

INTRODUCTION

Florida's freshwater environments are host to an interesting fish fauna including both native freshwater and marine species, as well as a large number of nonindigenous taxa. Within these groups exists a great diversity of shape, size, color, and species. From the western edge of the Florida panhandle to the tip of Key West, a distance of almost 900 miles, a great shift in habitats occurs. Water bodies vary from the coastal plain rivers and creeks that predominate in the northern reaches of the state, to the many sinkhole lakes and canals of the central and southern peninsula, to the vast but much modified Everglades, and to the small, isolated freshwater pools and ditches in the Florida Keys. As the habitats change, so do the fish communities. Despite a great interest in Florida's fishes by generations of wildlife watchers, conservationists, aquarists, sport fishers, ichthyologists, and policy makers, a book that attempts a complete accounting of fishes in the fresh waters of Florida has not been produced since 1955 (Carr and Goin 1955).

Much has changed in the 63 years since the earlier book. Florida's human population has grown more quickly than that of most states, and with this growth the freshwater environments have been altered. Some fishes have become so imperiled by Florida's growth and development as to be afforded federal and state protections, such as the Gulf, Atlantic, and Shortnose sturgeons (*Acipenser desotoi*, *A. oxyrinchus*, and *A. brevirostrum*). Many new species have been discovered and formally described, including conspicuous examples such as the Shoal Bass, *Micropterus cataractae*, which was described in 1999. Two species, the Apalachicola Redhorse, *Moxostoma* species, and the Choctaw Bass, *Micropterus* species, are known but await formal description. Evolutionary relationships have been clarified and new classifications established, with dozens of new fish names introduced to the literature. An entirely new assemblage of fishes has been established in Florida, largely from foreign countries. While most are found in the warmer waters of South Florida, these newcomers are expanding their ranges as scientists struggle to measure their impact and keep pace of their dispersal. One species, the Brown Hoplo, *Hoplosternum littorale*, has spread throughout peninsular Florida in 20 years.

Our understanding of the extent to which marine fishes venture into fresh water has improved. Studies of fish physiology have revealed how some marine fishes reduce cellular permeability, reducing sodium loss, through the use of calcium ions in Florida's fresh waters. Further adaptations to low-sodium freshwater environments, through the use of sodium uptake mechanisms, have also been discovered. New records of marine fishes from Florida's freshwater streams demonstrate a more extensive distribution for several species, plus one

not previously recorded from the fresh waters of Florida, the Speckled Worm Eel, *Myrophis punctatus*.

Even with the large environmental changes of recent decades, fishing remains of substantial economic value to Florida. For the year 2011, the most recent year for which published statistics are available, the U.S. Fish and Wildlife Service and U.S. Census quantified the total economic impact of fishing in Florida at \$3.9 billion, with \$709 million attributable to freshwater fishing. A major sport fish attraction is the presence of four species of native basses, genus *Micropterus*, all of which can be fished in the Florida panhandle. Recreational and commercial interests in other native species, such as sunfishes, genus *Lepomis*, and catfishes, family Ictaluridae, remain high as well. Recreational fisheries for the Butterfly Peacock Bass, *Cichla ocellaris*, a non-native species purposefully introduced by the state in the 1980s, and commercial fisheries for non-native tilapiine cichlids, such as the Blue Tilapia, *Oreochromis aureus*, and Nile Tilapia, *O. niloticus*, are of more recent origin.

Many who study the fishes of Florida make use of museum specimens. The earliest fish collected in Florida and archived in a U.S. museum, a Lake Chubsucker, *Erimyzon sucetta* (University of Michigan Museum of Zoology 87056), dates to November 30, 1848. Thus, from Florida's earliest days as a state, scientists have deposited specimens in museums for research by future generations. The process continues today in a more developed form. Modern scientific collectors of museum specimens take tissue samples for molecular analysis, obtain digital photographs of life color and link the images to voucher specimens, and georeference their collections via global positioning systems. Together, historic and recent museum collections offer not only a record of the past but also a basis for examining the shifting environmental baseline that each new generation otherwise accepts as the norm. With computing technology that now makes sharing of information seemingly effortless, specimen-based data hold substantial promise for forecasting the impacts of future environmental change. Specimens carefully maintained in museums make it possible to share the information presented in this book.

The title of this book, *Fishes in the Fresh Waters of Florida*, reflects the freshwater habitats that define the scope of the work. In the pages that follow, 222 species in 48 families are treated. Our inclusion of the many marine fishes that visit this environment, while necessary for the work to be complete, also makes it necessary to form distinctions between freshwater and marine groups and to provide a brief synopsis of each.

Freshwater fishes are defined as those species obligated to complete their entire life cycle in fresh water. Included in this category are a number of diadromous species that spend the majority of their lives in fresh water or enter fresh water at critical points in their life history. Examples include the American Eel, *Anguilla rostrata*, which migrates to the Sargasso Sea to spawn after living most of its life in fresh water, and the Gulf Sturgeon, *Acipenser desotoi*, which lives in the ocean but spawns in Gulf Coast rivers. Marine fishes included in this book are those that generally enter fresh water for reasons other than reproduction, but if to spawn, belong to a group with unequivocally marine derivations. Examples of the latter include the River Goby, *Awaous banana* (family Gobiidae), and the Mountain Mullet, *Agonostomus monticola* (family Mugilidae).

Museum collections document 169 species of freshwater fishes from 29 families in Florida. Within this group are 121 native species and 48 introduced and established (reproducing) nonindigenous species. In Florida, the greatest diversity of native freshwater fishes is found in the western and north-central drainages, an area defined by the Perdido River east to, and including, the Suwannee River. Large rivers in this region extend far inland and are characterized by greater topographic relief than those in the rest of the state. The western and north-central drainages provide habitat for species in the three families of fishes that make up the bulk of native freshwater fish diversity in the southeastern United States. These are the carps and minnows (Cyprinidae), suckers (Catostomidae), and perches and darters (Percidae). The peninsula, with lower average elevation and less habitat diversity, has experienced a different pattern of colonization than the western and north-central drainages. While some species found in this area are absent from the western and north-central drainages (e.g., Tessellated Darter, *Etheostoma olmstedi*), the overall species diversity of the peninsula is lower than that of the western and north-central drainages. The fewest native freshwater species are found in the southern peninsula, an area historically dominated by the Everglades but now characterized by a highly fragmented environment of canals and water-control structures with large numbers of nonindigenous fishes. Native freshwater fishes found only in Florida are the Seminole Killifish, *Fundulus seminolis*, Flagfish, *Jordanella floridae*, and the threatened Okaloosa Darter, *Etheostoma okaloosae*.

Nonindigenous species are those that occur outside their known historical range, independent of geographic scale (Fuller et al. 1999). Of the 48 such species established in Florida, 12 represent domestic introductions (from other areas of the United States) and 36 are foreign introductions (from other countries).

Nine of the 12 domestically nonindigenous species are restricted to North Florida. The White Bass, *Morone chrysops*, and Threadfin Shad, *Dorosoma petenense*, are more widespread. All except the Rio Grande Cichlid, *Herichthys cyanoguttatus*, have potential source populations in neighboring states. Methods of introduction for species with populations in states adjacent to Florida include bait-bucket release by anglers and intentional stocking by governmental agencies or unauthorized individuals.

All 36 foreign species are found in South Florida. With a warm average annual temperature, this region is host to a large tropical fish industry, with the largest facilities found near Tampa and Miami. The pathway of introduction for most foreign fishes in Florida is presumed to be escape from these facilities or through aquarium release. Most of these fishes were established during the same half-century in which the tropical fish industry experienced its greatest growth, aided in part by air transport of fishes and improved shipping techniques (Fuller et al. 1999). Many foreign species are expanding their ranges. Some species, such as the Asian Swamp Eel, *Monopterus javanensis*, are widespread but difficult to collect, owing to unusual habits such as burrowing. Foreign fishes are the most recently arrived fishes in the state. Consequently, maps in this book for these species may not represent distributions as fully as those of other species. A list of nonindigenous fishes collected from, but not known to be established in Florida's fresh waters is provided in Appendix I.

Fifty-three species of marine fishes from 23 families are considered the most likely to be

encountered in fresh waters of Florida and are treated in this book. While many of these species are found primarily near the coast, some range far inland. With about 1,350 miles of coastline, and approximately 2,300 miles of tidal shoreline, Florida provides considerable access to inland habitats for marine fishes. A variety of factors have an effect on fish distribution in coastal inland habitats. At river mouths, tidal effect on fish communities is pronounced, and species assemblages can change with the tidal cycle. Longer term effects on coastal fish communities may be seen in times of drought when river levels fall and salt water intrudes, or in times of heavy precipitation when fresh water is pushed out to sea. A list of marine species occasionally encountered from Florida's freshwater environments is provided in Appendix II.

Florida's Inland Waters

Florida is one of two southeastern states located entirely within the Coastal Plain Physiographic Province (Schmidt 1997). Its location in the Coastal Plain and its subtropical position between 24 and 31 degrees north latitude combine to significantly influence the biotic components of terrestrial and aquatic ecosystems. Sea-level fluctuations during the Miocene, Pliocene, and Pleistocene epochs also played an important role in shaping much of present-day Florida (Scott 1997). The geologic formations that make up the Coastal Plain in Florida are primarily sediments of marine origin. This province is a relatively homogenous platform characterized by low relief with elevations varying from sea level to just over 100 m in the western and north-central region and approximately 90 m in the peninsula. Nearly two-thirds of Florida is less than 15 m above sea level with a maximum elevation of 105.2 m at Britton Hill in Walton County near the Alabama border, which is the lowest high elevation of all 50 states in the United States.

Florida freshwater resources are maintained, in part, by the relatively high average annual rainfall of about 1.4 m. Areas of highest rainfall rate are typically the western portion of the state (Escambia to Apalachicola Rivers) and the extreme southern Atlantic Coast. The highest monthly statewide averages occur in June through September; however, the highest monthly averages for the western portion of the state are in the winter months, which are among the driest months in the southern peninsula (Henry 1998).

Freshwater habitats of Florida are products of the interactions of geology, topography, and climate. There are more than 1,700 streams and 7,700 lakes larger than 10 acres in Florida, accounting for approximately 18.5 percent of the total area of the state. Florida has more than 31,000 km² covered with inland waters, ranking it 22nd among the 50 states (Miller 1997). Freshwater ecosystems in Florida are geomorphically diverse and include springs, creeks, rivers, lakes, ponds, swamps, and marshes. The many springs and lakes are due, wholly or in part, to the karst geology of the state. Large portions of some river basins, including the Apalachicola, Choctawhatchee, Escambia, Ochlockonee, St. Marys, Suwannee, and Yellow, are shared with Alabama and/or Georgia. Other river basins (e.g., St. Johns) are contained within Florida. All Florida basins (Map 1) ultimately flow into either the Gulf of Mexico or Atlantic Ocean.