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THE ECOLOGY OF THE MANGROVES OF SOUTH FLORIDA: A COMMUNITY PROFILE

by

William E. Odum
Carole C. McIvor
Thomas J. Smith, III

Department of Environmental Sciences
University of Virginia
Charlottesville, Virginia 22901

Project Officer

Ken Adams
National Coastal Ecosystems Team
U.S. Fish and Wildlife Service
1010 Gause Boulevard
Slidell, Louisiana 70458

Performed for
National Coastal Ecosystems Team
Office of Biological Services
Fish and Wildlife Service
U.S. Department of the Interior
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and

New Orleans OCS Office
Bureau of Land Management
U.S. Department of the Interior
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CHAPTER 7. COMMUNITY COMPONENTS - FISHES

Of the six mangrove community types discussed in section 1.5, fishes are an important component of four: (1) basin forests, (2) riverine forests, (3) fringe forests, and (4) overwash island forests. For convenience we have divided fringe forests into two sub-components: (a) forests which fringe estuarine bays and lagoons and (b) forests which fringe oceanic bays and lagoons. This division is necessary because the fish communities differ markedly.

Mangroves serve two distinct roles for fishes and it is conceptually important to distinguish between them. First, the mangrove-water interface, generally red mangrove prop roots, afford a relatively protected habitat which is particularly suitable for juvenile fishes. Secondly, mangrove leaves, as discussed in section 3.6, are the basic energy source of a detritus-based food web on which many fishes are dependent. The habitat value of mangroves can be considered strictly a function of the area of interface between the water and the mangrove prop roots; it is an attribute shared by all four types of mangrove communities. The importance of the mangrove detritus-based food web is dependent on the relative contribution of other forms of energy in a given environment, including phytoplankton, benthic algae, sea grass detritus, and terrestrial carbon sources. Figure 11 provides a diagrammatic representation of the relative positions along a food web continuum of the four mangrove communities.

Fishes recorded from mangrove habitats in south Florida are listed in Appendix B. Although the fish communities are discussed separately below, they have been combined into certain categories in Appendix B; fishes from mangrove basins and riverine forests have been combined under the heading of tidal streams; fishes from fringing forests along estuarine bays and lagoons are listed under the heading of estuarine bays; fishes from oceanic bays and lagoons have been listed under oceanic bays. Since no surveys have been published specifically relating to overwash island forests, there is no listing for this community type in Appendix B. Site characteristics and sampling methods for these community types are summarized in Appendix A. Nomenclature and taxonomic order follow Bailey et al. (1970).

7.1 BASIN MANGROVE FORESTS

The infrequently flooded pools in the black mangrove-dominated zone provide an extreme habitat which few species of fishes can tolerate. The waters are darkly stained with organic acids and tannins leached from the thick layer of leaf litter. Dissolved oxygen is frequently low (1-2 ppm) and hydrogen sulfide is released from the sediments following physical disturbance. Salinities are highly variable ranging from totally fresh to hypersaline. The fish families best adapted to this habitat are the euryhaline cyprinodonts (killifishes) and the poeciliids (livebearers). The killifishes include Fundulus confluentus (Heald et al. 1974), Rivulus marmoratus (M. P. Weinstein, Va. Commonwealth Univ., Richmond, Va.; personal communication 1981), Floridichthys carpio, and Cyprinodon variegatus (Odum 1970). The poecillids include Poecilia latipinna (Odum 1970) and, the most common, Gambusia affinis (Heald et al. 1974). While the species richness of fishes in this habitat is low, the densities of fish are often very high. Weinstein (pers. comm.) has recorded up to 38 fish/m^2.

All of these fishes are permanent residents, completing their life cycles in this habitat. They feed primarily on mosquito larvae and small crustaceans such as amphipods which, in turn, feed on mangrove detritus and algae. These small fishes enter coastal food webs when they are flushed into the main watercourses during high spring tides or following seasonally heavy rains. Here they are eaten by numerous piscivorous fishes including snook, ladyfish, tarpon, gars, and mangrove snappers. The alternate energy pathway for fishes of the black mangrove basin wetlands occurs when the pools shrink during dry weather, the fishes are concentrated into smaller areas, and are fed-upon by various wading birds including

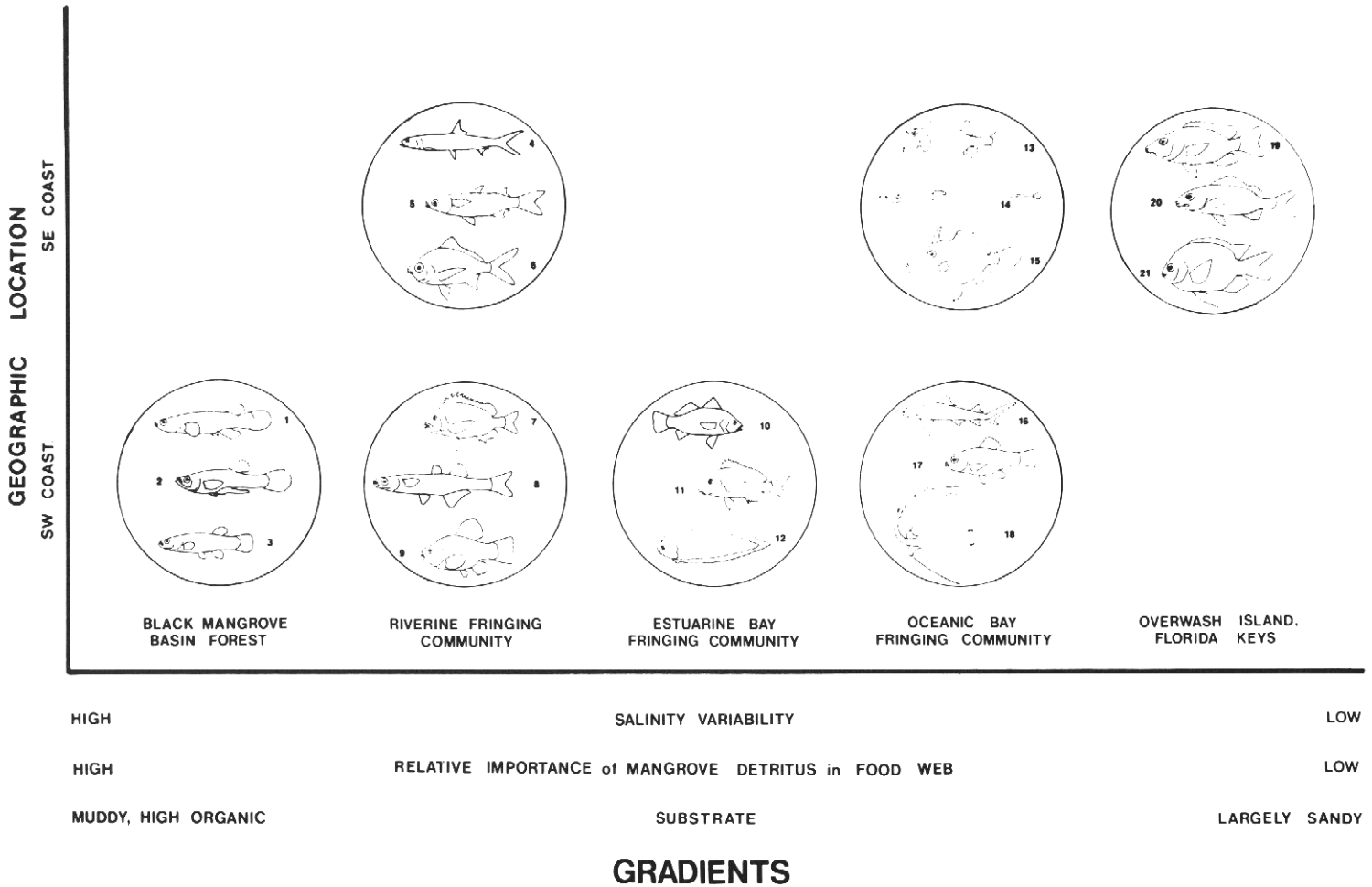

Figure 11. Gradient of mangrove-associated fish communities showing representative species. Fish are not drawn to scale. 1 = rivulus, 2 = mosquitofish, 3 = marsh killifish, 4 = ladyfish, 5 = striped mullet, 6 = yellowfin mojarra, 7 = juvenile sheepshead, 8 = tidewater silversides, 9 = sheepshead minnow, 10 = silver perch, 11 = pigfish, 12 = blackcheek tonguefish, 13 = scrawled cowfish, 14 = fringed pipefish, 15 = fringed filefish, 16 = lemon shark, 17 = goldspotted killifish, 18 = southern stingray, 19 = juvenile schoolmaster, 20 = juvenile tomtate, 21 = juvenile sergent major. See Appendix B for scientific names.

herons, ibis and the wood stork (Heald et al. 1974).

7.2 RIVERINE FORESTS

Tidal streams and rivers, fringed largely by red mangroves, connect the freshwater marshes of south Florida with the shallow estuarine bays and lagoons (Figure 12). Few of these streams have been studied thoroughly. The exception is the North River which flows into Whitewater Bay and was studied by Tabb (1966) and Odum (1970). Springer and Woodburn (1960) collected fishes in a bayou or tidal pass connecting Boca Ciega Bay and Old Tampa Bay. Carter et al. (1973) reported on the fishes of two tidal streams entering Fahkahatchee and Fahka Union Bays. Nugent (1970) sampled fishes in two streams on the western shore of Biscayne Bay. Characteristics of these areas and sampling gear used by the investigators are summarized in Appendix A.

These tidal streams and associated riverine mangrove forests exhibit extreme seasonal variability in both physical characteristics and fish community composition. Salinity variations are directly related to changes in the make-up of the fish assemblage. During the wet season (June - November), salinities fall throughout the water courses and, at some locations in certain heavy runoff years, become fresh all of the way to the mouth (Odum 1970). Opportunistic freshwater species, which are normally restricted to the sawgrass and black needle rush marshes of the headwaters, invade the mangrove zone. These include the Florida gar, Lepisosteus platyrhincus; several centrarchid sunfishes of the genus Lepomis and the largemouth bass, Micropterus salmoides; the freshwater catfishes, Ictalurus natalis and Noturus gyrinus; and the killifishes normally considered freshwater inhabitants such as Lucania goodei and Rivulus marmoratus.

During the dry season (December to early May) salinities rise as a result of decreased freshwater runoff and continuing evaporation. Marine species invade the tidal streams primarily on feeding forays. Examples include the jewfish, Epinephelus itajara, the stingrays (Dasyatidae), the needlefishes (Belonidae), the jacks (Carangidae), and the barracuda, Sphyraena barracuda. Other seasonal movements of fishes appear to be temperature related. Tabb and Manning (1961) documented movements of a number of species from shallow inshore waters to deeper water during times of low temperature stress. The lined sole, the hogchoker, the bighead searobin, and the striped mullet, for example, are much less frequently caught in winter in shallow inshore waters.

A third type of seasonality of fish populations in the tidal rivers is related to life cycles. Many of the fish which utilize the tidal stream habitat do so only as juveniles. Thus, there are peaks of abundance of these species following offshore spawning when larval or juvenile forms are recruited to the mangrove stream habitat. In general, recruitment occurs in the late spring or early summer following late winter and spring spawning offshore or in tidal passes (Reid 1954). Numerous species are involved in this life cycle phenomenon including striped mullet, grey snapper, sheepshead, spotted sea trout, red drum, and silver perch.

The only estimate of fish standing crop from tidal stream habitats is that of Carter et al. (1973). They recorded 27 species weighing 65,891 g (wet wt.) from an area of 734 m^2 or about 90 g/m^2. This is probably an overestimate since an unknown portion of the fish community had moved from the flooded lowlands to the stream on the ebb tide; sampling occurred at low tide in October. Nonetheless, this is an indication of the high fish standing crop which this mangrove-associated habitat can support. The number of species reported from individual tidal streams annually ranges from 47 to 60 and the total from all tidal streams in southwest Florida is 111 species (Appendix B).

The food webs in these riverine mangrove ecosystems appear to be predominantly mangrove detritus-based, although the Biscayne Bay stream studied by Nugent

Figure 12. Aerial photograph of the mangrove belt of southwest Florida near Whitewater Bay. Note the complex system of pools and small creeks which connect with the tidal river system.

(1970) may be an exception. The basic link between the mangrove leaf and higher order consumers is provided by microorganisms (fungi, bacteria, Protozoa) which colonize the decaying leaf and convert them into a relatively rich protein source (Odum 1970; Odum and Heald 1975a). These decaying leaf fragments with associated microorganisms are fed upon by a group of omnivorous detritivores including amphipods, mysids, cumaceans, ostracods, chironomid larvae, harpacticoid and calanoid copepods, snapping shrimp, caridean and penaeid shrimp, a variety of crabs, filter-feeding bivalves, and a few species of fishes (Odum 1970; Odum and Heald 1972; Odum and Heald 1975b). These detritivores, in turn, are consumed by a number of small carnivorous fishes, which in turn, are consumed by larger piscivorous fishes. The concept of mangrove trophic structure is also discussed in section 3.6. See Appendix B for species specific dietary information.

The tidal creeks studied by Nugent (1970) on the western shore of Biscayne Bay differ from the previously discussed streams in the Everglades estuary. The mouths of the Biscayne Bay creeks have dense growths of sea grasses which contribute sea grass detritus. The salinities are considerably greater and the streams are located only a few kilometers from coral reefs, which are largely absent on Florida's west coast, at least close to shore. As a result, 23 species listed in Appendix B were captured by Nugent (1970) and are not recorded from riverine mangrove habitat on the west coast of Florida. Examples include several of the grunts (Pomadasyidae), the gray triggerfish, Balistes capriscus, the barbfish, Scorpaena brasiliensis, the scrawled boxfish, Lactophrys quadricornis, and the snappers, Lutjanus apodus and L. synagris.

Riverine mangrove communities and associated tidal streams and rivers are typified by the following families of fishes: killifishes (Cyprinodontidae), livebearers (Poeciliidae), silversides (Atherinidae), mojarras (Gerreidae), tarpon (Elopidae), snook (Centropomidae), snappers (Lutjanidae), sea catfishes (Ariidae), gobies (Gobiidae), porgys (Sparidae), mullets (Mugilidae), drums (Sciaenidae), and anchovies (Engraulidae). The mangrove-lined streams and associated pools are important nursery areas for several marine and estuarine species of gamefish. The tarpon, Megalops atlantica, snook, Centropomus undecimalis, and ladyfish, Elops saurus, utilize these areas from the time they reach the estuary as post-larvae, having been spawned offshore. Gray snapper, Lutjanus griseus, sheepshead, Archosargus probatocephalus, spotted seatrout, Cynoscion nebulosus, and red drum, Sciaenops ocellata, are recruited to grass beds of shallow bays and lagoons as post-larvae and enter the mangrove-lined streams for the next several years (Heald and Odum 1970). Of these species, only the spotted seatrout probably spawns in the estuary (Tabb 1966). Other species of commercial or game importance which use the riverine fringing habitat include crevalle jack, gafftopsail catfish, jewfish, striped mojarra, barracuda, Atlantic thread herring, and yellowfin menhaden (Odum 1970).

7.3 FRINGING FORESTS ALONG ESTUARINE BAYS AND LAGOONS

Mangrove-fringed estuarine bays and lagoons are exemplified by the Ten Thousand Islands area and Whitewater Bay. Quantitative fish data are available from Fahkahatchee Bay (Carter et al. 1973; Yokel 1975b; Seaman et al. 1973), Fahka Union Bay (Carter et al. 1973), Rookery Bay (Yokel 1975a), the Marco Island Estuary (Weinstein et al. 1977; Yokel 1975a), and Whitewater Bay (Clark 1970). Individual site characteristics are summarized in Appendix A. All except Fahka Union Bay contain significant amounts of sea grasses. Macroalgae dominate the benthic producers of Fahka Union Bay. Studies by Reid (1954) and Kilby (1955) near Cedar Key, Florida, were not included in our summary because mangroves are sparse in this area and no mention of mangrove collecting sites were made by these authors. Studies of Caloosahatchee Bay (Gunter and Hall 1965) and of Charlotte Harbor (Wang and Raney 1971)

were omitted because the areas studied have been highly modified and because data from many habitats were pooled in the final presentation.

All of the bays reviewed in our summaries are fringed by dense growths of red mangroves and all contain small mangrove islets. Carter et al. (1973), in their studies of Fahkahatchee and Fahka Union bays, estimated that 57% to 80% of the total energy budget of these two bays is supported by exports of particulate and dissolved organic matter from the mangroves within the bays and inflowing tidal streams. Lugo et al. (1980) estimated that the mangroves surrounding Rookery Bay provide 32% of the energy base of the heterotrophic community found in the bay.

Salinities in these bays tend to be higher than in the tidal streams and rivers and the fish assemblages reflect both this feature and the added habitat dimension of sea grass and macro algae beds. Truly freshwater species are rare in these communities and a proportionally greater percentage of marine visitors is present. The dominant fish families of the benthic habitat include drums (Sciaenidae), porgys (Sparidae), grunts (Pomadasyidae), mojarras (Gerreidae), snappers (Lutjanidae), and mullet (Mugilidae). Other familes with sizeable contributions to the benthic fauna include pipefishes (Syngnathidae), flounder (Bothidae), sole (Soleidae), searobins (Triglidae), and toadfishes (Batrachoididae).

Numerically abundant fishes of the mid and upper waters include anchovies (Engraulidae), herrings (Clupeidae) and needlefishes (Belonidae). At all locations studied, the benthic fauna was dominated by the pinfish, Lagodon rhomboides, the silver perch, Bairdiella chrysura, the pigfish, Orthopristis chrysoptera, and the mojarras, Eucinostomus gula and E. argenteus. The most common midwater and surface species include the two anchovies, Anchoa mitchilli and A. hepsetus, and two clupeids, Brevoortia smithi and Harengula pensacolae. The total number of species recorded in the individual studies ranged from 47 to 89; a total of 117 species was collected in these mangrove-fringed bays and lagoons (Appendix B).

In none of these studies were the fishes specifically utilizing the fringing mangrove habitat enumerated separately from those collected in the bay as a whole. The collections were most often at open water stations easily sampled by otter trawl. Carter et al. (1973) had two shore seine stations adjacent to mangroves but the data were pooled for publication. Of the four stations in Rookery Bay sampled by Yokel (1975a), one was immediately adjacent to the fringing mangrove shoreline and had moderate amounts of sea grasses.

The typical pattern which emerges from many estuarine studies is that relatively few fish species numerically dominate the catch. This is certainly true in mangrove-fringed estuaries. In Rookery Bay (Yokel 1975a) six species comprised 88% of the trawl-catchable fishes, in Fahkahatchee Bay seven species comprised 97% of the catch from three capture techniques (Carter et al. 1973), and in the Marco Island estuary 25 species comprised 97% of the trawl-catchable fishes (Weinstein et al. 1977).

Like tidal river and stream communities, these shallow bays serve as nurseries for numerous species of estuarine-dependent fishes that are spawned offshore. Based on the distribution and abundance of juvenile fishes of all species in six habitats, Carter et al. (1973) ranked the mangrove-fringed bays as the most important nursery grounds; the tidal streams were a close second. Shallow bays and tidal streams provide safe nurseries due to seasonally abundant food resources and the low frequency of large predators (Carter et al. 1973; Thayer et al. 1978). The relative lack of large predaceous fishes is probably due to their general inability to osmoregulate in waters of low and/or fluctuating salinity.

As in tidal streams, the peak abundance of juvenile and larval fishes in the bays is in spring and early summer (Reid 1954). In general, the highest standing

crops and the greatest species richness of fishes occur in the late summer and early fall (Clark 1970). Fish densities decline in the autumn and winter as many fishes move to deeper waters.

7.4 FRINGING FORESTS ALONG OCEANIC BAYS AND LAGOONS

Mangrove-fringed "oceanic" bays and lagoons are exemplified by Porpoise Lake in eastern Florida Bay (Hudson et al. 1970), western Florida Bay (Schmidt 1979), southern Biscayne Bay (Bader and Roessler 1971), and Old Rhodes Key Lagoon in eastern Biscayne Bay (Holm 1977). Characteristics of these sites are summarized in Appendix A. Compared to the mangrove-fringed bays discussed in the previous section, these environments generally exhibit clearer water, sandier substrates, and higher and less variable salinities. Closer proximity to the Florida reef tract, the Atlantic Ocean, and the Gulf of Mexico results in a larger potential pool of fish species. These four locations have produced reports of 156 fish species (Appendix B).

Mangrove fringes make up a relatively small proportion of these environments; accordingly, their contribution to the bay food webs is probably not very large. Bader and Roessler (1972) estimated that the fringing mangrove community contributes approximately 1% of the total energy budget of southern Biscayne Bay; they considered only mainland mangroves and did not include the small area of mangrove islands. The main ecological role of the fringing mangroves in this type of environment is probably twofold. First, they increase the habitat diversity within an otherwise relatively homogeneous bay system. Second, they provide a relatively protected habitat for juvenile fishes (and certain invertebrates) that later move to more open water or coral reef communities. The second role is analogous to one of the ecological roles of sea grass communities (see Zieman, in prep.) although the fish species involved may be different.

Based primarily on habitat designations of Voss et al. (1969), the fishes of Biscayne Bay can be characterized as to preferred habitat. Of the three main habitat types, (1) rock/coral/seawall, (2) grassbed/tidal flat, and (3) mangrove, the grassbed/tidal flat ranked first in fish species occurrences. One hundred and twenty-two of 156 species (79%) are known to occur in this environment. Rock/coral/seawall habitats were frequented by 49 species (32%) and mangroves are known to be utilized by 54 species (35%) of the total fish species recorded from this bay.

7.5 OVERWASH MANGROVE ISLANDS

In terms of fish-related research, these communities are the least studied of all mangrove community types in south Florida. They are typified by the low-lying mangrove-covered islands that occur in the Florida Keys and Florida Bay and may be overwashed periodically by the tides. Examples include Shell Key, Cotton Key, and the Cowpens. Islands of this type extend southwest from the Florida mainland through the Marquesas. The Dry Tortugas lack well-developed mangrove communities although stunted trees are found (Davis 1942).

These islands are the most oceanic of any of the mangrove communities discussed. They are characterized by relatively clear water (Gore 1977) and are largely free of the freshwater inflow and salinity variations which characterize other Florida mangrove communities to varying degrees. Numerous statements exist in the literature acknowledging the frequent proximity of mangrove islands to coral reefs and sea grass beds (McCoy and Heck 1976; Thayer et al. 1978). Olsen et al. (1973) working in the U.S. Virgin Islands, found 74% to 93% overlap in the fish species composition of fringing coral reefs and shallow mangrove-fringed oceanic bays. Voss et al. (1969) listed fish species that were collected from all three types of communities: fringing mangroves, coral reefs and sea

grass beds in Biscayne Bay, but there appears to have been no systematic survey of the fish assemblage characteristic of the mangrove-covered or mangrove-fringed Florida Keys. No one has quantified the faunal connections which we hypothesize exist between the mangroves and sea grasses and between the mangroves and coral reefs.

In the absence of published data from the mangrove key communities, only tentative statements can be made. In general, we expect that while mangrove islands serve as a nursery area for juvenile fishes, this function is limited largely to coral reef and marine inshore fishes and not the estuarine-dependent species that we have discussed previously. The latter (juvenile snook, red drum, spotted seatrout) appear to require relatively low salinities not found in association with most of the overwash islands. Casual observation around the edges of these islands suggests that characteristic fishes include the sea bass family (Serranidae), triggerfishes (Balistidae), snappers (Lutjanidae), grunts (Pomadasyidae), porgies (Sparidae), parrotfishes (Scaridae), wrasses (Labridae), bonefishes (Albulidae), jacks (Carangidae), damselfishes (Pomacentridae), and surgeonfishes (Acanthuridae); many of these fishes occur on or are associated with coral reefs. We also suspect that considerable overlap occurs in the fish assemblage of these mangrove islands and sea grass communities; examples include puffers (Tetraodontidae), pipefishes (Syngnathidae), gobies (Gobiidae) and scorpionfishes (Scorpaenidae). Stark and Schroeder (1971) suggested that juvenile gray snapper, which use the fringing mangroves of the keys as shelter during the day, forage in adjacent sea grass beds at night. In the absence of salinity barriers, predatory fishes probably enter the fringes of these mangrove islands on the rising tide. Included in this group are sharks, tarpon, jacks, snook, bonefish and barracuda.

7.6 GRADIENT OF MANGROVE COMMUNITY INTERACTIONS

Mangrove communities occur under a wide range of conditions from virtually freshwater at the headwaters of tidal streams to nearly oceanic conditions in the Florida Keys. Attempting to present a single list of fish characteristic of mangrove environments (Appendix B) can be misleading. For this reason we presented the concept of a continuum or complex gradient in Figure 11 and have followed that scheme throughout section 7. The gradient stretches from seasonally fresh to oceanic conditions, from highly variable salinities to nearly constant salinity, from muddy and limestone substrates to sandy substrates, from dark-stained and sometimes turbid waters to clear waters, and from food webs that are predominantly mangrove detritus-based to food webs based primarily on other energy sources. Clearly, there are other gradients as one moves from north to south in the State of Florida. At the northern end of the State, temperatures are more variable and seasonally lower than in the south. Sediments change from predominantly silicious in central and north Florida to predominantly carbonate in extreme south Florida. Nevertheless, the complex gradient shown in Figure 11, while greatly simplified for graphic purposes, suggests that characteristic fish assemblages replace one another along a gradient of changing physical and biogeographic conditions. Such a concept is useful in understanding the factors controlling the composition of fish assemblages associated with mangroves of the four major community types in south Florida.