yerger 1967).

Table 4. Fishes documented from southern Florida fresh waters in the present study, but not listed from this region by other authors. Number(s) in parentheses refer(s) to the citations in which the range of the species does not include extreme southern Florida. 1 = Lee et al. (1980), 2 = Stevenson (1976), 3 = Carr and Goin (1955), 4 = Kushlan and Lodge (1974).

Anguilla rostrata (1)	*Elassoma evergladei* (1)
Dorosoma cepedianium (1)	*Enneacanthus gloriosus* (1)
Dorosoma petenense (1)	*Lepomis marginatus* (1, 3, 4)
Notropis maculatus (1)	*Lepomis punctatus* (3)
Notropis petersoni (1, 2)	*Etheostoma fusiforme* (1)
Erimyzon sucetta (1)	*Caranx hippos* (1)
Ictalurus punctatus (1)	*Agonostomus monticola* (1, 4)
Fundulus seminolis (1, 2)	*Gobiomorus dormitor* (1)
Labidesthes sicculus (1)	

DISCUSSION

Range Revisions and New Records

A number of range clarifications resulted from our study (Table 4). New distributional data have extended the ranges of the coastal shiner (*Notropis petersoni*), gulf killifish (*Fundulus grandis*), and Seminole killifish (*Fundulus seminolis*) beyond those presented by Stevenson (1976). Carr and Goin (1955) did not include extreme southern Florida in the ranges of dollar sunfish (*Lepomis marginatus*) and spotted sunfish (*Lepomis punctatus*), but we have found both species to be quite common there. Our collection data also showed that the known freshwater ranges of 16 species extend into extreme southern Florida, thus revising the ranges presented by various authors in species accounts in Lee et al. (1980).

The ranges of several species have been reported to extend into extreme southern Florida, but our sampling and literature review have provided no support for such reports. The chain pickerel (*Esox niger*) and black crappie (*Pomoxis nigromaculatus*) range south only to the vicinity of Tamiami Trail rather than to the tip of the peninsula (Briggs 1958; Stevenson 1976). Carr and Goin (1955), Briggs (1958), and Stevenson (1976) stated that the ranges of the longnose gar (*Lepisosteus osseus*), ironcolor shiner (*Notropis chalybaeus*), pugnose minnow (*Notropis emiliae*), and pirate perch (*Aphredoderus sayanus*) extend into extreme southern Florida, when, in actuality, they do not extend south of the vicinity of Lake Okeechobee (Gilbert and Bailey 1972; Wiley 1980b; Swift 1980a; Lee 1980b). Brown's (1956) record of the banded topminnow (*Fundulus cingulatus*) from the Tamiami Canal was found to be based upon a misidentification (Foster 1967), while the reported occurrence of the pygmy killifish (*Leptolucania ommata*) throughout the peninsula is incorrect (Relyea 1975). We have found no records for two species of menhaden (*Brevoortia* spp.) reported to occur in extreme southern Florida fresh water by Kushlan and Lodge (1974).

From our sampling, and during our literature review of southern Florida fishes in fresh water, we found specimen records for euryhaline species that had rarely or never been taken from fresh water. Freshwater records for several species had been published but were not listed from fresh water by Robins et al. (1980). These included the diamond killifish (*Adinia xenica*) (Tabb and Manning 1961; Odum 1971; present study), goldspotted killifish (*Floridichthys carpio*) and silver jenny (*Eucinostomus gula*) (Odum 1971; Tabb et al. 1974; present study), the longnose killifish (*Fundulus similis*) (Gilmore 1977; present study), jewfish (*Epinephelus itajara*) (Tabb et al. 1974), crevalle jack (*Caranx hippos*) (Odum 1971; Gilmore 1977; present study), leatherjacket (*Oligoplites saurus*) (Tabb et al. 1974), great barracuda (*Sphyraena barracuda*) (Tabb et al. 1974), emerald goby (*Gobionellus smaragdus*) (Tabb and Manning 1961), and the crested goby (*Lophogobius cyprinoides*) (Odum 1971; Hogg 1976a; present study).

Records for other species that are infrequent in fresh water in southern Florida included rivulus (*Rivulus marmoratus*) (Tabb and Manning 1961), spotfin mojarra (*Eucinostomus argenteus*) (Odum 1971; Tabb et al. 1974), code goby (*Gobiosoma robustum*) (Odum 1971), mountain mullet (*Agonostomus monticola*) (Tabb et al. 1974; Loftus et al. 1984), and pinfish (*Lagodon rhomboides*) (Hogg 1976a). We collected the first freshwater specimens of mangrove gambusia (*Gambusia rhizophorae*) for the United States, and we also took specimens of two species that are uncommon in Florida freshwater collections--the bull shark (*Carcharhinus leucas*) and gulf killifish. Many of these euryhaline species are not uncommon in southern Florida fresh water, especially in the estuaries, but specimen records are quite rare due to difficulties in collecting and problems of accessibility. We think that more intensive collecting along the southwestern coast of Florida would yield freshwater records for additional euryhaline species.

Relyea (1975) discussed the paucity of specimen records for three species of euryhaline killifishes along the southwestern coast of Florida. He stated that the gulf killifish, longnose killifish, and the rainwater killifish (*Lucania parva*) had similarly disjunct distributions between Everglades City and Cape Sable. However, Odum (1971) found that the rainwater killifish and gulf killifish were common within this area, and our sampling data have shown that no such disjunctions in distributions exist (Figs. 27, 29). Thus, these species range along the entire southwestern tip of Florida. We believe that the inaccessibility of the area and resulting lack of collecting effort have produced the mistaken impression that allopatric Gulf, Atlantic, and Florida keys populations exist for those species.

Duggins (1980a) studied the taxonomic relations of several species of silversides and killifishes using electrophoretic techniques. He interpreted his results with respect to the range disjunctions reported by Relyea (1975). Because our data show that the assumed range disjunctions do not exist, Duggins's interpretations must be re-evaluated. He suggested that a climatic warming trend has made southern Florida unsuitable for the gulf and rainwater killifishes. However, because we found both species to be locally abundant, we must doubt that interpretation.

During our study, we found a substantial number of misconceptions in accepted range data for southern Florida freshwater fishes. We have provided many range extensions and corrections. Systematic surveys of areas like southern Florida, which form the terminus of ranges for many species, are particularly important because such areas weigh heavily in considerations of speciation, environmental limitations, and zoogeography. An incomplete understanding of species distributions can lead to erroneous assumptions and interpretations of zoogeographic patterns and taxonomic differentiation.

Faunal Derivation and Salinity Relations

The entry of marine fishes into fresh water, particularly in Florida, has been a matter of interest for many years (Gunter 1942; Odum 1953; Gunter and Hall 1963b; Kushlan and Lodge 1974). In addition, the classification of freshwater fishes according to their salinity tolerances has been of value in both zoogeographical and ecological studies. Based upon our work, we set the number of fishes known from fresh water in extreme southern Florida at 92 species (Table 5). We collected or observed 70 of these during our sampling. Records of the remaining 22 species were obtained from the literature and from personal communications. Of the 92 species, 80 (87%) are native, and 12 (13%) are introduced. The native primary freshwater fishes belong to eight families and include 20 (25.3%) species. Native secondary freshwater fishes belong to two families and include 8 (10%) species. Native peripheral fishes belong to 24 families and include 52 (65%) species (Table 5). Of the typically freshwater species, 16 seem to be restricted to fresh water, while another 10 species enter brackish areas. Several fishes of "primary" freshwater families, particularly largemouth bass and redear sunfish, breed in low-salinity, brackish waters in southern Florida. Few native fishes belong to the category of secondary freshwater fishes, but 10 of 12 exotic species in the study area are secondary freshwater fishes.

All native primary and secondary freshwater species in southern Florida are derived from temperate North American fish stocks. No native species has its origin in the neotropical region. Most species are widespread throughout the southeastern United States coastal plain, and the ranges of several extend north to the Great Lakes region. Although no endemic species occur in southern Florida, several of the most abundant species are restricted to Florida and adjacent states: *Jordanella floridae*, *Lucania goodei*, *Heterandria formosa*, and *Lepisosteus platyrhincus* (Swift et al. 1977).

Most primary and secondary freshwater families in southern Florida experience a reduction in the number of genera and species from north to south on the peninsula. As a result, the southern Florida freshwater ichthyofauna is rather depauperate in comparison to that of northern Florida and the southeastern United States. At the southern end of the peninsula, the Lake Okeechobee region is the site of a faunal break for six species that are widespread to the north but do not enter the Everglades. These species are

Lepisosteus osseus, *Esox americanus*, *Notropis chalybaeus*, *Notropis emiliae*, *Ictalurus catus*, and *Aphredoderus sayanus*. Reasons for the progressive reduction in species from north to south in Florida have been discussed by Briggs (1958) and Kushlan and Lodge (1974). The most important of these seems to be the unsuitability of the available aquatic habitats or the climate for temperate species.

Of the 52 peripheral species, four are diadromous (American eel, *Anguilla rostrata*; mountain mullet, *Agonostomus monticola*; fat sleeper, *Dormitator maculatus*; and bigmouth sleeper, *Gobiomorus dormitor*); 36 species are restricted to coastal waters, and 15 marine species are found far inland in fresh water. Peripheral species that penetrate far inland, but occur only in canals, include snook (*Centropomus undecimalis*), tarpon (*Megalops atlanticus*), American eel (*Anguilla rostrata*), and striped mullet (*Mugil cephalus*). Several peripheral species that have been able to colonize fresh water in the Everglades marsh and Big Cypress Swamp are the diamond killifish, sheepshead minnow (*Cyprinodon variegatus*), sailfin molly (*Poecilia latipinna*), and marsh killifish (*Fundulus confluentus*). Outside of the Florida peninsula, these species rarely penetrate freshwater habitats and are often restricted to coastal areas (Johnson 1980; Burgess 1980g; Hardy 1980). In the Ochlockonee River of the Florida panhandle, the abovementioned cyprinodontoids, as well as the rainwater killifish, flagfish (*Jordanella floridae*), Seminole killifish, and inland silverside (*Menidia beryllina*), are restricted to within 10 km of the coast (Swift et al. 1977). Two factors that may account for this restriction in the panhandle are the cooler winter temperatures and the higher gradient streams there (Swift et al. 1977). Additionally, the greater diversity of primary freshwater fishes in the panhandle (e.g. 15 species of cyprinids compared to 3 species in southern Florida) may present competitive barriers to colonization by these secondary and peripheral fishes. In southern Florida, the paucity of small primary freshwater species, due in part to high ambient water temperatures, seasonal droughts, and habitats generally unsuitable for temperate stream fishes, probably accounts for domination of natural habitats by cyprinodontids and poeciliids. Such dominance by peripheral fishes when primary species are rare or absent was also noted by Myers (1949).

The major factor influencing penetration of fresh water by euryhaline forms in southern Florida is water chemistry composition, particularly the relatively high concentrations of sodium, chloride, and calcium (Table 1). All areas of southern Florida and most of the peninsular coastal areas were submerged during the Pleistocene, when the Pamlico terrace was formed at sea levels ranging from 7.6 to 9.1 m above the present level (Alt and Brooks 1965). Sediments deposited at that time contribute to the present-day ionic composition of southern Florida fresh water (Table 1). The distribution of a number of peripheral freshwater species in Florida appears to correspond to

Table 5. Fishes known to occur in fresh water in southern Florida. An asterisk indicates a species that was not collected in this study, but that had been recorded previously from fresh water in the study area. Roman numerals following the common name denote the salinity classification of the species as either primary freshwater (I), secondary freshwater (II), or peripheral (III-VI) after Myers (1949). Exotic species are so noted.

Family		Species	Common Name
CARCHARHINIDAE	1.	*Carcharhinus leucas*	bull shark (VI)
DASYATIDAE	2.	*Dasyatis sabina*	Atlantic stingray (VI)
LEPISOSTEIDAE	3.	*Lepisosteus platyrhincus*	Florida gar (II)
AMIIDAE	4.	*Amia calva*	bowfin (I)
ELOPIDAE	5.	*Elops saurus*	ladyfish (VI)
	6.	*Megalops atlanticus*	tarpon (VI)
ANGUILLIDAE	7.	*Anguilla rostrata*	American eel (V)
CLUPEIDAE	8.	*Dorosoma cepedianum*	gizzard shad (IV)
	9.	*Dorosoma petenense*	threadfin shad (IV)
ENGRAULIDAE	* 10.	*Anchoa mitchilli*	bay anchovy (VI)
ESOCIDAE	11.	*Esox niger*	chain pickerel (I)
CYPRINIDAE	12.	*Notemigonus crysoleucas*	golden shiner (I)
	13.	*Notropis maculatus*	taillight shiner (I)
	14.	*Notropis petersoni*	coastal shiner (I)
CATOSTOMIDAE	15.	*Erimyzon sucetta*	lake chubsucker (I)
ICTALURIDAE	16.	*Ictalurus natalis*	yellow bullhead (I)
	17.	*Ictalurus nebulosus*	brown bullhead (I)
	18.	*Ictalurus punctatus*	channel catfish (I)
	19.	*Noturus gyrinus*	tadpole madtom (I)
CLARIIDAE	20.	*Clarias batrachus*	walking catfish (I) - Exotic
ARIIDAE	21.	*Arius felis*	hardhead catfish (VI)
	22.	*Bagre marinus*	gafftopsail catfish (VI)
LORICARIIDAE	* 23.	*Hypostomus* sp.	suckermouth catfish (I) - Exotic
BELONIDAE	* 24.	*Strongylura marina*	Atlantic needlefish (VI)
	* 25.	*Strongylura notata*	redfin needlefish (VI)
	26.	*Strongylura timucu*	timucu (VI)
CYPRINODONTIDAE	27.	*Adinia xenica*	diamond killifish (VI)
	28.	*Cyprinodon variegatus*	sheepshead minnow (IV, VI)
	29.	*Floridichthys carpio*	goldspotted killifish (VI)
	30.	*Fundulus chrysotus*	golden topminnow (II)
	31.	*Fundulus confluentus*	marsh killifish (VI)
	32.	*Fundulus grandis*	gulf killifish (VI)
	33.	*Fundulus seminolis*	Seminole killifish (II)
	34.	*Fundulus similis*	longnose killifish (VI)
	35.	*Jordanella floridae*	flagfish (II)
	36.	*Lucania goodei*	bluefin killifish (II)
	37.	*Lucania parva*	rainwater killifish (II)
	* 38.	*Rivulus marmoratus*	rivulus (II)
POECILIIDAE	39.	*Belonesox belizanus*	pike killifish (II) - Exotic
	40.	*Gambusia affinis*	mosquitofish (II)
	41.	*Gambusia rhizophorae*	mangrove gambusia (VI)
	42.	*Heterandria formosa*	least killifish (II)
	43.	*Poecilia latipinna*	sailfin molly (VI)
ATHERINIDAE	44.	*Labidesthes sicculus*	brook silverside (III)
	45.	*Menidia beryllina*	inland silverside (IV)
CENTROPOMIDAE	* 46.	*Centropomus ensiferus*	swordspine snook (VI)
	* 47.	*Centropomus parallelus*	fat snook (VI)
	* 48.	*Centropomus pectinatus*	tarpon snook (VI)
	49.	*Centropomus undecimalis*	snook (VI)

Table 5 continued.

Family	Species		Common Name
CENTRARCHIDAE	51.	*Elassoma evergladei*	Everglades pygmy sunfish (I)
	52.	*Enneacanthus gloriosus*	bluespotted sunfish (I)
	53.	*Lepomis gulosus*	warmouth (I)
	54.	*Lepomis macrochirus*	bluegill (I)
	55.	*Lepomis marginatus*	dollar sunfish (I)
	56.	*Lepomis microlophus*	redear sunfish (I)
	57.	*Lepomis punctatus*	spotted sunfish (I)
	58.	*Micropterus salmoides*	largemouth bass (I)
	59.	*Pomoxis nigromaculatus*	black crappie (I)
PERCIDAE	60.	*Etheostoma fusiforme*	swamp darter (I)
CARANGIDAE	61.	*Caranx hippos*	crevalle jack (VI)
	* 62.	*Oligoplites saurus*	leatherjacket (VI)
LUTJANIDAE	63.	*Lutjanus griseus*	gray snapper (VI)
GERREIDAE	64.	*Diapterus plumieri*	striped mojarra (VI)
	* 65.	*Eucinostomus argenteus*	spotfin mojarra (VI)
	* 66.	*Eucinostomus gula*	silver jenny (VI)
SPARIDAE	67.	*Archosargus probatocephalus*	sheepshead (VI)
	* 68.	*Lagodon rhomboides*	pinfish (VI)
SCIAENIDAE	* 69.	*Bairdiella chrysoura*	silver perch (VI)
	70.	*Sciaenops ocellatus*	red drum (VI)
CICHLIDAE	71.	*Astronotus ocellatus*	oscar (II) - Exotic
	72.	*Cichlasoma bimaculatum*	black acara (II) - Exotic
	73.	*Cichlasoma citrinellum*	midas cichlid (II) - Exotic
	* 74.	*Cichlasoma meeki*	firemouth (II) - Exotic
	* 75.	*Cichlasoma octofasciatum*	Jack Dempsey (II) - Exotic
	76.	*Hemichromis bimaculatus*	jewelfish (II) - Exotic
	77.	*Tilapia aurea*	blue tilapia (II) - Exotic
	78.	*Tilapia mariae*	spotted tilapia (II) - Exotic
	79.	*Tilapia mossambica*	Mozambique tilapia (II) - Exotic
MUGILIDAE	80.	*Agonostomus monticola*	mountain mullet (IV)
	81.	*Mugil cephalus*	striped mullet (VI)
SPHYRAENIDAE	* 82.	*Sphyraena barracuda*	great barracuda (VI)
ELEOTRIDAE	* 83.	*Dormitator maculatus*	fat sleeper (III)
	* 84.	*Eleotris pisonis*	spinycheek sleeper (III)
	85.	*Gobiomorus dormitor*	bigmouth sleeper (III)
GOBIIDAE	* 86.	*Gobionellus smaragdus*	emerald goby (VI)
	87.	*Gobiosoma bosci*	naked goby (VI)
	* 88.	*Gobiosoma robustum*	code goby (VI)
	89.	*Lophogobius cyprinoides*	crested goby (VI)
	90.	*Microgobius gulosus*	clown goby (VI)
SOLEIDAE	* 91.	*Achirus lineatus*	lined sole (VI)
	92.	*Trinectes maculatus*	hogchoker (VI)

Total number of species	92
Total number of native species	80
Total native primary species	20
Total native secondary species	8
Total native peripheral species	52
Total number of exotic species	12

areas that were submerged below the Pamlico terrace (Odum 1953; Johnson 1974).

Odum (1953) proposed that high chloride concentrations in fresh water were responsible for fostering marine invasions in Florida. Gunter (1961) disputed this hypothesis, indicating instead that freshwater penetration is made possible by the presence of calcium, an interpretation first proposed by Breder (1934). Other studies have also stressed the importance of calcium as an osmoregulatory aid for euryhaline organisms in fresh water (Pickford et al. 1966; Hulet et al. 1967; Carrier and Evans 1976). Evans (1980) presented a review of the means by which both freshwater and marine fishes regulate osmotic and ionic balances. For whatever reason, the chemical composition of southern Florida fresh waters is conducive to invasions and occasional establishment by euryhaline fishes.

Few freshwater species enter saline waters in our study area, in contrast to the large number of peripheral species that penetrate fresh water. In a study of salinity tolerance in *Fundulus*, Griffith (1974) found that typically freshwater species appear to have no tolerance for saline waters, whereas brackish-water inhabitants are highly tolerant of fresh water. He suggested that, although the freshwater *Fundulus* species evolved from euryhaline ancestors, they have lost the ability to adjust to saline habitats because of their prolonged isolation in fresh water. Odum (1953) also noted that the normal salinity fluctuations in estuaries probably act as a barrier to many freshwater species. These factors may account for the low incidence of freshwater fishes in brackish areas of the Everglades estuary.

Habitat Occurrence and Distribution Patterns

Everglades Marsh Prairies.--The marsh prairie habitat supports all 30 species of native fishes that occur in the southern Everglades (Table 6). During our study no exotic fishes were regularly collected in this habitat. Species composition of the marsh prairie is dominated by small poeciliids and cyprinodontids (36.6% of the species), juvenile centrarchids, and ictalurids. We found Florida gar (*Lepisosteus platyrhincus*), bowfin (*Amia calva*), and other large fishes in this habitat only during the wet season. Although there are 24 (80%) primary or secondary freshwater fish species in this habitat, secondary and peripheral species are numerically dominant.

Near the mangrove-Everglades marsh interface, the character of some marshes changes to one of sparse vegetation on marl substrates. Such marl-bottomed marshes are characterized by an assemblage of cyprinodontids and poeciliids that differs in relative abundance from that found in marshes with peat substrates. All of the fishes in these sparsely vegetated habitats have pale colorations, presumably to better match the substrate. The killifishes are especially adept at diving into the substrate for concealment at the slightest disturbance. Mosquitofish (*Gambusia affinis*), sailfin molly, diamond killifish, sheepshead minnow, marsh killifish, and flagfish are the typical inhabitants of these marshes. Most of the fishes tend to school or swim in small groups in this habitat. The coastal marshes are very important freshwater feeding grounds for wading birds in southern Florida (Ogden et al. 1976; Frohring and Kushlan, unpubl. data). Marl-bottomed marshes are also found in the East Everglades, where they support a similar ichthyofauna.

Everglades Sawgrass Marshes.--The sawgrass habitat is a difficult one for fishes. Only 16 (53%) of the 30 native Everglades fishes were collected there (Table 6). Larger fishes are uncommon in this habitat, probably because the high density of plant stems and the shallow water inhibit movement. Dissolved oxygen levels are often low. The earlier dry-down in spring and accompanying low oxygen levels tend to force fishes from sawgrass habitats into prairies and ponds. The fish community in sawgrass strands is mainly composed of cyprinodontids and poeciliids (50% of the total) and small centrarchids. Most of the fishes are primary and secondary freshwater species.

In the rocky gladelands, sawgrass stands are restricted to solution holes that are subject to frequent, rapid dry-downs. This is a particularly harsh habitat for aquatic animals, and fish diversity and numbers there are consistently low. This is one of the few natural areas of the Everglades that has been successfully colonized by the black acara (*Cichlasoma bimaculatum*) and walking catfish (*Clarias batrachus*).

Everglades Alligator Ponds.--These ponds are the deepest natural habitats in the Everglades marsh, and they hold water throughout the dry season except during the most severe droughts (Table 6). In the wet season, the ponds are occupied by small numbers of yellow bullheads (*Ictalurus natalis*), gar, and large centrarchids in the open-water areas, and schools of large mosquitofish, sailfin mollies, and golden topminnows (*Fundulus chrysotus*) at the surface and along the margins. Overall, we collected 21 species in ponds during the wet season, of which 43% were poeciliids and cyprinodontids. When water levels begin to fall during the dry season, large fishes concentrate in the ponds (Kushlan 1974a, 1976a). We collected 12 species when ponds were drying, with Florida gar, yellow bullhead, and warmouth (*Lepomis gulosus*) predominating. At this time, poeciliids and cyprinodontids comprised only 26% of the species present. A total of 28 native species and two exotic species was collected in this habitat (Table 6), but the exotic species were rare.

The ichthyofauna of the three main habitats in the southern Everglades is numerically dominated by small fishes, especially killifishes and livebearers. Small centrarchids and ictalurids are also common in the marsh system. Larger species, such as gar, bowfin, and large centrarchids, invade the marshes during the wet season but occur only in alligator ponds and canals when waters recede in the dry season. Catostomids, percids, and cyprinids are each represented by only one to three species in the Everglades marsh and are relatively uncommon. Exotic fishes have made few inroads into the Everglades marsh so far.

Big Cypress Swamp.--We recorded 29 native and 3 exotic species in fresh water in the Big Cypress Swamp (Table 6). The species composition is nearly identical to that of the Everglades marsh, except that the tadpole madtom (*Noturus gyrinus*) was not collected in the swamp. The ichthyofauna is dominated by small fishes in the cypress sloughs and marshes, and by Florida gar, ictalurids, and centrarchids in ponds. Poeciliids and cyprinodontids comprise 36% of the species in the swamp, the same percentage as in the Everglades. Much of the swamp has a shorter hydroperiod than the southern Everglades, so that its marshes dry earlier and remain dry longer. The result is that fishes are confined to ponds for extended periods. However, most of the large cypress sloughs and strands contain many ponds that can support fishes while the marshes are dry.

Exotic fishes have colonized the natural areas of the Big Cypress Swamp to a greater extent than in the southern Everglades marsh. The black acara and walking catfish occur in a number of ponds and strands, and a population of spotted tilapia (*Tilapia mariae*) is also established. Several peripheral fishes have penetrated the Big Cypress Swamp through the canal system, so that striped mojarra (*Diapterus plumieri*), needlefish (*Strongylura timucu*), tarpon, striped mullet, and snook (*Centropomus undecimalis*) inhabit portions of Tamiami Canal in the Swamp. If these peripheral species are included in the total number collected, then 34 native species, and 37 species overall, occur within the Big Cypress Swamp.

Kushlan and Lodge (1974) suggested that differences exist between the faunas of the Big Cypress Swamp and Everglades. Our data on the ichthyofaunas suggest that differences in species richness and species composition between the two regions are presently minimal. However, there are differences in species abundance that seem to result primarily from differences in the available habitat types. The Everglades system has no extensive habitat similar to the heavily shaded, ponded cypress strands. In these strands, small poeciliids and cyprinodontids are less numerous than in the surrounding marshes, but large dollar sunfish, spotted sunfish, and warmouth are very common. Carlson and Duever (1977) reported similar species distributions in their study of wet prairies and strands in the northern Big Cypress Swamp. Apart from these minor differences, the two major natural areas of southern Florida presently possess nearly identical fish faunas.

Canal System.--We recorded 49 native species and 12 exotic species in canals in the study area (Table 6). To understand fish distribution in canals, we analyzed the eastern coastal ridge canals separately from canals in the

Table 6. Distribution of fishes in fresh water in seven major habitats in southern Florida, with a relative index of abundance. C = common, UC = uncommon, - = not collected in that habitat, L = localized occurrence, and ? = status uncertain. See Table 5 for common names of fishes.

Species	Everglades marsh prairies	Everglades sawgrass marsh	Everglades alligator ponds	Big Cypress Swamp	Canals in Everglades & Big Cypress	Borrow ponds and canals on east coast	Mangrove streams & ponds
1. *Carcharhinus leucas*	-	-	-	-	-	-	UC
2. *Dasyatis sabina*	-	-	-	-	-	-	UC
3. *Lepisosteus platyrhincus*	UC	UC	C	C	C	UC-L	C
4. *Amia calva*	UC	UC	UC	UC	C	UC-L	UC
5. *Elops saurus*	-	-	-	-	-	-	C
6. *Megalops atlanticus*	-	-	-	-	UC	UC-L	C
7. *Anguilla rostrata*	-	-	-	-	C	C	UC
8. *Dorosoma cepedianum*	-	-	-	-	?	UC-L	-
9. *Dorosoma petenense*	-	-	-	-	UC-L	UC-L	-
10. *Anchoa mitchilli*	-	-	-	-	-	-	UC
11. *Esox niger*	-	-	-	-	C-L	-	-
12. *Notemigonus crysoleucas*	UC	-	C	C	C-L	UC	UC
13. *Notropis maculatus*	UC	-	UC	UC	-	-	UC
14. *Notropis petersoni*	UC	-	UC	UC	UC	UC	UC
15. *Erimyzon sucetta*	UC	-	C	C	C	UC	UC
16. *Ictalurus natalis*	UC	UC	C	C	C	UC	UC
17. *Ictalurus nebulosus*	UC	-	UC	UC	UC	UC	-
18. *Ictalurus punctatus*	-	-	-	-	UC?	UC?	-
19. *Noturus gyrinus*	UC	UC	C	-	UC	UC	UC
20. *Clarias batrachus*	-	UC	UC	C	C	C	UC-L
21. *Arius felis*	-	-	-	-	-	-	C
22. *Bagre marinus*	-	-	-	-	-	-	UC
23. *Hypostomus* sp.	-	-	-	-	?	?	-
24. *Strongylura marina*	-	-	-	-	-	-	UC?
25. *Strongylura notata*	-	-	-	-	-	-	UC?
26. *Strongylura timucu*	-	-	-	-	UC?	UC?	C
27. *Adinia xenica*	UC	UC	-	UC	UC	-	C
28. *Cyprinodon variegatus*	C	-	UC	C	C-L	UC	C
29. *Floridichthys carpio*	-	-	-	-	-	-	UC

Table 6 Continued.

	Species	Everglades marsh prairies	Everglades sawgrass marsh	Everglades alligator ponds	Big Cypress Swamp	Canals in Everglades & Big Cypress	Borrow ponds and canals on east coast	Mangrove streams & ponds
30.	*Fundulus chrysotus*	C	C	C	C	C	UC-L	C
31.	*Fundulus confluentus*	C	UC	UC	C	C	UC-L	C
32.	*Fundulus grandis*	-	-	-	-	-	-	UC
33.	*Fundulus seminolis*	UC	-	UC	UC	C-L	-	UC
34.	*Fundulus similis*	-	-	-	-	-	-	UC
35.	*Jordanella floridae*	C	C	UC	C	C	UC-L	C
36.	*Lucania goodei*	C	C	C	C	C	C	UC
37.	*Lucania parva*	UC	-	-	UC	-	-	C
38.	*Rivulus marmoratus*	-	-	-	-	-	-	UC?
39.	*Belonesox belizanus*	-	-	-	-	-	C-L	C-L
40.	*Gambusia affinis*	C	C	C	C	C	C	C
41.	*Gambusia rhizophorae*	-	-	-	-	-	UC-L	-
42.	*Heterandria formosa*	C	C	C	C	C	C	C
43.	*Poecilia latipinna*	C	UC	C	C	C	C	C
44.	*Labidesthes sicculus*	UC-L	-	UC	C	C	C	UC
45.	*Menidia beryllina*	-	-	-	-	-	UC	C
46.	*Centropomus ensiferus*	-	-	-	-	-	UC?	?
47.	*Centropomus parallelus*	-	-	-	-	-	UC?	?
48.	*Centropomus pectinatus*	-	-	-	-	-	UC?	?
49.	*Centropomus undecimalis*	-	-	-	-	UC-L	UC-L	C
50.	*Epinephelus itajara*	-	-	-	-	-	-	?
51.	*Elassoma evergladei*	C	C	UC	C	UC	-	UC
52.	*Enneacanthus gloriosus*	UC	-	UC	UC	C	UC-L	UC
53.	*Lepomis gulosus*	C	UC	C	C	C	C	C
54.	*Lepomis macrochirus*	UC	-	C	C-L	C	C	UC
55.	*Lepomis marginatus*	C	C	C	C	C	UC-L	C
56.	*Lepomis microlophus*	UC	-	UC	C-L	C	C	C
57.	*Lepomis punctatus*	C	C	C	C	C	C	C
58.	*Micropterus salmoides*	UC	-	UC	C-L	C	C	C

59.	*Pomoxis nigromaculatus*	-	-	-	-	UC-L	UC-L	-
60.	*Etheostoma fusiforme*	UC	-	UC	UC	C-L	C-L	UC
61.	*Caranx hippos*	-	-	-	-	-	UC-L	C?
62.	*Oligoplites saurus*	-	-	-	-	-	-	?
63.	*Lutjanus griseus*	-	-	-	-	-	UC-L	C
64.	*Diapterus plumieri*	-	-	-	-	C-L	C-L	C
65.	*Eucinostomus argenteus*	-	-	-	-	-	-	?
66.	*Eucinostomus gula*	-	-	-	-	-	-	?
67.	*Archosargus probatocephalus*	-	-	-	-	-	-	C
68.	*Lagodon rhomboides*	-	-	-	-	-	UC-L	?
69.	*Bairdiella chrysoura*	-	-	-	-	-	-	?
70.	*Sciaenops ocellatus*	-	-	-	-	-	-	UC
71.	*Astronotus ocellatus*	-	-	-	-	UC-L	UC	-
72.	*Cichlasoma bimaculatum*	UC	UC	UC	C	C-L	C-L	-
73.	*Cichlasoma citrinellum*	-	-	-	-	-	?-L	?
74.	*Cichlasoma meeki*	-	-	-	-	-	?-L	-
75.	*Cichlasoma octofasciatum*	-	-	-	-	-	?-L	-
76.	*Hemichromis bimaculatus*	-	-	-	-	-	C-L	-
77.	*Tilapia aurea*	UC-L	-	UC-L	-	-	C-L	UC-L
78.	*Tilapia mariae*	-	-	-	-	C-L	C	-
79.	*Tilapia mossambica*	-	-	-	-	-	C-L	-
80.	*Agonostomus monticola*	-	-	-	-	-	?-L	?
81.	*Mugil cephalus*	-	-	-	-	UC-L	C-L	C
82.	*Sphyraena barracuda*	-	-	-	-	?	?	?
83.	*Dormitator maculatus*	-	-	-	-	-	UC?	UC
84.	*Eleotris pisonis*	-	-	-	-	-	UC?	-
85.	*Gobiomorus dormitor*	-	-	-	-	?	UC?	UC
86.	*Gobionellus smaragdus*	-	-	-	-	-	-	UC
87.	*Gobiosoma bosci*	-	-	-	-	-	-	C
88.	*Gobiosoma robustum*	-	-	-	-	-	-	UC?
89.	*Lophogobius cyprinoides*	-	-	-	-	-	UC-L	C
90.	*Microgobius gulosus*	-	-	-	-	-	-	C
91.	*Achirus lineatus*	-	-	-	-	-	-	UC
92.	*Trinectes maculatus*	-	-	-	-	-	-	C

Everglades and Big Cypress Swamp. Canals in the Everglades and Big Cypress Swamp generally have species compositions similar to those of the natural habitats that they dissect. They appear to function as long and deep alligator ponds and are inhabited by the same fishes that occur in natural ponds. Cyprinodontids, poeciliids, and other small fishes are numerous along the shores of these canals, where stands of cattail and beds of bladderwort and southern naiad provide cover. Large populations of centrarchids, Florida gar, and bowfin occur in the open waters. The black crappie and chain pickerel are restricted to such canals in the southern Everglades. Exotic fishes are present but are only locally numerous. A few peripheral fishes, such as the American eel, tarpon, and striped mullet, occur in the open waters of the canals, but most species in these canals are derived from primary and secondary freshwater families (Table 5).

Canals on the eastern coastal ridge differ in character from those in natural habitats. Aquatic and riparian vegetation is sparse because of mechanical removal and herbicide spraying. Killifishes, which comprise a high percentage of the biomass and species composition in the Everglades region, are mostly absent from canals along the coastal ridge. The primary reason appears to be the lack of suitable habitat in the deep, steep-sided canals. The use of herbicides may also impact certain species of fishes more than others, affecting the species composition of these canals. The bluefin killifish is the only widespread and numerous killifish in this habitat. The poeciliids have been more successful than the killifishes in urban canals. They inhabit all patches of shoreline vegetation. The mosquitofish is by far the most numerous small fish in the canal system. Historically, centrarchids were the dominant large fishes in the canals in terms of number, diversity, and distribution, and the larger species are still more numerous there than in the marshes and ponds of the southern Everglades. However, several of the smaller centrarchid species are virtually absent from the canal system. The redear sunfish (*Lepomis microlophus*) appears to be the most abundant centrarchid in these canals, followed by the bluegill (*L. macrochirus*). Both species inhabit open-water areas as adults but, as juveniles, occur in schools along the canal margins. Warmouth inhabit cavities in the limestone walls or hide in the *Chara* beds, rarely venturing far from cover. The spotted sunfish always nests and generally remains in very shallow water along shore, where it is usually the only adult centrarchid present. Largemouth bass (*Micropterus salmoides*) inhabit all canals, both in the open-water zone and near dense vegetation. The bass is the major piscine predator in the eastern coastal canals because gar and bowfin are usually rare or absent there.

The eastern canals support the highest diversity of exotic fishes of any habitat (12 species or 20%). Exotic species now appear to surpass centrarchids in number and biomass in many canals. Except for mangrove streams, peripheral fishes are most diverse in eastern coastal canals, comprising 50% of the native species (Table 5). However, the diversity of peripheral fishes there is considerably lower than that of natural coastal rivers, probably because salinity control structures on the canals prevent free access from salt water. The highest number of peripheral species came from the Coral Gables Waterway, the only major canal in the study area without a salinity control structure. Before the dams were improved in the 1950's, more marine fishes occurred in these canals (Kushlan, in prep.), and it is likely that the number and diversity of peripheral species then approached those of natural coastal rivers. Gilmore and Hastings (1983) also found that freshwater penetration by peripheral species in east central Florida rivers was limited by salinity control structures.

Small coastal canals, from the Black Creek area south to Florida City, differ in character from the larger drainage canals. These old canals were originally dug for mosquito control and agricultural drainage but are no longer maintained. Most are overgrown by dense stands of the exotic tree, Brazilian pepper (*Schinus terebinthifolius*). The fish fauna is depauperate, consisting of a few native species and three exotic fishes: the walking catfish, pike killifish, and black acara. In ditches where aquatic vegetation cover is sparse because of heavy shading, the only poeciliid found is the sailfin molly. It is probable that the mosquitofish and least killifish (*Heterandria formosa*) are more vulnerable than the larger sailfin molly to predation by pike killifish (*Belonesox belizanus*) in such open habitats.

Within southern Florida, the dollar sunfish and Everglades pygmy sunfish (*Elassoma evergladei*) are essentially restricted to natural habitats and are not often found in canals in the eastern part of the study area. Several other species that occur in natural areas but are rare in the eastern coastal canals include the bowfin, tadpole madtom, flagfish, and marsh killifish. We collected each of those species only once in eastern coastal canals. Florida gar, lake chubsucker (*Erimyzon sucetta*), and the bullheads are also uncommon along the eastern coastal ridge but do occur in a few canals.

It seems likely that the extensive canal system in southern Florida has allowed a number of species that are normally restricted to deep, open waters to extend their ranges into southern Florida. Chain pickerel, channel catfish (*Ictalurus punctatus*), and black crappie are common in central Florida but occur only in canals in southern Florida. Canals have provided large areas of suitable habitat for centrarchid colonization, and we feel that largemouth bass, bluegill, and redear sunfish populations have been enhanced by these excavations. Certainly, centrarchid populations are much larger in canals than in the marshes of the southern Everglades.

Canals act as pathways for dispersal by exotic fishes and by marine invaders, such as tarpon and American eels, that use them to travel many kilometers from salt water. Canals offer the only suitable freshwater habitat in southern Florida for schooling fishes like the shad species (*Dorosoma cepedianum* and *D. petenense*) (Table 6). Since this habitat is historically recent, it is probable that the freshwater fish fauna of southern Florida has changed in diversity, composition, and numbers in recent times. Canals now provide deep-water habitats year-round, act as pathways for dispersal, and have affected marsh and swamp fish communities by altering hydroperiods through drainage. By acting as dry season refugia they allow many fishes, which would otherwise have been eaten by predators (Kushlan 1976a), to survive and repopulate adjacent habitats when reflooding occurs. Canal excavation, in conjunction with levee construction and water management practices, has been the most consequential factor affecting the distribution of southern Florida freshwater fishes in historic times. Although canal excavation has benefitted a few fish species, it has certainly caused permanent changes in the aquatic habitats and fauna of this region.

Coastal Habitats.--The estuaries of the Everglades and Big Cypress Swamp form a complex network of ponds, rivers, and creeks, with interspersed marshes and prairies. The mangrove-lined streams provide pathways for peripheral fishes to enter freshwater areas where they cohabit with typically freshwater species. This mixing results in the highest diversity of native fishes (69 species) recorded from any habitat in the study area (Table 6). Of this total, 43 species or 62.3% are peripheral species. Only two exotic species, the walking catfish and blue tilapia (*Tilapia aurea*), have been found in this region, though it seems likely that the black acara may also be found there since it occurs nearby.

Small species are well represented in samples from this region because much suitable habitat is available in numerous shallow-water pools and marshes. The species composition of small fishes is similar to that of the Everglades marsh, except that the goldspotted killifish, gulf killifish, and longnose killifish reside in the mangrove areas but do not enter the marsh. The small-fish fauna is composed of 15 species of poeciliids and cyprinodontids. Many of these are typically freshwater species that enter the headwaters, streams, and pools from the Everglades marsh, whereas others, such as the rainwater killifish and goldspotted killfish, are euryhaline species that invade fresh water only in this region. Most of the small species primarily inhabit coastal marshes and densely vegetated ponds, but they also occur along creek banks around mangrove prop roots.

It is only in this area that pairs of several related species occur sympatrically. At several collection sites, we took large series of *Lucania goodei* and *Lucania parva* together, and *Labidesthes sicculus* and *Menidia beryllina* together. The same phenomenon was observed in coastal areas in northern Florida by Swift et al. (1977). Both *Labidesthes sicculus* and *Lucania goodei* occur in freshwater habitats throughout the study area but enter the headwaters region only near the upper reaches of the rivers. *Menidia beryllina* and *Lucania parva* are two of the most abundant small fishes in brackish water in southern Florida and only enter fresh water in the headwater creeks and pools of the coastal rivers. Neither species penetrates the Everglades marsh to any extent.

The mangrove-lined rivers, creeks, and ponds offer deep-water habitats for large fishes. As a result, centrarchids, Florida gar, and bowfin descend into the upper reaches of the river systems, while euryhaline fishes ascend the channels into fresh water. The centrarchids inhabit the smaller creeks under the cover of mangrove prop roots, and also occur in the marshes and ponds. Large schools of Florida gar inhabit the open, slow-flowing reaches of most coastal rivers. We collected ictalurid catfishes only in the upper sections of the rivers, and rarely collected them syntopically with ariid catfishes. Ariids, gobies, and mojarras are common bottom dwellers in the rivers; mullet are numerous at all levels; and needlefishes are common at the surface. Three gamefishes, tarpon, snook, and red drum, ascend the rivers to their upper reaches where the channels intersect the Everglades marsh. However, none of the larger euryhaline fishes enters the shallow Everglades marsh, despite its proximity to the river channels and pools.

We made our collections in the headwaters area during the time of heavy runoff from the marshes when the upper reaches of the rivers held only fresh water. As the dry season arrives and freshwater runoff slows, the salinity gradient, aided by tidal influences, moves gradually up the rivers toward the freshwater marsh system. In dry years, many of the river systems may become brackish for several months.

The fauna of freshwater marshes on north-central Cape Sable is similar to that of the true Everglades marsh north of Whitewater Bay but is relatively depauperate. Common Everglades species, such as *Lucania goodei*, *Fundulus chrysotus*, and most *Lepomis* were absent. Prior to 1960, the freshwater ichthyofauna there may have been more diverse. Durbin Tabb (pers. comm.) tells of "a substantial freshwater fish population" that included gar, largemouth bass, bluegill, and spotted sunfish. Tabb (pers. comm.) believes that Hurricane Donna in 1960, followed by years of severe droughts, may have adversely affected these populations. Such effects were undoubtedly exacerbated by canal building on the cape. Before the canals were excavated in the 1920s and 1950s, the surface waters of Whitewater Bay and the Cape were probably of low salinity during the wet season. Under present hydrological conditions, recolonization by freshwater fishes would be slow following disruptive events like hurricanes, unless the estuarine character of Whitewater Bay is restored.

Introduced Fishes

Within our study area, 12 species of exotic fishes have established breeding populations (Table 5). The majority (9 species) belong to the Cichlidae, additional species of which are established elsewhere in Florida. The three remaining species belong to the Clariidae, Loricariidae, and Poeciliidae. All of the exotic fishes are native to tropical regions.

Two non-native species, *Serrasalmus humeralis* (Shafland and Foote 1979) and *Tilapia zilli* (Hogg 1976b), occurred within the study area until their elimination by the Florida Game and Fresh Water Fish Commission. Four species, the koi (carp) (*Cyprinus carpio*), zebra cichlid (*Pseudotropheus zebra*), guppy (*Poecilia reticulata*), and swordtail (*Xiphophorus helleri*), are common in decorative ponds at tourist attractions and private homes but have not become established in natural waters in the study area. Other species, such as pacus (*Colossoma* spp.), are occasionally taken in canals, but their long-term persistence is uncertain.

Nearly all of the introduced fishes were originally imported for the aquarium trade and either escaped from fish farms, were released by home aquarists, or were introduced by anglers into natural waters. Several species, like the walking catfish, black acara, and spotted tilapia, have dispersed rapidly and have become widespread throughout our study area. Others, such as the jewelfish (*Hemichromis bimaculatus*), the firemouth (*Cichlasoma meeki*), and Jack Dempsey (*Cichlasoma octofasciatum*), have remained localized near their point of introduction. The diversity and abundance of exotics at a sampling site was often directly proportional to the distance from the east coast, with the highest numbers usually occurring closest to the coast.

In this study, we documented range extensions for several exotic fishes. Walking catfish occur farther south than reported by Hensley and Courtenay (1980), and the spotted tilapia, Mozambique tilapia (*Tilapia mossambica*), and black acara have extended their ranges into southern Dade County. The collections of the blue tilapia (*Tilapia aurea*) and midas cichlid (*Cichlasoma citrinellum*) within our study area represent new location records for both species. The jewelfish is now known to range several kilometers southward of its previously reported locations, and we recorded it for the first time within our study area. The pike killifish has moved north and south of its point of origin (Belshe 1961) but remains essentially restricted to coastal areas.

To date, most exotic fishes seem unable to successfully colonize the marsh system of the southern Everglades. Although exotic species occur in the canals bordering the Everglades, we rarely recorded exotic species from natural Everglades marsh habitats. The rocky gladelands were the exception. The walking catfish and black acara have been able to colonize that area, possibly because the native fauna is ill-adapted to survive its harsh conditions. The two exotic species can better tolerate the low oxygen concentrations and irregularly fluctuating hydrologic conditions. They have been more successful than most native fishes in this habitat, but even so they are not very numerous. We have also found that both of these exotics occur in the Big Cypress Swamp, especially in alligator ponds. Although not very numerous in our samples, they appear to be more widely dispersed there than in the Everglades. Courtenay and Hensley (1979a) stated that the black acara may regularly disperse across marshes and swamps but may not be recorded due to inadequate sampling. We feel that if that species was established in the southern Everglades marsh during our study, our extensive and frequent population sampling would have detected it.

All exotic species reach their greatest abundance in disturbed aquatic habitats, especially in urban areas along the lower east coast. The exotic species coexist to some extent with native fishes in canals that dissect both natural and disturbed habitats, but they are numerically superior to native fishes mainly in the urbanized canals (Hogg 1976b). It is possible that canals in urbanized areas have certain physicochemical characteristics, such as poor water quality and steep sides, that make them less than optimal for many native fishes. Therefore, exotic species are able to invade and establish themselves more easily. In non-urbanized canals, exotic fishes are present but are usually less numerous than native fishes. This is especially true in canals, like the Tamiami Canal, that dissect marsh habitats. During the four years of this study, we collected only one specimen of the oscar (*Astronotus ocellatus*) and two specimens of spotted tilapia in the canal along the northern border of Everglades National Park. The black acara is slightly more numerous than these species but is still uncommon in Everglades canals. These observations suggest that characteristics of canal morphometry, marginal and submerged vegetation, and water quality permit native fishes to maintain their populations and perhaps prevent or delay a large-scale takeover by exotics.

Non-urbanized canals on the east coast, such as those near Homestead, are instructive in this respect. Hogg (1976a) thought that canals near Homestead were free of cichlids because of saltwater intrusion. However, all of the canals have salinity gates preventing salt intrusion, and the walking catfish and cichlids do occur there. However, they are not numerous and usually occur with much larger numbers of native fishes. This suggests that large populations of native species in these non-urban canals may slow the colonization and multiplication of the exotic fishes.

An important factor in facilitating the colonization of east coast canals by exotics might be the limited number of predators. Florida gar and bowfin, both common piscine predators in Everglades canals, have low population densities along the east coast. Populations of other predators, such as wading birds and alligators, are low because of the urban character of the canals. Lack of predation pressure may have enabled exotic fishes to multiply relatively unchecked. Another factor contributing to the successful establishment of exotics is the high degree of parental protection exhibited by most of the species. Blue tilapia and Mozambique tilapia are mouthbrooders, a reproductive strategy that offers a great deal of protection for both eggs and fry. Although other cichlids are substrate nesters, like the native centrarchids, both parents vigorously guard the nesting site and the free-swimming fry until they are quite large. Such protection probably results in greater survival of the fry.

The diets of exotic fishes provide an advantage. While most native canal fishes are primarily carnivorous (unpubl. data), the most successful cichlids (black acara, blue tilapia, and spotted tilapia) are wholly or partially herbivorous or detritivorous (Courtenay and Hensley 1979a). Thus, they are able to use the large quantities of algae, macrophytes (e.g. *Hydrilla* sp. and *Najas* sp.), and detritus in the canal system, resources not exploited by most native species (unpubl. data). This combination of factors has aided exotic fishes in their colonization of southern Florida canals.

During the six years of the study, we noted decreases in the numbers of some previously abundant exotic fishes in our study area. However, we are uncertain whether these decreases represent actual reductions in population size, cyclical changes, or movement away from former concentration points. Our 1980 sampling produced only a few specimens of walking catfish from most canals, although similar samples several years previously produced hundreds of specimens. When the walking catfish first invaded these canals they were abundant. Recently, their numbers appear to have decreased, and their population levels have stabilized. An explosive population increase, followed by rapid decrease, is a common phenomenon among invading animals which eventually reach equilibrium with their environment (Roots 1976). The walking catfish is subject to a number of population controls. The unusual overland movements of the catfish during migratory periods in the wet season can often result in heavy mortality from dessication, predation, and even from automobiles (unpubl. data). A second control mechanism appears to be winter water temperatures followed by secondary infection by *Aeromonas hydrophila* and *Saprolegnia* sp. These organisms cause massive winter fish kills among walking catfish when population levels are high and fish are crowded in canals. We observed several such kills, notably in the Loop Road and Tamiami canals, after the freeze of 19-20 January 1977, again in December 1979 (Miami Herald, 15 January 1980) and in January 1983 in southern Dade County.

The black acara was once the most common cichlid in the study area, so much that Courtenay et al. (1974) stated that it had the potential of becoming the dominant freshwater fish in southeastern Florida. Our observations suggest, however, that the black acara is less common than in the past in the study area, except in canals in the Big Cypress Swamp. Similar decreases seem to have occurred with the oscar and firemouth. Our sampling suggests that the spotted tilapia is now more common than any other exotic fish in southern Florida and is continuing to expand its range. Courtenay and Hensley (1979b) suggested that spotted tilapia might displace the black acara and oscar. We found that, where its range overlaps with that of the black acara along the east coast, the spotted tilapia is usually more numerous and occurs over a wider cross-section of the canal. The few black acaras present with the spotted tilapia are usually in the shallowest waters of the canal. In situations in which the spotted tilapia is not yet abundant, such as in the Big Cypress Swamp and its portion of the Tamiami Canal, black acaras remain common and inhabit the entire breadth of the canal.

We know little about short-term or long-term ecological impacts of exotic species on our native fish fauna, but it is safe to assume that their presence is not beneficial to the preservation of natural ecological systems. The major problem in predicting the impact of exotics is that, for most areas, we have limited faunistic information on fish populations prior to establishment of the exotics. In a canal north of the study area, the number of exotic species has increased from one to five in 18 years, and populations of native centrarchids are considerably reduced (Kushlan in prep.). The fact remains that in canals, such as Snapper Creek, Black Creek, and the Coral Gables Waterway, exotic fishes comprise most of the numbers and biomass of fishes present. Although they do not seem to threaten the Everglades ecosystem at this time, we do not know enough about their potential for expansion and colonization during periods of severe drought, as only two of the past eight years have had normal dry seasons. It is impossible to conclude that exotic fishes pose no problems for native species in natural habitats based upon only a few years of observation, and we believe that close monitoring of the situation is needed. We have baseline quantitative data for native Everglades fish populations, collected without the presence of exotic fishes in the ecosystem (unpubl. data). If exotic fishes are successful in colonizing the Everglades marsh, it will be possible to assess changes in the ecological relationships of the fishes.

It does not seem possible to eliminate widespread exotic populations. However, our collections suggest that exotic species are not abundant in canals with healthy native fish populations. Management actions that alter the margins of existing canals to create littoral habitat would enhance native fish populations and perhaps retard the growth and dispersal of exotic populations.

Factors Affecting the Fishes

The freshwater fishes of southern Florida are affected by a number of environmental and biotic factors. We have already discussed the increasing species pollution of southern Florida waters by exotic fishes and some possible effects upon the native fauna. The building of canals throughout southern Florida has also adversely affected natural systems. Canals support unnatural assemblages of fishes, drain natural aquatic habitats, and rapidly flood adjacent aquatic marsh systems through flood-water releases from impoundments. Canals also receive and deliver chemical input from agriculture, urbanization, and aquatic weed control.

Several important natural factors also affect the fishes of southern Florida. The seasonal wet season-dry season cycle (Fig. 5) determines water levels and occasionally results in severe droughts accompanied by massive fish kills (Kushlan 1974a). This cycle is the most significant natural abiotic event to influence aquatic systems in southern Florida. Extremes of heat and cold can sometimes be lethal to fishes in southern Florida, especially if they persist for extended periods. Salinity changes in the upper portions of estuaries also affect freshwater fish populations during the dry season.

In most areas of the Everglades today, water levels are regulated by the system of canals and discharge structures. Some areas of marsh are kept constantly inundated, while others have artificially lengthened or shortened hydroperiods. The Everglades fish community is a dynamic assemblage (Kushlan 1980a). Fish communities respond to different hydroperiods through changes in biomass, species composition, and abundance (Kushlan 1976b; unpubl. data). For example, in an extended high-water period from 1968 to 1970, large numbers of brook silversides, coastal shiners, and Seminole killifish were collected in the Everglades (Kushlan 1980a), but all were rare in our samples.

The climate of southern Florida is considered to be sub-tropical, and certain aquatic habitats, such as deep-water urban canals, normally have moderate winter temperatures. However, this term can be misleading when applied to the shallow marshes of the interior Everglades and Big Cypress Swamp, far inland from the coasts. Minimum winter temperatures there can be quite low during the period of cool winter weather (Fig. 6), and water temperatures can drop to 6 or 7°C during a hard freeze. Cold temperatures have caused mortality of tarpon and snook in fresh water, but most native species appear to tolerate winter temperatures. The effects of cold on exotic fishes in nature has not been well-documented. Cold temperatures during the 1977 freeze appeared to stress walking catfish, making that species susceptible to secondary infections that resulted in high mortalities. During 1981, cold weather again killed many walking catfish in shallow canals when water temperatures fell to 9°C. Cichlids may be able to better tolerate cold temperatures. We have never observed a cold-related kill of cichlids in southern Florida, although all species have succumbed to above-freezing temperatures in aquaria (Shafland and Pestrak 1982).

Summer water temperatures can reach 35-37°C in the marshes and, combined with low oxygen conditions, may lead to summer fish kills. We have documented these on several occasions when rainfall was low and fishes were concentrated. Centrarchids are among the most sensitive fishes under those conditions. Summer kills have also occurred in Tamiami Canal in areas of dense hydrilla beds. We observed a kill of several hundred chain pickerel and centrarchids over a three-day period in August 1981, at the end of a prolonged drought. We attributed this die-off to oxygen depletion caused by increased respiration by aquatic organisms and the decomposition of decaying animal and plant material.

Of all environmental factors, the wet season-dry season regime of southern Florida, with ensuing water-level fluctuations, has the greatest impact on fish abundance and community composition in natural habitats (Kushlan 1974a, 1976 b). The seasonal cycle of flooding and drought is characteristic of many tropical systems where the fishes have adapted to water-level changes by developing aerial respiratory mechanisms, specialized breeding behaviors, and seasonal migrations (Beadle 1974; Lowe-McConnell 1975). The sub-tropical Everglades marsh and Big Cypress Swamp have been colonized by species derived from the temperate North American ichthyofauna, most members of which lack specialized adaptations for surviving seasonal dry-downs. Dry season conditions in southern Florida often result in significant fish kills that, in turn, can affect the species composition of the affected area for several years thereafter. The effects of a severe drought and subsequent fish kill in an alligator pond in the Big Cypress Swamp were documented by Kushlan (1974a). Similar situations occur in the Everglades. The progression of the dry season, with the lack of rain, high temperatures, and evapotranspiration rates, causes rapid drying of marshes and swamps. As in South American marshes (Lowe-McConnell 1975), larger fishes move into ponds as the water levels fall, and eventually the ponds become isolated refuges for the fishes. If large numbers of fishes are present, and if the start of the rains is delayed, conditions that result in a fish kill often develop. Environmental factors responsible for producing a fish kill include increased turbidity and decreased photosynthesis, decreased water volume, and increased respiration (Kushlan 1974a).

During a fish kill, centrarchids are usually the first fishes to die (Kushlan 1974a). Several native non-centrarchids possess physiological or behavioral mechanisms that aid them in surviving a dry-down. The Florida gar (McCormack 1967), bowfin (Johansen 1970), and bullheads (Gowanloch 1933) are able to utilize atmospheric oxygen, while small fishes with upturned mouths can extract oxygen from the well-oxygenated surface film (Lewis 1970). Since oxygen is a critical limiting factor in the crowded ponds, any mechanism or behavior that increases oxygen uptake is of benefit. In tropical areas, some fishes, such as the lungfishes (Lowe-McConnell 1975), survive droughts by burrowing under the mud of ponds. Similar behavior on a limited scale was noted in Everglades bowfin by Dineen (1974).

Several genera of tropical cyprinodontids lay resting eggs, which hatch at the beginning of the wet season, in the substrate of marshes and ponds (Myers 1942; Lowe-McConnell 1975). In this way, populations are maintained from year to year in temporary aquatic habitats. In southern Florida, the marsh killifish has evolved a similar strategy for inhabiting seasonal marshes (Harrington 1959; Kushlan 1973a). Other native cyprinodontids may also possess this capability. Most Everglades fishes begin to breed prior to and during the spring dry season (unpubl. data). The production of young that require little food or space at this time may enable the species to survive dry-downs and to rapidly recolonize the marshes during the wet season. The advent of the wet season opens up additional habitat and food sources that are not available during dry-down for the young fishes. Many smaller species of fishes remain in the marshes as water levels drop. This may enable them to escape predation in the crowded ponds but makes them vulnerable to predation by snakes, birds, and alligators in the drying marshes. Small species of fish probably find refuge in the burrows of the common Everglades crayfish, *Procambarus alleni*, until the arrival of the rains (Tabb 1963). Dispersal from ponds, canals, and burrows following the onset of the rains is rapid (Kolipinski and Higer 1969).

Because certain native fishes are better able than others to withstand dry season conditions in southern Florida marshes and swamps, differential survival results from a natural fish kill (Kushlan 1974a). Those species that survive and are able to reproduce rapidly and grow during the following wet season will become the dominant species in those natural areas. Thus, the dry season acts as a major selective agent in determining the make-up of natural fish communities in southern Florida.

Fish kills produced by droughts also occur to a lesser degree in the canals that drain marshes and swamps. Such canals are used as refugia by large marsh fishes and serve as artificial alligator ponds. Presumably, this results in higher survival of those fishes having access to canals when compared with those that remain in marshes. The canals also remove the fishes as potential prey for wading birds by drawing fishes from marshes, thus interfering with natural ecological processes. Fish kills in eastern coastal canals are uncommon. Water flow is reduced to conserve water during the dry season so that some stagnation may occur, but water levels are always maintained above a minimum level to prevent saltwater intrusion into the system. Conditions for fish kills seem to be rare under those water-management regimes.

SUMMARY

Of the 92 species of fishes that have persistent populations in extreme southern Florida fresh waters, 80 are native species and 12 have been introduced by man. All native primary and secondary freshwater species are derived from temperate North American stocks. All established exotic species are of tropical origin. Natural freshwater habitats in southern Florida consist of marshes, swamps, and headwaters of coastal rivers; true freshwater stream habitat is absent. Canals are artificial deep-water habitats that have impacted the native ichthyofauna by modifying natural habitats through drainage and by providing optimal habitats for large fishes. Many small fish species are uncommon in canals due to lack of protective cover. The canal fauna in natural areas is dominated by gar, bowfin, and centrarchids. In developed areas, several species of exotic fishes dominate the canal system, through which they have expanded their ranges.

The Everglades marsh fish community is dominated in numbers and diversity by poeciliids and cyprinodontids. The majority of species are primary and secondary freshwater fishes. Exotic fishes are uncommon in natural habitats. Differences in species composition and abundance exist among the three major aquatic habitats in the Everglades marsh, differences that are most pronounced during the dry season. The seasonal dry season is the most significant environmental factor affecting the fishes, and major fish kills often result from a severe dry-down.

The species composition of fishes in the Big Cypress Swamp is nearly identical to that of the Everglades marsh. Certain species, such as the warmouth, have been especially successful in the swamp. The hydroperiod there is often shorter than in the Everglades marsh, and large fishes spend much time in cypress strand ponds and sloughs. Fish kills during dry-down occur there frequently. Fish community composition and species abundance in the Everglades and Big Cypress Swamp appear to be ultimately controlled by abiotic factors, in particular the wet season-dry season cycle.

The headwaters of coastal rivers host a fish fauna that is a mixture of typically freshwater and euryhaline species. This combination of faunas results in the highest species richness of any habitat, including the highest percentage of peripheral species (62.3% of the total present) in southern Florida. Normally freshwater areas in this region may become slightly brackish during the dry season. Exotic fishes are uncommon.

Several distributional patterns are obvious from the collection data. A group of species ubiquitous in all habitats of the study area includes *Gambusia affinis*, *Heterandria formosa*, *Lucania goodei*, and *Lepomis punctatus*. A second species group is restricted to well-vegetated habitats and is essentially absent

from the eastern coastal canal system. Members of this group are *Noturus gyrinus*, *Elassoma evergladei*, and *Lepomis marginatus*. Several native species, especially *Ictalurus nebulosus*, *Lepomis microlophus*, and *Micropterus salmoides*, are more widespread in the canal system than in natural habitats. Most non-native fishes follow a similar distributional trend. The majority of euryhaline fishes are limited to coastal rivers and canals, although several large species, *Megalops atlanticus*, *Anguilla rostrata*, and *Mugil cephalus*, move far inland through the canal system.

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APPENDIX I

COLLECTION SITE DESCRIPTIONS

Nearly all of the collections were made by the authors, with the assistance of the many individuals mentioned in the acknowledgements. Salinities at all sites were $0^{o}/oo$, unless stated otherwise. Species code numbers correspond to those in the species accounts. Species codes followed by an asterisk represent sight observations by the authors at the locale. Collection locations and voucher sites are shown in Figure 13.

Tamiami Canal and Loop Road Canal (Big Cypress National Preserve)

These canals are old excavations that provided fill for roadbeds. Both cross the southern portion of the Big Cypress Swamp in a generally east to west direction. The average width of the Tamiami Canal (C-7) in this area is about 6-8 m, and its depth varies from 2 to 4 m. During the wet season, surface water flows into the canal from the north and continues southward through culverts. In the dry season, the canal becomes stagnant and completely dries in some areas. Both canals are bordered by cypress trees when they cross cypress strands, and other areas intersect open prairies. The banks are typically steep and provide a restricted littoral zone only where the edges have collapsed. Much of the canal banks are bordered by sawgrass, cattail, willow, and other emergents. Hydrilla and southern naiad are common submerged plants, that, with the floating water hyacinth, completely choke the entire water column in many sections. The water column and surface are open only when shaded by trees. Although the water is slightly stained, turbidity is low so that it is often possible to see to the bottom of the canals.

Collection Sites 1-32

1. Tamiami Canal and Culvert at Bridge #78 along U.S. Hwy. 41. Fl., Collier Co., T52S, R30E, Sec. 30. 10 Nov. 1977. Cast net, dip net, and sight. Brackish water ($12.5^{o}/oo$), stained, little current. Species #28, 35, 36, 37, 40, 43, 53, 57, 64, 67*, 87.
2. Intersection of Tamiami Canal and Turner River meander, east of Ochopee on U.S. Hwy. 41. Fl., Collier Co., T52S, R30E, Sec. 35. 30 May 1978. Rotenone, cast net, sight. Species #3, 7, 12*, 15, 16, 30, 33*, 35, 36, 40, 43, 44, 52, 53, 54, 55, 56, 57, 58*, 72.
3. Turner River Canal at U.S. Hwy.41. Fl., Collier Co., T52S, R30E, Sec. 35. 30 May 1978. Dip net, rotenone, sight, cast net. Moderate current flowing through main canal channel, which is bordered by dense beds of hydrilla. Species #3, 16, 20, 30, 31, 35, 36, 42, 43, 49*, 54*, 56*, 57, 58*, 64*, 72, 81*.

4. Tamiami Canal and Culvert at Bridge #87. Fl., Collier Co., T53S, R31E, Sec. 9. 30 May 1978. Dip net, sight. Culvert is shallow and weed-choked. Species #3*, 15, 20, 40, 56*, 57*, 58*, 72*.
5. Tamiami Canal and Culvert at Bridge #90. Fl., Collier Co., T53S, R31E, Sec. 11. 10 Nov. 1977; 23 July 1980. Dip net, cast net, rotenone. Species #3, 15, 16, 17, 20, 30, 35, 40, 42, 43, 54, 55, 56, 57, 58, 72.
6. Tamiami Canal at Bridge #92. Fl., Collier Co., T53S, R32E, Sec. 7. 10 Nov. 1977. Dip net, cast net. Species #3, 12, 15*, 20, 40, 53, 58*, 72.
7. Tamiami Canal at Bridge #97. Fl., Collier Co., T53S, R33E, Sec. 11. 10 Nov. 1977. Dip net, cast net. Species #3*, 4, 16, 20, 30, 36, 40, 42, 43.
8. Tamiami Canal at Bridge #100. Fl., Collier Co., T53S, R33E, Sec. 15. 10 Nov. 1977. Dip net, cast net. Species #3*, 4, 16, 20, 30, 36, 40, 42, 43, 72.
9. Tamiami Canal along U.S. Hwy. 41., at Bridge #105. Fl., Collier Co., T53S, R34E, Sec. 17. 4 Jan. 1977. Dip net, sight. Species #3*, 20*, 40, 72.
10. Tamiami Canal and Culvert at Bridge #107. Fl., Collier Co., T53S, R34E, Sec. 21. 14 Dec. 1976. Dip net, cast net. Species #3, 20, 30, 36, 40, 42, 53.
11. Tamiami Canal and Culvert Bridge #108. Fl., Collier Co., T53S, R34E, Sec. 21. 14 Dec. 1976. Dip net, cast net. Species #3, 20, 53, 72.
12. Tamiami Canal and Culvert Bridge #114. Fl., Collier Co., T53S, R34E, Sec. 22. 6 Dec. 1976. Dip net, cast net. Species #3, 16, 30, 35, 40, 42, 53, 55, 58.
13. Tamiami Canal along U.S. Hwy. 41. Fl., Collier Co., T53S, R34E, Sec. 36. 14 Dec. 1976. Dip net, cast net, sight. Species #3, 16, 20, 30, 35, 40, 42, 43, 57, 58*, 72.
14. Tamiami Canal at Bridge #109. Fl., Dade Co., T54S, R35E, Sec. 6. 6 Dec. 1976. Dip net, cast net, sight. Species #3, 4, 20*, 30, 35, 36, 40, 42, 53, 54, 55, 57, 58*.
15. Tamiami Canal along U.S. Hwy. 41. Fl., Dade Co., T54S, R35E, Sec. 8. 14 Dec. 1976. Dip net, cast net, sight. Species #12, 20, 30, 36, 40, 42, 55, 57, 58.
16. Tamiami Canal at 40-mile Bend, along U.S. Hwy. 41. Fl., Dade Co., T54S, R35E, Sec. 16. 6 Dec. 1976. Dip net, cast net, sight. Species #12, 20, 31, 35, 36, 40, 42, 43, 54, 55, 56, 57, 58.
17. Loop Road canal at first bridge W of 40-mile Bend. Fl., Dade Co., T54S, R35E, Sec. 20. 22 Dec. 1976. Dip net, cast net, sight. Species #20, 40, 53, 58.
18. Loop Road canal at second bridge W of 40-mile Bend. Fl., Dade Co., T54S, R35E, Sec. 20. 22 Dec. 1976. Sight, dip net. Species #3*, 12*, 20*, 40, 58*.
19. Loop Road canal at third bridge W of 40-mile Bend. Fl., Dade Co., T54S, R35E, Sec. 19. 6 Dec. 1976. Dip net, cast net, sight. Species #15, 20, 30, 36, 40, 42, 44, 53, 55, 56, 57, 58.
20. Loop Road Canal along Fl. Hwy. 94. Fl., Monroe Co., T54S, R35E, Sec. 24. 22 Dec. 1976. Sight, dip net. Species #12*, 15*, 20*, 40, 54*, 56*, 58*.
21. Loop Road Canal airboat landing. Fl., Monroe Co., T54S, R35E, Sec. 24. 6 Dec. 1976. Dip net, cast net. Species #3, 12, 28, 30, 31, 35, 36, 40, 42, 43, 44, 53, 54, 55, 56, 57, 58.
22. Loop Road Canal along Fl. Hwy. 94. Fl., Monroe Co., T54S, R35E, Sec. 20. 22 Dec. 1976. Dip net. Dense floating mat of water hyacinth. Species #3*, 36, 40, 42, 51, 72.

23. Loop Road Canal and adjacent cypress swamp. Fl., Monroe Co., T54S, R35E, Sec. 19. 22 Dec. 1976. Dip net, cast net. Open water, no submerged or floating vegetation. Species #15, 28, 36, 40, 43, 53, 58.
24. Loop Road Canal along Fl. Hwy. 94. Fl., Monroe Co., T54S, R35E, Sec. 24. 22 Dec. 1976. Dip net. Canal choked by southern naiad. Species #3, 16, 20, 58.
25. Loop Road Canal along Fl. Hwy. 94. Fl., Monroe Co., T54S, R35E, Sec. 23. 6 Dec. 1976. Dip net, cast net. Open, stained waters with rocky bottom and many submerged logs. Species #3, 20, 30, 35, 40, 42, 43.
26. Loop Road Canal and Culvert along Fl. Hwy. 94. Fl., Monroe Co., T54S, R35E, Sec. 15. 22 Dec. 1976. Dip net, cast net, sight. Rocky-bottomed pool in cypress strand. Species #20*, 30, 31, 35, 36, 40, 42, 43, 53, 72.
27. Loop Road Canal and Culvert along Fl. Hwy. 94. Fl., Monroe Co., T54S, R35E, Sec. 17. 22 Dec. 1976. Dip net. Shallow pool in the dense shade of a cypress strand. Species #16, 36, 40, 43, 53.
28. Loop Road Canal along Fl. Hwy. 94. Fl., Monroe Co., T54S, R35E, Sec. 13. 22 Dec. 1976. Sight, dip net. Cypress strand with no submerged vegetation. Species #20*, 40, 42, 53*, 58.
29. Loop Road Canal Culvert Pool at Long Bridge on Fl. Hwy. 94. Fl., Monroe Co., T54S, R35E, Sec. 14. 6 Dec. 1976. Dip net, cast net. Pool merges with flooded cypress strand. Water column open and shaded; slight flow over the detritus-covered rock bottom. Species #3, 16, 20, 30, 31, 35, 36, 40, 42, 53, 58, 72.
30. Loop Road Canal along Fl. Hwy. 94. Fl., Monroe Co., T54S, R35E, Sec. 11. 4 Jan. 1977. Dip net, cast net. Dense beds of southern naiad in canal. Species #3, 20, 40, 53.
31. Loop Road Canal at junction with westernmost airboat landing along Fl. Hwy. 94. Fl., Monroe Co., T54S, R35E, Sec. 34. 4 Jan. 1977. Dip net, cast net, sight. Canal flows into a cypress-bordered prairie. Species #3, 12, 15, 20*, 30, 36, 40, 42, 43, 53, 58.
32. Loop Road Canal along Fl. Hwy. 94. Fl., Collier Co., T53S, R32E, Sec. 26. 22 Dec. 1976. Sight, dip net. Deep area with open water, no submerged vegetation. Species #20*, 40, 58*.

Southern Big Cypress Swamp (Big Cypress National Preserve)

See habitat descriptions in text.

Collection Sites 33-39

33. Alligator pond and willow head NW of New River and Gator Hook Strand. Fl., Collier Co., T53S, R31E, Sec. 34. 2 Mar. 1979. Rotenone, dip net. Marsh surrounding pond was dry; no current. Pond with open canopy, surrounded by dense cattails. Willow head with many submerged logs, and dense growths of common cane (Phragmites australis)

and cattail. Water temperature 22-24°C. Species #12, 16, 30, 36, 40, 42, 51, 53, 54, 55, 56, 57, 58.

34. Cypress head, 5 km SW of W corner of Loop Road. Fl., Monroe Co., T54S, R32E, Sec. 28. 2 Mar. 1979. Rotenone, dip net. Isolated cypress pool in dry prairie. Shallow, clear water over marl bottom, with abundant algal cover and beds of Bacopa sp. Water temperature 21-24°C. Species #30, 31, 35, 36, 40, 42, 43, 51, 57.
35. Cypress strand pool at north end of Roberts Lake Strand. Fl., Collier Co., T53S, R33E, Sec. 32. 2 Mar. 1979. Rotenone, dip net. Clear-water pond surrounded by dense pond apple (Annona glabra) and willow stands. Water temperature 21-23°C. Species #12, 16, 20, 28, 30, 31, 35, 36, 40, 42, 43, 53, 55, 57, 72.
36. Marsh pond, 5 km N of Pinecrest, Fl. Fl., Monroe Co., T54S, R43E, Sec. 5. 3 Aug. 1978. Rotenone, dip net. Peat-bottomed pond, surrounded by dense Paspalidium sp., willow, and pond apple. Pond connected to surrounding marsh prairie. Species #3, 12, 30, 35, 36, 40, 42, 43, 51, 52, 53, 55, 57.
37. Alligator pond, 1.5 km N of Fl. Hwy. 94. Fl., Monroe Co., T54S, R34E, Sec. 18. 1968-1970 (Kushlan 1972a). Various methods. Species #3*, 4, 12, 13, 15, 16, 17, 28, 30, 31, 35, 36, 40, 42, 43*, 44, 51, 52, 53, 54, 56, 67, 58, 72.
38. Pond and marsh prairie in Gum Slough. Fl., Monroe Co., T55S, R33E, Sec. 5. 3 Aug. 1978. Rotenone, dip net. Large, peat-bottomed pond, surrounded by willows and pickerelweed. Pond connected to sawgrass marsh with areas of exposed rock. Species #3, 12, 16, 28*, 29, 30, 31, 34, 35, 36, 39, 40, 42, 43, 49, 51, 53, 56, 58, 60*.
39. Pond and marsh, 6 km S of Pinecrest. Fl., Monroe Co., T55S, R34E, Sec. 16. 3 Aug. 1978. Rotenone, dip net, sight. Large pond surrounded by dense stands of Paspalidium sp., pickerelweed, and common cane. Open prairie with sparse spikerush and maidencane. No surface periphyton mat present, but periphyton covers the bottom. Species #4*, 12, 16*, 28, 30, 31, 35, 36, 40, 42, 43, 54, 55, 56.

Tamiami Canal, Shark Valley Canal, Canal L-67 Extended (southern Everglades).

This portion of the Tamiami Canal is much wider (about 10-15 m) and deeper (5-8 m) than in the Big Cypress Swamp. Its waters are continuous with those of Everglades Water Conservation Area 3 and flow southward into the southern Everglades through a series of water control structures and culverts. This is a typical large canal with steep banks; a littoral zone occurs only where the banks have crumbled. Thick beds of submerged and emergent aquatic plants grow along the margins, and water hyacinth often covers large portions of the canal surface. Riparian cover is light at the western end, consisting of willow, pond apple, cocoplum (Chrysobalanus icaco), and various marsh plants. East of its intersection with Canal L-67, tall Australian pines (Casuarina sp.) line the southern edge of the canal. Fewer submerged and emergent aquatic plants occur in this recently-dredged section.

The Shark Valley Canal is a small, old canal which runs 11 km southward from Tamiami Trail into Everglades National Park. It ranges from 1 to 3 m deep and from 3 to 7 m wide. In the wet season, the canal is continuous with the surrounding marshes, but during the dry season, some sections become completely dry. The limestone substrate is covered by a layer of peat and detritus. Much of the canal is open to sunlight, resulting in dense beds of bladderwort, cattail, pickerelweed, and fireflag. Other sections are lined by willows, pond apple, cocoplum, and wax myrtle (Myrica cerifera). Shading of the canal by these trees, combined with the digging of alligators, results in sections of open-water habitat. Rockpits near the canal also provide deep, open-water habitats for fishes.

Canal L-67 Extended is a wide, deep canal which runs 15 km south from Tamiami Trail along the eastern border of Everglades National Park. Water flows slowly southward in the canal, which is continuous with the marsh on the west side for part of the year. The eastern border is edged by a high levee which blocks waterflow into and from the East Everglades. No trees or shrubs overhang the canal to shade the surface so that dense beds of hydrilla seasonally choke much of the water column. The littoral zone is very restricted in this canal, except at the southern terminus where dense stands of cattail grow. Elsewhere along the margins, riparian cover consists of sawgrass, cattail, cocoplum, and other marsh plants.

These three canals have intercepted the historical sheet-flow of water into the Shark River Slough, which has had a major impact on the hydrology of the southern Everglades by changing the extent of flooding and duration of the hydroperiod within Everglades National Park.

COLLECTION SITES 40-51

40. Canal and airboat landing at Tamiami Ranger Station, Everglades National Park. Fl., Dade Co., T54S, R35E, Sec. 16. 22 Dec. 1976; 31 May 1980. Dip net, cast net, sight. An old, deep canal with dense submerged vegetation. Airboat landing is a large, shallow pool continuous with surrounding marshes. Species #3, 12, 16, 20, 28, 30, 31, 35, 36, 40, 42, 43, 53, 55, 56, 57, 58.
41. Tamiami Canal at water control structure 12-C. Fl., Dade Co., T54S, R36E, Sec. 21. 21 July 1978. Rotenone, dip net, sight. Rocky shoreline with beds of southern naiad and pondweed (Potamogeton illinoensis); deep, open water in mid-canal. Species #3, 9, 11, 12, 15, 30, 31, 33, 35, 36, 40, 42, 43, 44, 52, 53, 54, 55, 56*, 57, 58, 60.
42. Shark Valley Canal, Everglades National Park, 1.6 km S of Tamiami Trail. Fl., Dade Co., T54S, R35E, Sec. 25. 20 Apr. 1977. Dip net, cast net, electrofishing. Species #40, 53.
43. Shark Valley Canal, Everglades National Park, 5 km S of Tamiami Trail. Fl., Dade Co., T55S, R35E, Sec. 1. 20 Apr. 1977. Dip net, cast net, electrofishing. Species #3, 16, 30, 31, 35, 36, 40, 42, 43, 53, 54, 55, 56*, 57, 58, 59.
44. Shark Valley Canal, Everglades National Park, 8 km S of Tamiami Trail. Fl., Dade Co., T55S, R35E, Sec. 12. 20 Apr. 1977. Dip net, cast net, electrofishing. Species #30, 40, 53, 58.

45. Shark Valley Canal, Everglades National Park, 10 km south of Tamiami Trail. Fl., Dade Co., T55S, R35E, Sec. 13. 20 Apr. 1977. Dip net, cast net, electrofishing. Species #3, 16, 40, 53, 58.

46a. Shark Valley tower pool, Everglades National Park. Fl., Dade Co., T55S, R36E, Sec. 30. 20 Apr. 1980. Dip net, cast net, electrofishing. Rocky shoreline, sparse submerged vegetation, and extensive open-water areas. Species #3, 4, 7, 11, 12, 15, 16, 20, 30, 31, 35, 40, 42, 43, 53, 54, 55, 56, 57, 58.

46b. Shark Valley airboat landing, Everglades National Park. Fl., Dade Co., T55S, R36E, Sec. 30. Various sightings and collections. 1977-1980. Dip net, electrofishing, cast net, sight. Species 3, 12, 15, 16, 20, 27, 28, 30, 31, 36, 40, 42, 43, 44, 53, 54, 55, 56, 57, 58.

47. Shark Valley rockpit, Everglades National Park, 1.1 km S of parking lot on East road. Fl., Dade Co., T54S, R36E, Sec. 30. 22 Aug. 1977. Dip net, cast net, electrofishing, sight. Deep, open-water pond continuous with surrounding marsh. Species #3, 7, 30, 31, 35, 36, 40, 42, 43, 44, 53, 54, 55, 56, 57, 58, 60.

48a. Tamiami Canal at the junction of L-67 Canal. Fl., Dade Co., T54S, R36 1/2E. 30 Jul. 1980. Electrofishing, rotenone, dip net, sight. Large canal with dense, submerged vegetation along the margins, and deep, open water at center. Species #3, 4, 6*, 11, 12, 15, 16, 19, 20, 30, 31, 33*, 36, 40, 42, 43, 44, 49, 52, 53, 54, 55, 56, 57, 58, 60, 71, 78*, 81*.

48b. Canal L-67 Extended, 1 km S of Tamiami Trail. Fl., Dade Co., T54S, R35 1/2E. 25 Mar. 1977. Dip net, cast net, electrofishing, angling, sight. Species #3, 4*, 12, 15, 28, 30, 31, 35, 40, 42, 43, 52, 53, 54, 55, 56, 57, 58, 60.

49. Canal L-67 Extended, from the plug to the southern terminus. Fl., Dade Co., T55S, R36 1/2E. 25 Jan. 1977.; 25 Mar. 1977; 2 Feb. 1978; 30 Jul. 1980. Dip net, cast net, electrofishing, sight. Species #3, 4, 6, 7, 11, 15, 16, 28, 30, 31, 35, 36, 40, 42, 43, 44, 49, 51, 52, 53, 54, 55, 56, 57, 58, 60, 81*.

50. Tamiami Canal Culvert, 8 km E of L-67 Canal on U.S. Hwy. 41. Fl., Dade Co., T54S, R37E, Sec. 11. 17 Nov. 1977. Dip net, cast net, electrofishing, sight. Culvert pool with open water at center surrounded by dense emergent and submerged vegetation. Slight flow. Species #3, 4*, 20, 30, 35, 36, 40, 42, 43, 53, 55, 57.

51. Tamiami Canal Culvert, about 2 km W of U.S. Hwy. 27, along U.S. Hwy. 41. Fl., Dade Co., T54S, R38E, Sec. 11. 1 Nov. 1977. Cast net, dip net, electrofishing. Species #3, 16, 20, 40, 42, 43, 44*, 53, 54, 55, 57, 58.

Shark River Slough (Everglades National Park)

See habitat description in text.

COLLECTION SITES 52-62.

52. Marsh Prairie, about 3 km W of Canal L-67 Extended, Everglades National Park. Fl., Dade Co., T55S, R35E, Sec. 14. Fish Study reproduction sampling site, sampled monthly from 1977-1980. Extensive surface periphyton mat, peat substrate, and several stands of pickerelweed. Species #15, 16, 19, 20, 27, 28, 30, 31, 35, 36, 40, 42, 43, 51, 52, 53, 54, 55, 56, 57.

53a. Alligator ponds, 6-7 km SE of Shark Valley Tower, Everglades National Park. Fl., Dade Co., T55S, R36E, Sec. 26. Fish Study food habits sampling site, sampled from Jan. 1977-May 1977. Dip net, rotenone, angling, cast net, seine. Wet season sample: Species #3, 12, 15, 16, 19, 30, 31, 35, 36, 40, 41, 42, 43, 51, 53, 54, 55, 56, 57, 58, 60. Dry season sample: Species #3, 16, 40, 42, 43, 52, 53, 54, 55, 56, 57, with Species #3, 16, 40, and 53 predominating.

53b. Marsh prairies, same location and sampling data. Wet season sample: Species #3, 16, 19, 28, 30, 31, 35, 36, 40, 41, 42, 43, 51, 52, 53, 54, 55, 56, 57. Dry season sample: Species #16, 28, 30, 31, 35, 36, 40, 42, 43, 51, 54, 55, 56, 57.

53c. Sawgrass marshes, same location and sampling data. Wet season sample: Species #3, 16, 19, 28, 30, 31, 35, 36, 40, 42, 43, 51, 53, 55, 57. Dry season sample: Species #30, 31, 35, 36, 40, 42, 43, 51, 55, 57.

54. Marsh prairie, about 4 km SE of Shark Valley tower. Fl., Dade Co., T55S, R36E, Sec. 33. Fish population sampling and monitoring site, sampled monthly from 1977-1982 (also the site of a study from 1965-1972 (Kushlan 1980a)). Throw trap, dip net, pull-up trap. Species #15, 28, 30, 31, 35, 36, 40, 42, 43, 44, 51, 53, 54*, 55, 57*, 58.

55. Marsh prairie and alligator pond at Shark Slough staff gauge #7. Fl., Dade Co., T56S, R36E, Sec. 8. 23 May 1977; 19 May 1980. Pond species #3, 16, 40, 43, 53, 55. Marsh Prairie Species #3, 16, 30, 31, 35, 36, 40, 42, 43, 51, 55, 56*, 57, 58.

56. Alligator pond and marsh prairie, about 3 km SE of hydrologic station P-33. Fl., Dade Co., T56S, R36E, Sec. 14. 10 Jan. 1978. Rotenone, dip net. Species #12, 30, 31, 35, 36, 40, 42, 51, 55, 72.

57. Marsh prairie and alligator pond at Shark Slough staff gauge #11. Fl., Dade Co., T56S, R35E, Sec. 25. Fish population sampling and monitoring site, sampled monthly from 1977-1982; also, 23 May 1978. Pond sampled on 27 Oct. 1977. Rotenone, throw trap, dip net. Pond Species #16, 30, 40, 43, 53. Marsh Prairie Species #3*, 4*, 15, 16, 27, 28, 30, 31, 33, 35, 36, 40, 42, 43, 44, 51, 53, 54*, 55, 56*, 57, 58.

58. Alligator pond and sawgrass marsh, 6-7 km NW of Panther Mound. Fl., Dade Co., T56S, R35E, Sec. 29. 2 Aug. 1978. Rotenone, dip net. Species #15, 16, 19, 30, 31, 35, 36, 40, 42, 43, 51, 57.

59. Alligator pond and marsh prairie, between Shark Slough staff gauges #12 and #13. Fl., Dade Co., T57S, R35E, Sec. 2. 23 May 1978. Rotenone, dip net, electrofishing, sight. Pond Species #16, 40, 57*, 58*. Marsh Prairie Species #30, 31, 35, 36, 40, 42, 43, 55, 57.

60. Alligator pond and marsh prairie (Ironpot Hammock), 8 km S of Tamiami Ranger Station. Fl., Dade Co., T55S, R35E, Sec. 17. 2 Aug. 1978. Rotenone, dip net. Species #16, 20, 28, 30, 31, 35, 36, 40, 42, 43, 53, 54, 57.
61. Alligator pond and marsh prairie, 7 km SE of Panther Mound. Fl., Dade Co., T57S, R36E, Sec. 10. 26 Jul. 1978. Rotenone, dip net, sight. Pond with algal-covered rocky substrate; marsh with mixed peat and periphyton substrate. Species #3*, 16, 30, 31, 35, 36, 40, 42, 43, 55, 57.
62a. Marsh prairies between Shark Slough staff gauges #15 and #16. Fl., Dade Co., T57S, R35E, Sec. 22. Fish population sampling and monitoring site, sampled monthly from 1977-1982. Throw trap, dip net, sight. Sparsely vegetated prairie with mixed marl and periphyton substrate; prairie subject to yearly dry-down. Species #3*, 4*, 15, 16, 19, 28, 30, 31, 33, 35, 36, 37, 40, 42, 43, 51, 55, 57, 58.
62b. Marsh prairie at Shark Slough staff gauge #16. Fl., Dade Co., T57S, R35E, Sec. 27. 23 May 1978. Rotenone, dip net. Peat-bottomed prairie with dense spikerush. Species #30, 35, 36, 40, 42, 53, 57.

East Everglades Region

This region contains a heterogeneous assortment of aquatic habitats, all of which have been affected by drainage. The East Everglades region is located between the eastern boundary of Everglades National Park on the west and Fl. Hwy. 27 (997) and U.S Hwy. 1 on the east.

Water flow into this region has been disrupted by levees, canals, and roadways. Most of the area is presently subjected to frequent dry-downs, resulting in shortened hydroperiods. Southern sections of this region are subject to the opposite effect because a series of levees artificially impounds water throughout the year. The East Everglades area receives most of its water from rainfall and some flow from the north through culverts under the Tamiami Trail. The East Everglades region is the source of Taylor Slough which drains the eastern areas of Everglades National Park. Much of the East Everglades is presently under great development pressure for agriculture and housing. Drainage associated with development will result in further impact to the aquatic ecosystems there.

Deep-water habitats in this region originally consisted of alligator ponds and solution holes. Both still hold water during dry-downs but, because of the shortened marsh hydroperiod, are more likely to dry completely. Today, the system of canals in the region, especially C-111, L-31N, and L31W, provide the only extensive deep-water habitats.

Everglades sawgrass marshes and marsh prairies are characteristic of areas having the longest hydroperiods and are found today in the extreme northern and southern sections. The marl and peat substrates are shallow so that the limestone base is often exposed. In areas of short hydroperiods, as near Context Road, the limestone has been eroded into pinnacle rock formations interspersed by solution holes containing sawgrass. These solution holes and road culverts concentrate fishes as the surrounding areas dry. Higher prairies are dominated by muhly (Muhlenbergia filipes).

COLLECTION SITES 63-88

63. Alligator pond and sawgrass marsh, 5 km E of Canal L-67 Extended. Fl., Dade, Co., T54S, R37E, Sec. 28. 26 Jul. 1978. Rotenone, dip net. Shallow pond (1 m) with peat bottom and submerged logs; sparse sawgrass marsh, no periphyton mat, with peat-periphyton substrate. Species #12, 30, 31, 35, 36, 40, 42, 43, 53, 57.
64. Willow head pond and sawgrass marsh, 5 km S of Tamiami Trail and 5 km W of Fl. Hwy. 27 (997). Fl., Dade Co., T54S, R38E, Sec. 28. 26 Jul. 1978. Rotenone, dip net. Small head surrounded by dense sawgrass. Marsh sparsely vegetated, with peat-periphyton substrate. Species #28, 30, 31, 35, 40, 42, 43, 53, 55.
65. Solution hole, 4 km N of Grossman Hammock Ridge. Fl., Dade Co., T55S, R37E, Sec. 15. 21 Dec. 1978. Rotenone, dip net. Collectors: N. Deschu, K. Kronner. Shallow open-water hole with rocky bottom, surrounded by cattails, arrowhead, and pickerelweed. Species #28, 35, 36, 40, 42, 43, 44, 54, 55.
66. Alligator pond, 12 km S of Tamiami Trail and 5 km W of L-31N Canal. Fl., Dade Co., T55S, R38E, Sec. 8. 9 Mar. 1979. Rotenone, dip net. Collectors: N. Deschu and K. Kronner. Pond 0.5 m deep, surrounded by willows, with cattails and submerged logs at center; substrate of peat and pinnacle rock. Species #20, 31, 35, 40, 72.
67. Marsh prairie, 2 km E of Canal L-67 Extended. Fl., Dade Co., T55S, R37E, Sec. 18. Fish sampling site, sampled monthly from 1978-1980. Collectors: N. Deschu, K. Kronner, D. Peck, R. Wideman. Throw trap, dip net. Species #28, 30, 31, 35, 36, 40, 42, 43, 51, 53, 55, 57.
68. Rockpit and ditch, Chekika State Park. Fl., Dade Co., T55S, R37E, Sec. 25. 5 Dec. 1977. Seine, dip net, cast net, sight. Artificial pond, with several 2 m holes and extensive shallows; fed by artesian well water with high sulphur content. Ditch narrow (0.5 m-0.75 m) and deep, with bladderwort, southern naiad, and submerged logs. Species #3, 12, 20*, 30, 31, 35, 36, 40, 42, 43, 53, 54*, 56, 57, 58, 72.
69. Solution hole and marsh, 4 km south of Grossman Hammock Ridge. Fl., Dade Co., T56S, R37E, Sec. 5. 21 Dec. 1978. Rotenone, dip net. Collectors: N. Deschu, K. Kronner. Large hole surrounded by rocks, sawgrass, wax myrtle, and cattails. Rocky bottom covered by marl. Hole contained bladderwort, Bacopa sp., and Proserpinaca sp. Species #16, 19, 30, 36, 40, 42, 43, 53, 55, 57.
70. Solution Hole, 3 km N of Context Road. Fl., Dade Co., T56S, R37E, Sec. 21. 9 Mar. 1979. Rotenone, dip net. Collectors: N. Deschu, K. Kronner. Exposed hole, surrounded by pinnacle rock, willow, and pickerelweed. Peat and pinnacle rock substrate. Species #3, 5, 16, 20, 35, 40, 72.
71. Drying marsh pool, about 12 km from south end of Context Road. Fl., Dade Co., T57S, R37E, Sec. 2. 6 Jan. 1977. Dip net. Species #35, 40.
72. Culvert pool, 10.1 km from south end of Context Road. Fl., Dade Co., T57S, R37E, Sec. 2. 6 Jan. 1977. Cast net, dip net, sight. Species #3*, 20, 36, 40, 43, 53.
73. Culvert pool, 8.8 km from south end of Context Road. Fl., Dade Co., T57S, R37E, Sec. 2. 6 Jan. 1977. Dip net. Species #40, 43, 55.

74. Culvert pool, 8 km from south end of Context Road. Fl., Dade Co., T57S, R37E, Sec. 3. 6 Jan. 1977. Cast net, dip net. Species #3, 33, 40, 43, 53, 54, 55, 56.

75a. Solution hole and culvert pool, 6.3 km from south end of Context Road. Fl., Dade Co., T57S, R37E, Sec. 4. 6 Jan. 1977; 3 Aug. 1978. Cast net, dip net. Species #12, 16, 27, 28, 31, 35, 40, 42, 43, 53, 54, 55, 57.

75b. Same Location; 30 Nov. 1978. Rotenone, dip net. Collectors: N. Deschu, K. Kronner. Pool nearby was dry. Species #16, 20, 27, 28, 30, 31, 35, 40, 42, 43, 53, 55.

76. Culvert pool, 5 km from south end of Context Road. Fl., Dade Co., T57S, R37E, Sec. 5. 6 Jan. 1977. Cast net, dip net. Species #35, 40, 43, 55.

77. Culvert pool, 4 km from south end of Context Road. Fl., Dade Co., T57S, R37E, Sec. 5. 6 Jan. 1977. Cast net, dip net. Species #3, 16, 20, 35, 36, 40, 53, 57, 72.

78. Drying pool, 1.6 km from south end of Context Road. Fl., Dade Co., T57S, R37E, Sec. 7. 6 Jan. 1977. Dip net. Species #3*, 40.

79. Drying pool, 0.8 km from south end of Context Road. Fl., Dade Co., T57S, R37E, Sec. 18. 6 Jan. 1977. Dip net. Species #28*, 31, 35, 40, 43.

80a. C-113 Canal and culvert on SW 197th Avenue, north of SW 320th Street. Fl., Dade Co., T57S, R38E, Sec. 10. 31 May 1978. Dip net, sight. Large drainage canal, with deep, clear, open water. Culvert with dense southern naiad and bladderwort along margin; open in center. Species #40, 42, 54, 56*, 57*, 58*. On 12 June 1980: Species #3, 12, 30, 36, 40, 42, 43, 54, 55, 56, 57, 58.

80b. Homestead General Aviation Airport borrow pond. Fl., Dade Co., T57S, R38E, Sec. 5. Various dates 1978-1981. Cast net, dip net, sight. Pond with marl bottom, low turbidity, open shorelines. Species #30, 35, 36, 40, 43, 54, 55, 56, 57, 58, 72, 77. Also a hybrid of 54 x 57.

81. L-31W Canal at first water control structure N of Fl. Hwy. 27 (9336). Fl., Dade Co., T57S, R38E, Sec. 31. 30 Nov. 1979. Sight, angling, dip net. Large, deep, low turbidity canal with beds of hydrilla along margin and in patches at center. Steep banks, no canopy. Species #3, 7, 14, 15, 20, 30, 36, 40, 42, 43, 53, 54, 56, 57, 58, 72*, 77*.

82. Southern terminus of Canal L-31W, S of Fl. Hwy. 27 (9336). Fl., Dade Co., T58S, R38E, Sec. 30. 22 Aug. 1980. Electrofishing, rotenone, dip net, cast net, sight. Wide, deep canal with dense hydrilla. Species #3, 4, 7, 13, 14, 15, 30, 31, 33, 35, 36, 40, 42, 43, 44, 51, 53, 54, 56, 57, 58, 77*.

83. Cypress head, east of L-31W Canal, S of Fl. Hwy. 27 (9336). Fl., Dade Co., T58S, R38E, Sec. 30. 11 Jan. 1979. Rotenone, dip net. Collectors: N. Deschu, K. Kronner. Flooded head containing solution holes bordered by sawgrass. Marl substrate, water depth 7 cm-23 cm. Species #30, 31, 35, 40, 57.

84. Solution holes and marsh, SE of L-31W, and 1.5 km SW of Aerojet road terminus. Fl., Dade Co., T59S, R38E, Sec. 7. 15 Feb. 1979. Rotenone, dip net. Collectors: N. Deschu, K. Kronner. Interconnected solution holes bordered by sawgrass, arrowhead, and muhly. Peat and periphyton substrate over pinnacle rock. Species #16, 30, 31, 35, 36, 40, 42, 43, 55.

85. C-111 culvert pool, 8 km W of U.S. Hwy. 1. Fl., Dade Co., T59S, R38E, Sec. 10. 5 Oct. 1978. Rotenone, gill net, dip net, cast net, sight. Large pool with moderate flow; dense submerged vegetation with several large open areas. Species #3, 12, 14, 20, 30, 31, 35, 36, 40, 42, 43, 44, 52, 53, 54, 55, 56, 57, 58, 60, 64.
86. Alligator pond and marsh, S of C-111. Fl., Dade Co., T59S, R38E, Sec. 17. 16 Jan. 1978. Rotenone, dip net. Two ponds connected by spikerush marsh; ponds surrounded by willow and southern naiad along margins, but open at center. Bottom of marl and sand. Surrounding marsh was dry. Species #3, 15, 16, 20, 30, 35, 36, 40, 43, 52, 53, 54, 55, 56, 57, 58.
87a. Marsh prairie along C-109, N of C-111. Fl., Dade Co., T59S, R38E, Sec. 18. 10 Nov. 1976. Rotenone, throw trap, dip net. Marl-bottomed, sparsely vegetated marsh. Species #16, 28, 30, 31, 35, 36, 40, 42, 43, 55.
87b. Same location. Fish population sampling site, sampled monthly from 1978-1979. Throw trap, dip net. Collectors: N. Deschu, K. Kronner, D. Peck, R. Wideman. Species #28, 30, 31, 35, 36, 40, 42, 53, 55, 56, 57.
88. Old canal, SE of prison on Fl. Hwy. 27 (9336). Fl., Dade Co., T58S, R38E, Sec. 11. 5 Aug. 1980. Rotenone, electrofishing, dip net. Canal with dense, submerged beds of muskgrass (Chara sp.), interspersed with open-water areas. Species #3*, 12, 15, 20, 30, 35, 36, 40, 42, 43, 44, 52, 53, 54, 56, 57, 58, 60.

Main Park Road Culverts and Associated Rockpits

The main park road, an extension of Florida Highway 27 (9336), runs west and south through Everglades National Park to Flamingo. Culverts cut under the road permit surface waters to flow between marshes. At each culvert, small rocky-bottomed pools have formed on both sides of the road. Water flow is moderate through the culverts during the wet season but ceases completely during the dry season. Many culverts remain completely dry for several months. Plant cover in and around the culverts is sparse.

Several freshwater habitats are traversed by the park road from the entrance station to Flamingo. From northeast to southwest, the road intersects Taylor Slough, rocky gladelands, seasonally flooded marshes with dwarf cypress trees, and marshes dotted with bayheads and small red mangrove trees, before entering the mangrove region. Much of the area along the park road is located between Taylor and Shark River Sloughs and receives its water primarily from rainfall and sheet flow. These marshes are subject to periodic dry-downs each year, at which time the fishes remain only in the culverts, solution holes, and rockpits.

Several large rockpits have been excavated along the park road. These rockpits offer stable, open-water habitats the year round. Most have ample littoral zones in which cattails, sawgrass, and pickerelweed grow. Typical submerged plants include bladderwort, southern naiad, and pondweed. The substrate can be either rock or sand, covered by detritus and marl. Water clarity is high.

COLLECTION SITES 89-108

89. Culvert along main road, 6.0 km W of entrance station. Fl., Dade Co., T58S, R37E, Sec. 4. 10 Aug. 1977. Dip net, electrofishing. Species #16, 30, 31, 35, 40, 43, 53, 55, 57.
90. Culvert along main road, 8 km W of entrance station. Fl., Dade Co., T58S, R37E, Sec. 5. 10 Aug. 1977. Dip net, electrofishing. Species #40.
91. Culvert along main road, 12.1 km W of entrance station. Fl., Dade Co., T58S, R36 1/2E, Sec. 5. 10 Aug. 1977. Dip net, electrofishing. Species #28, 40.
92. Alligator pond, 2.5 km N of main road. Fl., Dade Co., T58S, R36 1/2E. 9 Aug. 1978. Rotenone, dip net. Large solution hole surrounded by willows and pickerelweed. Rocky substrate covered by peat; central area of open water. Surrounding marsh dry. Species #16, 20, 28, 30, 31, 35, 36, 40, 42, 43, 55, 72.
93. Solution hole along main road, 13.3 km W of entrance station. Fl., Dade Co., T58S, R361/2E. 15 Dec. 1976. Sight, dip net. Water was stagnant and hole was rapidly drying. Species #3*, 40*.
94. Culvert along main road, 15 km W of entrance station. Fl., Dade Co., T58S, R36E, Sec. 12. 10 Aug. 1977. Dip net, electrofishing. Species #28, 40.
95. Culvert along main road, 15.7 km W of entrance station. Fl., Dade Co., T58S, R36E, Sec. 12. 10 Aug. 1977. Dip net, electrofishing. Species #28, 31, 35, 40, 42.
96. Culvert along main road, 18.6 km W of entrance station. Fl., Dade Co., T58S, R36E, Sec. 9. 10 Aug. 1977. Dip net, electrofishing. Species #28, 35, 40, 43.
97a. Culvert along main road, 20.8 km W of entrance station. Fl., Dade Co., T58S, R36E, Sec. 8. 10 Aug. 1977. Dip net, electrofishing. Species #20, 28, 31, 35, 40, 43, 53, 55.
97b. Same location; 15 Dec. 1976. Dip net. Culverts drying and stagnant; surrounding marshes dry. Species #16, 28, 31, 35, 40, 43.
98. Culvert along main road, 20 km W of entrance station. Fl., Dade Co., T58S, R36E, Sec. 18. 15 Dec. 1976. Dip net. Culvert and surrounding marshes drying. Species #35, 40.
99a. Culvert along main road, 21.2 km W of entrance station. Fl., Dade Co., T58S, R36E, Sec. 18. 10 Aug. 1977. Dip net, electrofishing. Wet season sample: Species #3, 27, 28, 31, 35, 36, 40, 53, 54, 58.
99b. Same location; 21 Jan. 1977. Dip net. Dry season sample: Species #40, 53.
100. Culvert and solution hole along Pa-hay-okee Road, 1.4 km from main road. Fl., Dade Co., T58S, R36E, Sec. 7. 21 Jan. 1977; 28 Jan. 1978. Dip net. Species #16, 30, 35, 36, 40, 42, 43, 53.
101. Alligator pond near Pa-hay-okee parking lot. Fl., Dade Co., T58S, R36E, Sec. 7. 21 Jan. 1977; 28 Jan. 1978. Dip net, cast net. Isolated solution hole surrounded by dense willows. Rocky substrate, open water with one large alligator. Species #3, 16, 17, 35, 40, 43, 53, 57.
102. Culvert along main road, 23 km SW of entrance station. Fl., Dade Co., T58S, R35E, Sec. 35. 15 Dec. 1976. Dip net. Surrounding marsh dry; culvert pool drying. Species #16, 53.

103. Culvert along main road, about 27.2 km SW of entrance station. Fl., Dade Co., T58S, R35E, Sec. 35. 15 Dec. 1976; 21 Jan. 1977. Dip net. Culvert and marsh drying. Species #35, 40.
104. Culvert along main road, 28.8 km SW of entrance station. Fl., Dade Co., T59S, R35E, Sec. 4. 21 Jan. 1977. Dip net. Culvert nearly dry. Species #40.
105. Culvert on Mahogany Hammock Road. Fl., Dade Co., T59S, R35E, Sec. 17. 21 Jan. 1977. Dip net. Species #28, 31, 40, 42, 43.
106. Culvert along Main Road, 38.7 km SW of entrance station. Fl., Dade Co., T59S, R35E, Sec. 26. 21 Jan. 1977. Dip net. Marsh surrounding culvert was dry. Species #40, 42.
107. Big Ficus Pond. Fl., Dade Co., T58S, R35E, Sec. 34. 21 Jan. 1977. Dip net, sight. Deep rockpit surrounded by marsh. Species #15*, 30, 40, 42, 43, 53, 54*, 55*, 56*, 57*, 58*, 72.
108. Sweet Bay Pond and canal. Fl., Dade Co., T59S, R35E, Secs. 14-15. 27 Jan. 1977. Fish study reproduction sampling site, sampled monthly from 1979-1980. Dip net, angling, seine, electrofishing, rotenone. Large rockpit connected to old canal, choked with southern naiad, and surrounded by seasonally flooded marsh. Periphyton and marl substrate present. Pond species #3, 28, 30, 31, 32, 33, 35, 40, 43, 53, 54, 56, 57, 58, 60. Canal and marsh: Species #3, 12, 14, 15, 16, 19, 28, 30, 31, 35, 36, 40, 42, 43, 51, 52, 53, 55, 57, 60, 72*.

Taylor Slough, Homestead Canal and Associated Ditches

Taylor Slough, rising in the East Everglades region and emptying into northeastern Florida Bay, is the second largest natural freshwater drainage in Everglades National Park. The major plant communities of the upper slough consist of sawgrass marsh and muhly prairie, with scattered willow ponds. On the edges of the slough, seasonally flooded, sparsely vegetated marshes with many solution holes occur. The hydroperiod of the upper slough has been reduced by development and drainage, and the marshes are subject to seasonal drying and dramatic water level fluctuations. The large rockpits at the Anhinga Trail visitor area and the natural alligator ponds serve as dry season refugia for fishes.

Plant communities in the lower slough consist of spikerush and sawgrass marshes, dotted by dwarf cypress trees, hammocks, and bayheads. The hydroperiod is longer there than in the upper slough, but is still shorter than in Shark River Slough. In the lower slough, the marshes intergrade with the mangrove zone where mangrove-lined pools and streams offer deep-water habitats the year round. Salinities there vary seasonally, but are near $0^{0}/oo$ for much of the year.

The Homestead Canal and associated ditches run south and west along the western edge of Taylor Slough. This old established canal cuts through seasonally flooded sawgrass marshes. Open areas of the canal are choked with southern naiad and bladderwort, both of which provide cover for small fishes. Submerged logs and brush are common. Most sections of the canal are bordered by dense stands of wax myrtle, poisonwood (Metopium toxiferum), and cocoplum, all of which form a canopy that shades much of the canal. Cattails and pickerelweed are the dominant emergent plants along the canal. Large sections of the water column are kept clear of plants by alligators, and these open areas serve as important refuges for fishes as the surrounding marshes dry.

COLLECTION SITES 109-133

109. Taylor Slough marsh at pump station. Fl., Dade Co., T57S, R37E, Sec. 35. Fish population sampling site, sampled monthly from 1978-1979. Throw trap, dip net. Collectors: N. Deschu, K. Kronner, D. Peck, R. Wideman. Species #3, 15, 20, 28, 30, 31, 35, 36, 40, 42, 43, 51, 55.

110. Taylor Slough bridge on main park road. Fl., Dade Co., T58S, R37E, Sec. 11. 4 Nov. 1976; 15 Dec 1976. Dip net, minnow trap, cast net, sight. Ponded area between two willow ponds, with dense stands of pickerelweed and cattails; open-water areas with slow southward flow during the wet season. Species #3, 12*, 19, 30, 31, 35, 36, 40, 42, 43, 53, 54*, 55, 56*, 57, 58.

111. Taylor Slough culvert, 2.2 km W of entrance station along main park road. Fl., Dade Co., T58S, R37E, Sec. 11. 15 Dec. 1976; 10 Aug. 1977. Dip net, electrofishing . Small pools with open-water areas bordered by southern naiad and Bacopa sp. Species #16, 20, 35, 36, 40, 42, 43, 51, 52, 53, 55, 57, 72.

112. Rockpits at Anhinga Trail, Everglades National Park. Fl., Dade Co., T58S, R37E, Sec. 14. Cumulative records taken on 14 Jan. 1977; 27 Apr. 1977; 24 Jan. 1978; 26 May 1978; 25 Dec. 1979; 2 Jun. 1980; Jan. 1983. Dip net, cast net, sight, electrofishing. Large, open-water ponds with rocky substrates; thick beds of southern naiad and bladderwort in many sections. The ponds are bordered by willow, pondapple, cocoplum, cattails, and common cane, but the canopy is open. Species #3, 4*, 6*, 7, 12, 14, 15, 16, 19, 20, 30, 31, 33*, 35, 36, 40, 42, 43, 53, 54, 55, 56, 57, 58, 71*.

113. Taylor Slough airboat landing. Fl., Dade Co., T58S, R37E, Sec. 14. 14 Jan. 1977; 21 Mar. 1980. Dip net, electrofishing. Species #3, 12, 14, 16, 30, 31, 33, 35, 36, 40, 42, 53, 54, 55, 56, 57, 58, 72.

114. Marsh prairie, lower Taylor Slough. Fl., Dade Co., T59S, R37E, Sec. 11. Fish population sampling site, sampled monthly during 1978-1979. Throw trap, dip net. Collectors: N. Deschu, K. Kronner, D. Peck, R. Wideman. Species #15, 28, 30, 31, 35, 36, 40, 42, 43, 57.

115. Marsh prairie and pond, 5 km NW of Taylor River. Fl., Dade Co., T59 1/2S, R36E. 16 Jan. 1978. Rotenone, dip net. Spikerush marsh with periphyton mat; marsh continuous with mangrove-bordered pond. Some bladderwort in pond, but water column mainly open. Species #12, 13, 28, 30, 33, 35, 36, 40, 42, 43, 44, 51, 52, 55, 56, 57, 58.

116. Hidden Lake, Everglades National Park. Fl., Dade Co., T58S, R37E, Sec. 15. 29 Dec. 1976; 3 Apr. 1978. Angling, dip net. Large rockpit 5 m-7 m deep, with extensive beds of southern naiad. Species #3, 15, 30, 36, 40, 42, 54, 56*, 57, 58.

117. Homestead Canal, 1 km S of gate on Old Ingraham Hwy. Fl., Dade Co., T58S, R37E, Sec. 21. 29 Dec. 1976. Dip net. Shallow ditch under a dense cover of willow and cocoplum. Water column open; marl substrate. Species #40, 43.

118. Homestead Canal, 1.8 km S of gate on Old Ingraham Hwy. Fl., Dade Co., T58S, R37E, Sec. 21. 29 Dec. 1976. Dip net, sight. 4 m wide canal, 2 m deep; periphyton near shore, open water in middle. Species #3, 30, 35, 36, 40, 42, 43, 53, 57.

119. Homestead Canal, 2.2 km S of gate on Old Ingraham Hwy. Fl., Dade Co., T58S, R37E, Sec. 28. 12 Jan. 1977. Angling, sight. Species #3*, 53, 57, 58.

120. Homestead Canal, 3.8 km S of gate on Old Ingraham Hwy. Fl., Dade Co., T58S, R37E, Sec. 33. 29 Dec. 1976. Dip net. Open canopy, water column choked by southern naiad. Species #30, 35, 36, 40, 42, 51, 52, 53.

121. Homestead Canal, 4.6 km S of gate on Old Ingraham Hwy. Fl., Dade Co., T58S, R37E, Sec. 32. 29 Dec. 1976. Angling, dip net, sight. Open section of canal, 5 m wide, 2-3 m deep, with southern naiad and pondweed around margins. Species #3, 12, 16, 35*, 40, 51, 53, 54, 56, 58.

122. Homestead Canal, 5.7 km S of the gate on Old Ingraham Hwy. Fl., Dade Co., T58S, R37E, Sec. 32. 29 Dec. 1976; 12 Jan. 1977. Angling, dip net, sight. Open canopy, water column with beds of bladderwort; margins of sawgrass, cocoplum, and wax myrtle. Species #15, 30, 31, 35, 40, 42, 43, 53, 54, 55, 57, 58.

123. Homestead Canal, 6.3 km S of gate on Old Ingraham Hwy. Fl., Dade Co., T59S, R36E, Sec. 31. 10 Jan. 1977. Angling. Species #40, 57, 58.

124. Homestead Canal, 8.0 km S of gate on Old Ingraham Hwy. Fl., Dade Co., T58S, R36E, Sec. 13. 10 Jan. 1977. Sight. Dense beds of muskgrass and bladderwort, with open water at center of canal. Species #40*, 54*, 57, 58.

125. Homestead Canal, 8.5 km S of gate on Old Ingraham Hwy. Fl., Dade Co., T58S, R36E, Sec. 14. 10 Jan. 1977. Dip net, cast net, angling. Canal with open canopy, 4 m wide, 1.5 m-2m deep, with dense southern naiad and open water in center. Canal continuous with sawgrass marsh. Species #12, 15, 30, 36, 40, 42, 44, 52, 53, 54, 57, 58.

126. Homestead Canal, 9.6 km S of gate on Old Ingraham Hwy. Fl., Dade Co., T58S, R36E, Sec. 14. 10 Jan. 1977. Dip net, sight. Steep-sided canal with dense southern naiad. Alligator trails through vegetation provide open-water habitat. Species #14*, 30, 35, 36, 40, 42, 53.

127. Homestead Canal, along Old Ingraham Hwy. Fl., Dade Co., T58S, R36E, Sec. 15. 24 Mar. 1977. Dense bladderwort and southern naiad; little water present. Species #3*, 40, 42.

128. Homestead Canal, Old Ingraham Hwy. Fl., Dade Co., T58S, R36E, Sec. 16. 24 Mar. 1977. Dip net, sight. Dense vegetation with alligator trails providing open-water areas. Species #3, 4*, 12, 15, 40, 42, 54*, 57, 58.

129. Homestead Canal, along Old Ingraham Hwy. Fl., Dade Co., T58S, R36E, Sec. 17. 24 Mar. 1977. Dip net. Canal shaded by willows. Cattail stands growing in mid-canal. Species #36, 40, 42, 57, 58.

130. Rockpits near Long Pine Key campground, Everglades National Park. Fl., Dade Co., T58S, R37E, Sec. 7. 3 Apr. 1978. Dip net, snorkeling, sight, angling. Large rock-pits with dense beds of southern naiad and bladderwort. Shorelines open with isolated stands of cattails, willows, and wax myrtle. Species #3, 12, 15, 30, 35, 36, 40, 54, 56, 58.

131. Ditch along Research Center road, E of the Research Center. Fl., Dade Co., T58S, R36E, Sec. 25. 22 Mar. 1977. Rotenone, dip net, electrofishing. Steep, narrow ditch with limestone bottom covered by thick layer of detritus. Some sections have open-water zones with sunken logs; other areas contain dense beds of bladderwort and southern naiad. Ditch is subject to seasonally fluctuating water conditions, and portions dry completely each year. Species #12, 15, 16, 20, 30, 35, 36, 40, 42, 43, 53, 55, 57, 58, 72.

132. Ditch along dirt road, W of Research Center. Fl., Dade Co., T58S, R36E, Sec. 28. 31 Jul. 1978. Rotenone. Ditch 1.0 m wide, 1.5 m deep. Dense beds of southern naiad are interspersed with open-water areas. Portions of canal are shaded by canopy of willows. Species #36, 40, 42, 53, 56, 57, 58.

133. Ditch at park gate on road leading to Gould Hammock, W of the Research Center. Fl., Dade Co., T58S, R36E, Sec. 29. 22 Mar. 1977. Electrofishing, dip net. Species #42, 58.

Mangrove-bordered Headwater Ponds and Rivers.

See text for a description of this habitat.

COLLECTION SITES 134-147

134. Old canal on east side of Dad's Bay. Fl., Monroe Co., T55S, R32E, Sec. 30. 8 Dec. 1977. Rotenone, dip net, sight. Old canal with sandy bottom, 1.5 m deep and 3 m wide. Canal margins bordered by red mangroves which form a dense canopy and provide cover among the prop roots. Slight current issued from several side streams; submerged vegetation sparse. Canal continuous with surrounding marshes. Salinity $0.5^{o}/oo$-$1.0^{o}/oo$. Species #20, 28, 31, 35, 37, 40, 42, 43, 45, 53, 55, 56, 57, 64, 87, 89, 92*.

135. Marsh and pond, near southern border of Big Cypress Preserve. Fl., Monroe Co., T55S, R33E, Sec. 33. 5 Jan. 1978. Rotenone, dip net. Large pond, about 1.0 m deep, with open canopy surrounded by sawgrass marsh. Species #16, 20, 27, 28, 29, 30, 31, 35, 36, 37, 40, 42, 43, 45, 53, 55, 56, 57.

136a. Headwater marsh and alligator pond, 3 km SW of hydrologic station P-34. Fl., Monroe Co., T56S, R33E, Sec. 24. 2 Jan. 1978. Rotenone, dip net. Species #16, 30, 31, 35, 36, 40, 42, 53, 55, 57.

136b. Headwater stream, 3 km SW of hydrologic station P-34. Same location and date as above. Rotenone. Stream originating in marsh, provided a deeper-water (1.0 m-1.5 m) habitat than did the marsh. Open canopy with red mangroves along margins. Species #28, 33, 35, 36, 37, 40, 42, 43, 53, 55, 57.

137. Headwater stream and marsh, E of Rodgers River Bay. Fl., Monroe Co., T56S, R33E, Sec. 27. 19 Apr. 1978. Collectors: P. Frohring and J. Booser. Throw trap, dip net. Species #27, 28, 30, 31, 35, 40, 43.

138. North fork of Broad River. Fl., Monroe Co., T57S, R33E, Sec. 24. 7-8 Nov. 1977. Gill net, rotenone, dip net, sight. Wide, mangrove-lined river, 2 m deep, and fed by numerous small creeks issuing from surrounding sawgrass marshes. Species #1, 3, 5, 7, 16, 19, 21, 26*, 30, 31, 35, 36, 37, 40, 42, 43, 45, 51, 52, 53, 55, 57, 58, 67, 70*, 87, 92.

139. Headwater stream and marsh at hydrologic station P-35. Fl., Dade Co., T57S, R35E, Sec. 31. 12 Nov. 1976; 21-22 Dec. 1976. This is part of the Rookery Branch headwater system emptying into Shark River. Rotenone, gill nets, angling, electrofishing, sight. Species #3, 4*, 5, 6, 21, 26*, 28, 30, 35, 36, 37, 40, 42, 43, 44, 45, 49*, 52, 53, 54, 55, 56, 57, 58, 64, 65, 67, 81.

140. The junction of Avocado and Squawk Creeks. Fl., Monroe Co., T58S, R34E, Sec. 6. 21-22 Dec. 1977. Rotenone, gill net, angling, sight. Creeks feed into Tarpon Bay and Shark River. Species #3*, 21, 27, 28, 30, 31, 35, 36, 37, 40, 42, 43, 49*, 53, 67, 70, 81*.

141. Headwater streams of North River. Fl., Monroe Co., T58 1/2S, R34E. 30 Nov.-1 Dec. 1977. Rotenone, gill net, dip net, sight. Species #3*, 5, 6, 16, 21, 22, 26, 27, 28, 29 30, 31, 32, 34, 35, 36, 37, 40, 42, 43, 45, 53, 54, 55, 56, 57, 58, 60, 64, 81. Additional records from this river (Odum 1971) include species #6, 7, 24, 48, 49, 61, 63, 65, 66, 67, 88, 89, 90, 91, 92.

142a. Marsh prairie, E of Paurotis Pond. Fl., Dade Co., T59S, R35E, Sec. 26. 15 Aug. 1978. Rotenone, dip net. Sparse spikerush marsh, with mixed periphyton-marl bottom. Depth 0.2 m-0.3 m. Species #16, 20, 28, 30, 31, 33*, 35, 36, 40, 43, 55, 57, 58.

142b. Marsh prairie, 2-3 km S of Paurotis Pond. Fl., Dade Co., T59S, R36 1/2E. 30 May 1980. Rotenone, dip net, electrofishing. Species #30, 31, 35, 36, 40, 42, 43, 51, 55.

143. Nine-mile Pond. Fl., Dade Co., T59 1/2S, R35E. 27 Sep. 1977. Electrofishing, dip net, sight. Species #20*, 28, 30, 31, 32, 33, 35, 36, 37, 40, 44, 45, 53, 54, 55, 56, 57, 58.

144. Mangrove-bordered pond, 1.5 km SW of Nine-mile Pond. Fl., Dade Co., T60S, R35E, Sec. 4. 15 Aug. 1978. Rotenone, dip net. Species #3, 16, 30, 35, 36, 40, 42, 43, 44, 53, 55, 56, 57.

145. Upper reaches of Taylor River. Fl., Dade Co., T60S, R37E, Sec. 7. 21-22 Nov. 1977. Rotenone, gill net, dip net, hoop net, sight. Mangrove-lined pools, feeder creeks, and the main river channel were the habitats fished. Species #2*, 3, 5, 12, 16, 19, 21, 26, 28, 30, 31, 32, 35, 36, 37, 40, 42, 43, 44, 45, 49*, 53, 55, 56, 57, 58, 61*, 81*, 87, 89, 90, 92.

146. Headwaters marsh, 0.8 km N of eastern Joe Bay. Fl., Dade Co., T59S, R38E, Sec. 31. 30 Jan. 1978. Rotenone, dip net. Collectors: R. Wideman, L. Lagna. Spikerush marsh interspersed with red mangroves. Species #27, 28, 30, 31, 35, 36, 37, 40, 42, 43, 45, 90.

147. Small pool bordered by red mangroves and sawgrass, 1.5 km south of the Everglades National Park boundary, and east of Joe Bay. Fl., Dade Co., T59S, R38E, Sec. 26. 15

Feb. 1979. Rotenone, dip net. Collectors: N. Deschu, K. Kronner. Species #16, 28, 30, 35, 36, 40, 42, 43, 55, 57.

Eastern Coastal Ridge Canals and Ditches

The eastern coastal ridge of southern Florida is an area of slightly elevated land, separating the Everglades region from Biscayne Bay, that was originally covered by a forest of splash pine (Pinus elliotii var. densa). Several transverse glades once cut through the ridge and provided the major freshwater aquatic habitat in this region. Because the coastal ridge was the highest ground in southern Florida, it was the first area developed by settlers for towns and agriculture. To drain both the ridge and the Everglades marsh, canals were cut through the ridge to channel water directly into Biscayne Bay. The southern portion of the coastal region, near Homestead, consisted of marl gladelands that dissected and bordered the ridge. These gladelands were drained by small ditches and canals, primarily for potato farming. With the development of rock-plowing techniques during the past three decades, much of the ridge and transverse glades west of Homestead has been drained and farmed.

Historically, aquatic habitats along the ridge were less extensive than in other areas of southern Florida. Recently, there has been a change in the major type of freshwater habitat on the ridge from glades to ditches and canals. Only near Homestead do remnants of the original gladeland marsh habitat remain intact. The major freshwater habitat throughout the remainder of the coastal ridge consists primarily of large drainage canals and smaller ditches. Along the coast a few small creeks which carry freshwater during the wet season may persist, but most of these have also been channelized.

The major canals, such as Black Creek, Snapper Creek, Princeton and Mowry canals, are impacted by urbanization and agriculture. They receive runoff from fields and storm sewers that affects water quality and turbidity. Those located near tropical fish farms are also loci for the introduction of exotic fish. Although the large canals now have salinity barriers, they were previously subject to salt water intrusion. All of these factors have influenced the freshwater fish fauna of the canals and ditches along the coastal ridge.

The large canals can be divided into two types, based upon their water color and turbidity. The first, represented by Black and Snapper Creeks, pass through agricultural fields where they collect a heavy burden of suspended solids that produces brown-tinted, turbid water. This canal type is more common in the northern portions of the study area, where peaty soils are characteristic. The second canal type drains marl, sand, or rock substrates and normally exhibits low turbidity and minimal particulate loading. Canals such as C-102, Mowry, Florida City, and Kendall area canals are of this type. Beck (1965) discussed the physiochemical and faunal characteristics of the canal system.

COLLECTION SITES 148-179

148. Tamiami Canal at Krome Ave. (Fl. Hwy. 997). Fl., Dade Co., T53S, R38E, Sec. 1. 20 Aug. 1980. Electrofishing, dip net, rotenone, sight. Wide, deep canal with brown, turbid water. Center portions free of vegetation, but bladderwort, Bacopa sp., and cattails occur along the margins. Species #3, 4, 7, 17, 19, 20, 30*, 31*, 36, 40, 42, 43, 52, 53, 54, 56, 57, 58, 60, 78*.

149. Tamiami Canal at the junction of Snapper Creek Canal. Fl., Dade Co., T54S, R39E, Sec. 1. 20 Aug. 1980. Electrofishing, dip net, angling, sight. Rocky substrate with little submerged vegetation. Brown, slightly turbid water with moderate flow. Species #3, 7, 16, 20, 40, 43, 44, 53, 54, 56, 57, 58, 72*, 78, 85.

150. Snapper Creek Canal at SW 97th Avenue. Fl., Dade Co., T54S, R40E, Sec. 32. 19 Aug. 1980. Electrofishing, dip net, cast net, sight. Wide canal connected to two cul-de-sac canals. Slowly flowing water, slightly turbid, with dense muskgrass beds in the cul-de-sacs. Rocky bottom with some large boulders. Species #3, 7, 36, 40, 42, 43, 44, 53, 54, 56, 57, 58, 59, 60, 71*, 72, 78, 81, 85.

151a. Snapper Creek Canal along SW 57th Avenue, near Parrot Jungle. Fl., Dade Co., T55S, R41E, Sec. 6. 1 Oct. 1980. Electrofishing, dip net, cast net. Turbid canal with moderate flow; dense beds of southern naiad along shore. Species #3, 7, 20, 40, 42, 43, 44, 53, 54, 56, 57, 58, 60, 72, 78.

151b. Stream in Parrot Jungle emptying into Snapper Creek Canal. Fl., Dade Co., T55S, R41E, Sec. 6. 23 Jan. 1981; 23 Jun. 1982. Electrofishing, dip net, seine. Clear, shallow, freshwater stream, flowing slowly over a sand and peat substrate. Little submerged vegetation, due to the dense canopy and overhanging vegetation. Rocks along shore and in stream provide cover. Species #3, 4, 7, 12, 40, 41, 43, 53, 54, 58, 72, 78, 80, 83*, 85.

152. Canal along Bird Road at SW 127th Ave. Fl., Dade Co., T54S, R39E, Sec. 23-24. 30 Sep. 1980. Electrofishing, dip net, cast net. Very turbid canal with moderate flow; half of the canal is shaded by large Australian pine trees. A portion opens into a wide, shallow basin with dense bed of vegetation. Species #3, 4, 12, 36, 40, 43, 44, 45, 53, 54, 56, 57, 58, 71, 72, 78.

153. Tamiami Canal at Junction of Coral Gables Canal. Fl., Dade Co., T54S, R40E, Sec. 10. 30 Sep. 1980. Electrofishing, rotenone, dip net, cast net. Brown, turbid water with scant aquatic vegetation. Tilapia mariae is very numerous. Species #3, 7, 20, 31, 35, 40, 42, 43, 53, 54, 56, 57, 58, 72, 76, 78, 79, 81*.

154. Coral Gables Waterway at SW 57th Avenue. Fl., Dade Co., T54S, R40E, Sec. 18. 1 Oct. 1980. Electrofishing, dip net, sight. Turbid canal with moderate flow. Wide littoral zone with beds of tape grass. Tilapia mariae extremely numerous. Species #3, 7, 26*, 36, 40, 42, 43, 49, 53, 54, 56, 57, 58, 61*, 63, 64, 72, 76, 78, 81.

155. C-100 in Kendall area along SW 137th Avenue. Fl., Dade Co., T54S, R39E, Sec. 34. 19 Aug. 1980. Rotenone, dip net, cast net, angling, sight. One section of canal was

brown and turbid, with dense hydrilla beds. An adjoining section was less turbid but also had dense hydrilla. Species #3*, 8, 12, 20, 36, 40, 42, 44, 53, 54, 56, 57, 58, 60, 78.

156. C-100 at SW 117th Avenue and Turnpike. Fl., Dade Co., T55S, R40E, Sec. 18. 25 Sep. 1980. Electrofishing, rotenone, dip net, sight. Clear, deep canal with dense muskgrass beds and some marginal periphyton. Species #3, 7, 12, 16, 20, 30, 36, 40, 42, 43, 44, 52, 53, 54, 56, 57, 58, 78.

157. C-100 at SW 168th Street. Fl., Dade Co., T55S, R40E, Sec. 34. 2 Oct. 1980. Electrofishing, dip net, sight. Deep, clear canal with dense hydrilla beds throughout. Species #7, 16, 17, 36, 40, 42, 44, 53, 56, 57, 58, 60, 72, 78.

158. Ditch at Kendall Drive (SW 88th Street) and Fl. Hwy. 27 (997). Fl., Dade Co., T54S, R39E, Sec. 31. 4 Aug. 1980. Rotenone, dip net. The open-canopied section of the ditch was choked with dense muskgrass; the water column of an adjacent section under Australian pine trees was open. Site was 0.5-0.8 m deep, with southern naiad and fallen branches for cover. Species #3*, 20, 35, 36, 40, 42, 43, 53, 54*, 58*, 71*, 72, 78.

159. Black Creek Canal (C-1) at Fl. Hwy 27 (997). Fl., Dade Co., T55S, R39E, Sec. 17. 31 Jul. 1980. Electrofishing, rotenone, dip net. Turbid, brown water, slight flow, patches of southern naiad and hydrilla along margins. Center of canal with water column open. Runoff from adjacent farm fields flowed into canal. Species #3*, 16, 20, 36, 40, 42, 43, 44*, 53*, 54*, 58, 60, 72.

160. Black Creek Canal (C-1) at SW 160th Street. Fl., Dade Co., T55S, R39E, Sec. 27. 25 Sep. 1980. Electrofishing, rotenone, dip net, sight. Deep, turbid canal connected to a small drainage pool by a culvert. Dense hydrilla throughout canal. Culvert pool species #40, 43, 57, 72. Canal species #7, 20, 36, 40, 42, 52, 53, 54, 56, 57, 58, 59, 78.

161. Drainage ditch along SW 232nd Street, emptying into Black Creek Canal (C-1). Fl., Dade Co., T56S, R40E, Sec. 21. 28 Aug. 1980. Electrofishing, rotenone, dip net, cast net, sight. Shallow drainage ditch with fairly clear water, few aquatic plants,and a substrate of mud and detritus. Species #7, 12, 20, 39, 40, 43, 53, 54, 56, 58, 72, 78, 79.

162a.Black Creek Canal (C-1) at SW 240th Street. Fl., Dade Co., T56S, R40E, Sec. 21. 28 Aug. 1980. Electrofishing, rotenone, dip net. Highly eutrophic canal, with clumps of algae covering all submerged objects. Very turbid water, few submerged macrophytes; shallow, wide littoral areas present. Species #7, 15, 20, 54, 56, 57, 58, 72, 73, 78, 79, 81.

162b.Same canal sampled by angling, dip net, rotenone, and sight on 1 Apr. 1978. Low turbidity water, margins with dense hydrilla beds and periphyton. Much cleaner appearance than in 1980. Species #3, 12, 13, 35, 36, 39, 40, 42, 43, 54, 56, 57, 58, 72, 78, 79, 81.

163. Coastal marsh and ditch, about 5 km N of Black Point. Fl., Dade Co., T56S, R40E, Sec. 3. 2 Oct. 1980. Rotenone, dip net, electrofishing. White mangrove (Laguncularia racemosa) swamp with cattail stands fed by rainwater, and connected to a muskgrass-filled drainage ditch. Species #20, 39, 43, 72.

164. C-102 on SW 192nd Street at SW 194th Avenue. Fl., Dade Co., T56S, R38E, Sec. 2. 27 Aug. 1980. Electrofishing, rotenone, dip net, sight. Brown, turbid water; dense

southern naiad and muskgrass along shore. Species #3, 7, 15, 16, 17, 20, 36, 40, 42, 52, 53, 54, 55, 56, 57, 58, 72.

165. C-102 at SW 147th Avenue. Fl., Dade Co., T56S, R39E, Sec. 9. 11 Sep. 1980. Electrofishing, rotenone, dip net, sight. Clear canal with sandy substrate. Beds of pondweed and muskgrass at center; margins with gently sloping littoral zone. Species #7, 16, 17, 36, 40, 42, 43, 44, 53, 56, 57, 58, 81.

166. C-102 at SW 107th Avenue. Fl., Dade Co., T56S, R40E, Secs. 31-32. 24 Sep. 1980. Electrofishing, rotenone, dip net, cast net, sight. Clear canal with sand-marl bottom; moderate flow. Dense pondweed and muskgrass cover the substrate. Species #7, 15*, 20, 36, 40, 42, 43, 44, 53, 54, 56, 57, 58, 60, 78, 89.

167. Farm ditch E of Princeton, near SW 256th Street. Fl., Dade Co., T56S, R40E, Sec. 28. 28 Dec. 1978. Rotenone, dip net. 40% open canopy, no submerged vegetation; some branches in water but column mostly open. 24°C. Species #39, 40, 43.

168. Coastal ditch at Waldin Drive. Fl., Dade Co., T57S, R40E, Sec. 5. 22 Jul. 1980. Rotenone, dip net. 0.1-1.1 m deep ditch overgrown by dense Brazilian pepper stands; water flowing slowly to the east. Muddy peat bottom, fallen branches and dense Bacopa stands in open areas. Species #3, 16, 20, 36, 39, 52, 53, 57, 72.

169. Ditch along Moody Drive. Fl., Dade Co., T56S, R39E, Sec. 36. 22 Jul. 1980. Electrofishing, dip net, sight. Ditch with dense muskgrass and little open water. Adjacent ditch shallow; muddy bottom with much debris. Species #39, 43, 58*, 72.

170. C-103 at SW 197th Avenue. Fl., Dade Co., T56S, R38E, Sec. 34. 27 Aug. 1980. Electrofishing, rotenone, dip net, cast net. Canal with brown water, and low turbidity; dense beds of southern naiad throughout canal. Species #15, 16, 36, 40, 42, 43, 44, 52, 53, 54, 55, 56, 57, 58, 72.

171. C-103 at SW 157th Avenue. Fl., Dade Co., T56S, R39E, Sec. 28. 11 Sep. 1980. Electrofishing, rotenone, dip net, sight. Deep, clear canal with dense beds of muskgrass, bladderwort, southern naiad throughout steep littoral zone. Fish fauna depauperate. Species #36, 40, 42, 53, 54, 56, 57, 58, 78.

172. C-103 at SW 172nd Avenue and SW 328th Street. Fl., Dade Co., T57S, R39E, Sec. 18. Aug. 1977; 18 Sep. 1980; winter 1980. Electrofishing, cast net, dip net, sight. Deep, slightly turbid cul-de-sac canal with moderate flow. Aquatic vegetation sparse. Species #3, 7, 20, 36, 40, 42, 43, 44, 45, 52, 53, 54, 56, 57, 58, 61, 64*, 77, 78, 81*. Additional species observed at this locale in Aug. 1978: Species #8*, 63*, 72*.

173. Drainage Canal along SW 328th Street, at SW 137th Avenue. Fl., Dade Co., T57S, R39E, Sec. 14. 18 Sep. 1980. Electrofishing, rotenone, dip net, sight. Deep, clear canal with moderate flow. Margins bordered by tall common cane and taro (Colocasia sp.). Bottom sandy and sparsely vegetated. Species #3, 7, 12, 20, 36, 40, 42, 44, 53, 54. 56. 57. 58. 64. 81.

174. Disturbed marsh and associated ditch along SW 167th Avenue, S of Florida City. Fl., Dade Co., T57S, R39E, Sec. 32. 6 Aug. 1980. Rotenone, dip net, sight. Spikerush marsh near farm fields; areas of slightly deeper water (0.5 m) caused by tire ruts in marl.

Highly-eutrophic ditch that traverses potato farm fields. Species #3*, 12, 30*, 35, 36, 39, 40, 42, 43, 53, 54*, 55, 56*, 57, 58*, 72*.

175. Marsh along SW 137th Avenue, 4 km S of Florida City Canal. Fl., Dade Co., T57S, R39E, Sec. 35. 22 Jul. 1980. Rotenone, dip net. Shallow spikerush and sawgrass marsh with periphyton mat. Vegetation dense. Species #3, 6* (in bordering canal), 20, 30, 31, 35, 36, 39, 40, 42, 43, 53, 55, 58, 72.
176. Ditch along SW 107th Avenue, near Homestead Bayfront Park. Fl., Dade Co., T57S, R40E, Sec. 19. 26 Aug. 1980. Rotenone, dip net, cast net, angling, sight. Species #3, 15, 30, 31, 36, 39, 40, 42, 43, 53, 54, 55, 56, 58, 72.
177. L-31 N Canal, W of Mangrove Point. Fl., Dade Co., T58S, R40E, Sec. 18. 26 Aug. 1980. Electrofishing, rotenone, dip net, cast net, sight. Deep canal with sloping littoral zone. Species #3, 6*, 7, 15, 16, 28, 30, 35, 36, 39, 40, 42, 43, 45, 53, 54, 56, 57, 58, 72, 81*.
178. Ditch between U.S. Hwy. 1 and Card Sound Road, 4 km S of their junction. Fl., Dade Co., T58S, R39E, Sec. 17. 6 Dec. 1978. Rotenone, dip net. 2.0 m deep and 3.0 m wide ditch with dense muskgrass beds and cattail stand at one end of ditch; some open areas present. Species #7, 12, 16, 30, 31, 35, 36, 40, 42, 43, 53, 55, 57.
179. Ditch and canal along Card Sound Road, 8 km SE of U.S. Hwy. 1 junction. Fl., Dade Co., T58S, R39E, Sec. 27. 5 Dec. 1978. Rotenone, gill net. Deep, open canal with little aquatic vegetation; connected to shallow, heavily vegetated ditch. Species #3, 12, 16, 30, 35, 36, 29, 40, 42, 43, 53, 54, 55, 56, 57, 58, 72.

Cape Sable

A small area of freshwater marsh exists on north-central Cape Sable. Eleocharis marsh is mixed with hummocks of sawgrass. Clumps of red mangrove occur around shallow freshwater pools. Most of the freshwater in this area is the result of local rainfall events rather than overland surface flow. During the dry season, these marshes occasionally may dry completely. Elsewhere on Cape Sable, the marshes and ponds are brackish to saline for most of the year.

COLLECTION SITES 180-181

180. Marsh and pool systems, S of Little Fox Lake, Cape Sable. Fl., Monroe Co., T60S, R33E, Sec. 20. 17 Jan. 1983. Rotenone, dip net. Shallow pools with muck and peat bottom, 6.0^{o}/oo. Paspalidium marsh with a great deal of periphyton, 1.0^{o}/oo. Pool species #35, 37, 40, 42, 43, 45. Marsh species #28, 31, 35, 40, 42, 43.
181. Marsh pool and marsh, 2-3 km NW of Little Fox Lake, Cape Sable. Fl., Monroe Co., T60S, R35E, Sec. 7. 17 Jan. 1983. Rotenone, dip net, sight. Eleocharis marsh with clumps of Cladium, Distichlis, and Rhizophora interspersed. Utricularia and periphyton abundant. 0^{o}/oo. Species #20, 28, 31, 35, 40, 42, 43, 53.

APPENDIX II

A LISTING OF THE VOUCHER SAMPLES AND MUSEUM CATALOGUE NUMBERS

Specimens saved for the voucher samples (VS) were fishes taken at the following collection sites (CS). Descriptions of the collection sites appear in Appendix I. Specimens from the voucher samples have been deposited at the Florida State Museum (UF), Gainesville, Florida. For each voucher sample, the specimens taken are listed by the species code number, followed by the Florida State Museum catalogue numbers for that species lot (in parentheses). Sometimes, unusual specimens were taken at collection sites not designated as voucher samples. Those specimens were also deposited at the museum. The collection site number and museum catalogue numbers of those specimens are also listed below.

VS 1-CS 48A; 48B

Species #3 (UF 34349; UF 34380), 4 (UF 34359), 11 (UF 34458), 12 (UF 34342), 15 (UF 34341), 28 (UF 34350), 30 (UF 34343), 31 (UF 34351), 35 (UF 34909), 36 (UF 34344), 40 (UF 34352), 42 (UF 34354), 43 (UF 34345; UF 34353), 52 (UF 34346), 53 (UF 34356), 54 (UF 34381), 55 (UF 34357), 56 (UF 34382), 57 (UF 34347; UF 34910), 58 (UF 34348), 60 (UF 34355), 71 (UF 34383).

VS 2-CS 49

Species #3 (UF 34384), 4 (UF 34368), 15 (UF 34369), 16 (UF 34360), 28 (UF 34361), 30 (UF 34362), 31 (UF 34370), 35 (UF 34363), 36 (UF 34364; UF 34371), 40 (UF 34365), 42 (UF 34366), 43 (UF 34367), 44 (UF 34372), 51 (UF 34373), 52 (UF 34374), 53 (UF 34375), 54 (UF 34376), 55 (UF 34377), 56 (UF 34378), 57 (UF 34379), 58 (UF 34386).

VS 3-CS 74-77

Species #3 (UF 34387), 16 (UF 34388), 20 (UF 34389), 27 (UF 34390), 28 (UF 34391), 30 (UF 34402), 31 (UF 34392), 33 (UF 34393), 35 (UF 34394), 40 (UF 34395), 43 (UF 34396), 53 (UF 34397), 55 (UF 34398), 56 (UF 34399), 57 (UF 34400), 72 (UF 34401).

VS 4-CS 110-111

Species #16 (UF 34403), 19 (UF 34404), 30 (UF 34405), 31 (UF 34406), 36 (UF 34407), 40 (UF 34408), 42 (UF 34409), 43 (UF 34410), 52 (UF 34411), 53 (UF 34412), 55 (UF 34413), 57 (UF 34414), 72 (UF 34415).

VS 5-CS 121-123

Species #3 (UF 34416), 12 (UF 34418), 15 (UF 34417), 16 (UF 34419), 30 (UF 34420), 31 (UF 34421), 35 (UF 34422), 36 (UF 34423), 40 (U 34435), 43 (UF 34424), 44 (UF 34425), 51 (UF 34426), 52 (UF 34427), 53 (UF 34428), 54 (UF 34430), 55 (UF 34431), 56 (UF 344432), 57 (UF 34433), 58 (UF 34434).

VS 6-CS 40

Species #3 (UF 34436), 12 (UF 34437), 16 (UF 34438), 20 (UF 34439), 28 (UF 34440), 30 (UF 34441), 31 (UF 34442), 35 (UF 34443), 40 (UF 34444), 42 (UF 34445), 43 (UF 34446), 53 (UF 34447), 55 (UF 34448), 57 (UF 34449).

VS 7-CS 46

Species #3 (UF 34450), 7 (UF 34451), 12 (UF 34453), 15 (UF 34452), 16 (UF 34454), 30 (UF 34455), 35 (UF 34456), 40 (UF 34457), 42 (UF 34458), 43 (UF 34459), 53 (UF 34460), 54 (UF 34461), 55 (UF 34462), 56 (UF 34463), 57 (UF 34464), 58 (UF 34465).

VS 8-CS 57

Species #3 (UF 34466), 16 (UF 34467), 28 (UF 34468), 30 (UF 34469), 31 (UF 34470), 35 (UF 34471), 36 (UF 34472), 40 (UF 34473), 42 (UF 34474), 43 (UF 34475), 51 (UF 34476), 53 (UF 34477), 57 (UF 34478).

VS 9-CS 100-101

Species #16 (UF 34479), 17 (UF 34480), 35 (UF 34481), 36 (UF 34482), 40 (UF 34483), 43 (UF 34484), 53 (UF 34485), 57 (UF 34486).

VS 10-CS 108

Species #16 (UF 34487), 30 (UF 34488), 31 (UF 34489), 35 (UF 34490), 40 (UF 34491), 42 (UF 34492), 43 (UF 34493), 52 (UF 34495), 53 (UF 34496), 55 (UF 34497), 57 (UF 34498), 60 (UF 34494).

VS 11-CS 143

Species #28 (UF 34499), 32 (UF 34500), 33 (UF 34501), 35 (UF 34502), 37 (UF 34503), 40 (UF 34504), 45 (UF 34505), 53 (UF 34506), 54 (UF 34507), 56 (UF 34508), 57 (UF 34509).

VS 12-CS 10-11

Species #3 (UF 34510), 20 (UF 34511), 30 (UF 34512), 35 (UF 34513), 40 (UF 34514), 42 (UF 34515), 53 (UF 34516).

VS 13-CS 21

Species #12 (UF 34517), 30 (UF 34518), 31 (UF 34519), 35 (UF 34520), 36 (UF 34521), 40 (UF 34522), 42 (UF 34523), 43 (UF 34524), 44 (UF 34525), 53 (UF 34526), 54 (UF 34527), 55 (UF 34528), 57 (UF 34529), 58 (UF 34530).

VS 14-CS 136

Species #16 (UF 34532), 28 (UF 34533), 30 (UF 34534), 31 (UF 34535), 33 (UF 34544), 35 (UF 34536), 36 (UF 34537), 37 (UF 34538), 40 (UF 34531), 42 (UF 34539), 43 (UF 34540), 53 (UF 34541), 55 (UF 34542), 57 (UF 34543).

VS 15-CS 138

Species #1 (UF 34545), 5 (UF 34546), 7 (UF 34547), 16 (UF 34548), 19 (UF 34549), 20 (UF 34550), 30 (UF 34551), 31 (UF 34552), 36 (UF 34553), 37 (UF 34554), 40 (UF 34555), 42 (UF 34556), 43 (UF 34557), 45 (UF 34559), 51 (UF 34560), 53 (UF 34561), 55 (UF 34562), 57 (UF 34563), 58 (UF 34564), 67 (UF 34565), 87 (UF 34566), 92 (UF 34558).

VS 16-CS 141

Species #3 (UF 34567), 5 (UF 34568), 16 (UF 34571), 20 (UF 34572), 21 (UF 34569), 22 (UF 34570), 27 (UF 34573), 28 (UF 34574), 29 (UF 34575), 30 (UF 34576), 31 (UF 34577), 32 (UF 34578), 35 (UF 34579), 36 (UF 34580), 37 (UF 34581), 40 (UF 34582), 43 (UF 34583), 45 (UF 34584), 53 (UF 34585), 54 (UF 34586), 55 (UF 34587), 57 (UF 34588), 64 (UF 34589).

VS 17-CS 35

Species #12 (UF 34590), 16 (UF 34591), 20 (UF 34592), 28 (UF 34593), 30 (UF 34594), 31 (UF 34595), 35 (UF 34596), 36 (UF 34597), 40 (UF 34598), 42 (UF 34599), 43 (UF 34600), 53 (UF 34601), 55 (UF 34602), 57 (UF 34603), 72 (UF 34604).

VS 18-CS 26-27

Species #16 (UF 34605), 53 (UF 34606).

VS 19-CS 135

Species #16 (UF 34607), 20 (UF 34608), 28 (UF 34616), 30 (UF 34609), 31 (UF 34617; UF 34577), 35 (UF 34610), 36 (UF 34618; UF 34580), 37 (UF 34619), 40 (UF 34611), 42 (UF 34620), 43 (UF 34612), 45 (UF 34621), 53 (UF 34622), 54 (UF 34613), 55 (UF 34614), 56 (UF 34615), 57 (UF 34624).

VS 20-CS 87

Species #16 (UF 34625), 28 (UF 34628), 30 (UF 34626), 31 (UF 34627), 35 (UF 35587), 36 (UF 35588), 40 (UF 34629), 42 (UF 35589), 43 (UF 34630), 55 (UF 34631).

VS 21-CS 42-43, 47

Species #3 (UF 34632), 7 (UF 34633), 16 (UF 34634), 30 (UF 34635; UF 34942), 31 (UF 34636), 35 (UF 34637; UF 34943), 36 (UF 34638), 40 (UF 34639), 42 (UF 34640), 43 (UF 34641), 44 (UF 34642), 53 (UF 34645), 55 (UF 34646), 56 (UF 34647), 57 (UF 34648), 58 (UF 34649), 59 (UF 34650).

VS 22-CS 139

Species #3 (UF 34651), 5 (UF 34652), 6 (UF 34653), 14 (UF 34913), 21 (UF 34654), 31 (UF 34655), 35 (UF 35590), 36 (UF 34656), 40 (UF 34657), 42 (UF 35591), 44 (UF 34912; UF 35592), 45 (UF 34658), 52 (UF 34659), 53 (UF 34660), 55 (UF 34662), 56 (UF 34663), 57 (UF 34664), 58 (UF 34666), 67 (UF 34667), 81 (UF 34668).

VS 23-CS 51

Species #16 (UF 34671), 20 (UF 34672), 35 (UF 35594), 40 (UF 34673), 42 (UF 35595), 53 (UF 34674), 54 (UF 34675), 55 (UF 34676), 57 (UF 34678), 58 (UF 34679).

VS 24-CS 145

Species #5 (UF 34706), 12 (UF 34680), 16 (UF 34703), 19 (UF 34704), 21 (UF 34681), 26 (UF 34689), 28 (UF 34692), 30 (UF 34693), 31 (UF 34682), 32 (UF 34683), 35 (UF 34694), 36 (UF 34695), 37 (UF 35593), 40 (UF 34696), 42 (UF 34685), 43 (UF 34586), 44 (UF 34697), 45 (UF 34705), 51 (UF 34687), 53 (UF 34698), 55 (UF 34699), 56 (UF 34700), 57 (UF 34701), 58 (UF 34688), 87 (UF 34690), 89 (UF 34702), 90 (UF 34691).

VS 25-CS 86

Species #3 (UF 34707), 15 (UF 34708), 16 (UF 34709), 20 (UF 34710), 30 (UF 34711), 35 (UF 34712), 36 (UF 34713), 40 (UF 34714), 42 (UF 35596), 43 (UF 35597), 53 (UF 34715), 54 (UF 34716), 55 (UF 34717), 56 (UF 34718), 57 (UF 34719), 58 (UF 34720).

VS 26-CS 2-3

Species #3 (UF 34721), 15 (UF 34722), 30 (UF 34723), 31 (UF 34734), 35 (UF 34724), 36 (UF 34725), 40 (UF 34726), 42 (UF 34735), 43 (UF 34727), 44 (UF 34728), 53 (UF 34729), 54 (IF 34730), 56 (UF 34731), 57 (UF 34732), 72 (UF 34733).

VS 27-CS 173

Species #3 (UF 34736), 7 (UF 34737; UF 34749), 12 (UF 34738), 36 (UF 34739), 40 (UF 34740), 42 (UF 34741), 44 (UF 34742), 54 (UF 34744; UF 34750), 56 (UF 34745; UF 34751), 57 (UF 34746), 58 (UF 34747), 64 (UF 34748), 81 (UF 34743).

VS 28-CS 41

Species #9 (UF 34752), 12 (UF 34754), 15 (UF 34753), 30 (UF 34755), 31 (UF 34756), 33 (UF 35598), 35 (UF 34757), 36 (UF 34758), 40 (UF 34759), 42 (UF 34760), 43 (UF

34761), 44 (UF 34762), 52 (UF 34764), 53 (UF 34765), 55 (UF 34766), 57 (UF 34767), 58 (UF 34768), 60 (UF 34763).

VS 29-CS 179

Species #3 (UF 34769), 12 (UF 34770), 16 (UF 34771), 30 (UF 34772), 35 (UF 34773), 36 (UF 34774), 39 (UF 34775), 40 (UF 34776), 42 (UF 34777), 43 (UF 34778), 53 (UF 34779), 54 (UF 34780), 55 (UF 34781), 56 (UF 34782), 57 (UF 34783), 58 (UF 34784), 72 (UF 34785).

VS 30-CS 33

Species #12 (UF 34786), 16 (UF 34787), 30 (UF 34788), 36 (UF 34789), 40 (UF 34790), 51 (UF 34791), 53 (UF 34792), 54 (UF 34793), 55 (UF 34794), 56 (UF 34795), 57 (UF 34796), 58 (UF 34797).

VS 31-CS 38

Species #12 (UF 34798), 30 (UF 34799), 31 (UF 34800), 35 (UF 34801), 36 (UF 34802), 40 (UF 34803), 42 (UF 34804), 43 (UF 34805), 51 (UF 34806), 53 (UF 34807).

VS 32-CS 85

Species #12 (UF 34808), 20 (UF 34809), 30 (UF 34810), 31 (UF 34811), 35 (UF 34670), 36 (UF 34812), 40 (UF 34813), 42 (UF 34814), 43 (UF 34815), 44 (UF 34816), 52 (UF 34817), 53 (UF 34818), 54 (UF 34819), 55 (UF 34820), 57 (UF 34821), 58 (UF 34822).

VS 33-CS 178

Species #7 (UF 34823), 12 (UF 34824), 16 (UF 34825), 30 (UF 34826), 31 (UF 34827), 35 (UF 34828), 36 (UF 34829), 40 (UF 34830), 43 (UF 34831), 53 (UF 34832), 55 (UF 34833), 57 (UF 34834).

VS 34-CS 134

Species #20 (UF 34835), 28 (UF 34836), 31 (UF 34837), 35 (UF 34838), 37 (UF 34839), 40 (UF 34840), 42 (UF 34841), 43 (UF 34842), 53 (UF 34843), 55 (UF 34844), 56 (UF 34845), 57 (UF 34846), 64 (UF 34847).

VS 35-CS 115

Species #12 (UF 34848), 13 (UF 35599), 30 (UF 34849), 35 (UF 34850), 36 (UF 34851), 40 (UF 34852), 42 (UF 35600), 43 (UF 34853), 44 (UF 35601), 52 (UF 34854), 55 (UF 34855; UF 35602), 56 (UF 34856), 57 (UF 34857), 58 (UF 34858), 89 (UF 34869).

VS 36-CS 63

Species #12 (UF 34859), 30 (UF 34860), 31 (UF 34861), 35 (UF 34862), 36 (UF 34863), 40 (UF 34864), 42 (UF 34865), 43 (UF 34866), 53 (UF 34867), 57 (UF 34868).

VS 37-CS 150

Species #3 (UF 34870), 36 (UF 34871), 40 (UF 34872), 42 (UF 34873), 43 (UF 34874), 44 (UF 34875), 53 (UF 34878), 54 (UF 34879), 56 (UF 34880), 58 (UF 34881), 59 (UF 34882), 60 (UF 34877), 72 (UF 34883), 78 (UF 34884), 81 (UF 34876), 85 (UF 34885).

VS 38-CS 170

Species #15 (UF 34886), 16 (UF 34887), 36, (UF 34888), 40 (UF 34889), 44 (UF 34890), 52 (UF 34891), 53 (UF 34892), 54 (UF 34893), 56 (UF 34894), 57 (UF 34895), 58 (UF 34896).

VS 39-CS 161-162

Species #7 (UF 34897), 12 (UF 34898), 20 (UF 34899), 53 (UF 34901), 54 (UF 34902), 56 (UF 34903), 57 (UF 34904), 58 (UF 34905), 72 (UF 34906), 73 (UF 31651), 78 (UF 34907), 79 (UF 34908), 81 (UF 34900).

Additional museum specimens from collection sites that were not designated as voucher samples:

CS-55

Species #30 (UF 34939), 42 (UF 34940), 55 (UF 34941).

CS-58

Species #15 (UF 34917).

CS-80b

Species #77 (UF 34914).

CS-82

Species #13 (UF 34918), 14 (UF 34919).

CS-112

Species #14 (UF 35603).

CS-113

Species #33 (UF 34920).

CS-149

Species #85 (UF 34911).

CS-151b

Species #41 (UF 34915), 80 (UF 34916).

CS-154

Species #40 (UF 34921), 53 (UF 34923), 54 (UF 34924), 56 (UF 34925), 58 (UF 34926), 63 (UF 34927), 64 (UF 34928), 72 (UF 34929), 76 (UF 34930), 78 (UF 34931), 81 (UF 34922).

CS-155

Species #12 (UF 35604).

CS-160

Species #59 (UF 35605).

CS-164

Species #17 (UF 34932), 52 (UF 34933).

CS-165

Species #17 (UF 34934).

CS-166

Species #39 (UF 34935), 89 (UF 34936).

CS-167

Species #40 (UF 34944).

CS-172

Species #45 (UF 34937), 78 (UF 34938).

CS-180

Species #28 (UF 36184), 31 (UF 36185), 35 (UF 36186), 37 (UF 36187), 40 (UF 36188), 42 (UF 36189), 43 (UF 36190), 45 (UF 36191).

CS-181

Species #20 (UF 36192), 28 (UF 36193), 31 (UF 36194), 35 (UF 36195), 40 (UF 36196), 42 (UF 36197), 43 (UF 36198).

APPENDIX III

AN ARTIFICIAL KEY TO JUVENILE SUNFISHES OF THE GENUS *LEPOMIS* FROM SOUTHERN FLORIDA

Obtaining accurate identifications of juvenile sunfishes (genus Lepomis) has posed a problem in southern Florida. Five species of Lepomis, with juveniles of similar appearance, occur within this area. Identification difficulties result from the fact that the identifying characters of the adults are less apparent in the immature forms.

We examined several hundred specimens of the five Lepomis species, both living and preserved, while constructing this key. It has since been used satisfactorily by a number of workers and is helpful in identifying juveniles that exceed 10 mm SL. We have included the bluespotted sunfish, Enneacanthus gloriosus, in the key because of its superficial similarity to juvenile Lepomis spp.

KEY

1a. Tail rounded, dark suborbital bar present; light spots present on unpaired fins .... Enneacanthus gloriosus.

1b. Tail slightly emarginate, no suborbital bar present; no spots on unpaired fins.................... 2 (Lepomis spp.)

2a. Maxillary reaching to middle of orbit.................... L. gulosus

2b. Maxillary reaching only to anterior portion of orbit.................... 3

3a. Pectoral fin long and pointed, reaching to and beyond the third anal spine 4

3b. Pectoral fin short and rounded, not reaching to the third anal spine.................... 5

4a. Opercular spot black to margin; gill rakers long and slender; black spot on posterior portion of the dorsal fin.................... L. macrochirus

4b. Opercular spot with a red or light margin; gill rakers shorter and slightly thicker; no spot on posterior portion of the dorsal fin .... L. microlophus

5a. Body and subopercle with dark specks; opercular spot stiff; gill rakers short, but each touches the raker below .... L. punctatus

5b. Body with a few brownish specks, subopercle unspotted; opercular spot flexible; gill rakers very short and stubby, not touching one another .... L. marginatus

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Florida State Museum
University of Florida
Gainesville FL 32611
U.S.A.