Chapter 7
Southeast Florida

Stephen P. Geiger, Florida Fish and Wildlife Conservation Commission
Kara R. Radabaugh, Florida Fish and Wildlife Conservation Commission
Ryan P. Moyer, Florida Fish and Wildlife Conservation Commission

Description of the region

Southeast Florida features some of the most highly altered landscapes in the state, in Broward and Miami-Dade counties, as well as unique habitats in the Florida Keys archipelago. Broward and Miami-Dade counties are the most populous in Florida; the estimated 2017 population between the two counties was nearly 4.7 million (U.S. Census 2018). Oyster reefs are extremely limited, primarily due to suboptimal salinity, so there are no mapped oyster reefs or shellfish harvesting areas in this region of Florida.

Broward County

Before it was developed, much of the coast of Broward County (Fig. 7.1) was dominated by sawgrass (Cladium jamaicense) and other freshwater marsh plants (USFWS 1999a, FDEP 2006). The Intracoastal Waterway was constructed in Broward County in 1912, and the creation of inlets through barrier islands led to a brackish nearshore environment, killing freshwater species (FDEP 2006). The Intracoastal Waterway connects to the Atlantic Ocean in the north in Palm Beach County at Boca Raton Inlet, at the Hillsboro Inlet, and at Port Everglades. Dense urban development is now found along the coast of Broward County, including thousands of residences lining finger canals in dredge-and-fill developments. Most of this county has a hardened shoreline consisting of seawalls and riprap, and the main source of freshwater is urban runoff.

The few natural areas remaining in Broward County include Deerfield Island Park, Von D. Mizell and Eula Johnson State Park, Hugh Taylor Birch State Park (oysters uncommon), and the areas around West Lake (some oysters attached to mangrove roots). Small populations of oysters live on many of the extensive seawalls in this area. Oyster species include the flat tree oyster (Isognomon alatus) and the eastern oyster (Crassostrea virginica). Oysters have been noted during some seagrass surveys, but there are no known studies on the extent of oysters in Broward County (Linda Sunderland, pers. comm.).
Miami-Dade County: Biscayne Bay

Biscayne Bay is a semiclosed basin in Miami-Dade County approximately 75 km (47 mi) long and 16 km (10 mi) across at its widest point. The bay includes two aquatic preserves and Biscayne Bay National Park (Fig. 7.2). The average depth of the bay is around 2 m (6.5 ft), excluding dredged channels (Comp and Seaman 1985). Biscayne Bay was historically connected to the Everglades watershed via rivers and creeks that ran through and around the Atlantic Coastal Ridge, a ridge of limestone that runs along part of Biscayne Bay’s western shore. Wetlands surrounded Biscayne Bay, and surface water entered the bay as a diffuse sheet of freshwater and through nu-
umerous small creeks and groundwater springs (Browder et al. 2005). Northern Biscayne Bay, which is partly enclosed and separated from the Atlantic Ocean by a series of barrier islands, used to be a brackish estuary as a result of freshwater input from the Everglades. Eastern oysters, whose survival and reproductive rates are greatest between 14 and 28 salinity (Shumway 1996), were relatively abundant in northern Biscayne Bay in those moderate-salinity waters, as evidenced by remnant oyster shells in sediments and historical accounts (Smith 1896, Meeder et al. 1999, 2001, CERP 2012). Shell middens along Biscayne Bay also show evidence of oyster harvest by Native Americans (Gambordella 2007, FDEP 2013). The northern part of the bay supported numerous oyster reefs and even a small oyster fishery in the late 1890s (Smith 1896, Meeder et al. 2001). Smith (1896) described oysters as being abundant on mangrove roots, pilings, boats, and submerged logs. Dense reefs also existed in the bay and near rivers, particularly near Little River and Indian Creek.

Central Biscayne Bay is broadly connected to the Atlantic Ocean. It is separated by a submerged ridge of Pleistocene-age coral reef, which is emergent at Key Biscayne, Elliott Key, and several smaller keys. Southern Biscayne Bay is partly sheltered from the Atlantic by Elliott Key and other islands in the northernmost extent of the Florida Keys. The central and southern parts of the bay historically had higher salinity than did northern Biscayne Bay, as determined by the marine mollusk species whose shells were found in sediment cores from those areas (Stone et al. 2000, Gambordella 2007). Relict oyster reefs have been found at the mouths of mangrove creeks in central Biscayne Bay (Meeder et al. 2001), but central and southern Biscayne Bay likely did not host extensive oyster reefs even before humans altered the watershed (Gambordella 2007).

The construction of canals, ditches, and levees in the 1800s and 1900s drastically altered the hydrology of Biscayne Bay and concentrated freshwater flow into constructed canals. This led to the loss of many of the mangrove creeks and resulted in large seasonal fluctuations in salinity due to variable freshwater input (Browder et al. 2005). The high-velocity release of fresh water does not readily mix with salt water in the bay, resulting in rapid changes in salinity that may kill estuarine organisms (Chin-Fatt and Wang 1987, CERP 2012). The Biscayne Aquifer, which contributes fresh groundwater to Biscayne Bay, is found in highly permeable limestone and sand from Miami-Dade County through Broward to southern Palm Beach County and supplies water for much of the population of south Florida (USFWS 1999b, CERP 2010). Canal construction in the early 1900s lowered the water table, and groundwater levels continue to decline due to urban and agricultural freshwater withdrawal (FDEP 2013).

The western shore of the southern half of the Biscayne Bay is largely lined with mangrove forests that are often cut through by tidal creeks. Historically, these creeks drained a small watershed, but as the area was developed, many of the creeks were disconnected by a series of water management canals and mosquito control ditches. The main waterflow is bisected by the L-31E canal, which disrupts the coastal sheet flow that once fed the creeks. The canal system still diverts most of the local watershed flow into a few canals, such that sheet flow from land into the bay has been largely eliminated by 1962 (Buchnan and Klein 1976). Near the southernmost point of the bay, the Turkey Point nuclear power plant dispenses water into an impoundment containing a large series of dredged canals, the intent of which is to cool thermal effluent.

Under the present hydrological regime, salinity exceeds 30 across Biscayne Bay in the spring and ranges from 25 to 30 in the fall, although areas along the coast with many canals can have an average salinity of 12–20 (CERP 2012). Today, the extent of oyster distribution is smaller than that before the hydrology was altered. In northern Biscayne Bay, where oysters had been abundant enough to support a fishery, they are now found, only occasionally, on mangrove roots, docks, or pilings. Oyster reefs are now limited to upstream areas of the Oleta River (FDEP 2013). Oleta River State Park has a large area of urban park with mangrove-lined creeks, but few oysters. Land between Oleta River State Park and Virginia Key is mostly urbanized with hardened shorelines. Oysters are occasionally found on these seawalls and riprap, especially in those areas that receive urban runoff from storm drains (Voss 1976). Most are eastern oysters. At some creeks, flat tree oysters are also found, but they do not form reefs or accumulate substrate. In central Biscayne Bay, relict oyster reefs are present near some tidal creeks (Meeder et al. 2001) and a small number of live oysters may occasionally be found associated with mangrove roots.

The Comprehensive Everglades Restoration Plan (CERP) includes efforts to redirect freshwater flow from canals into coastal wetlands to restore hydrology to a more natural state (CERP 2012). Projects relevant to Biscayne Bay include the Biscayne Bay coastal wetlands plan, the C-111 spreader project, and L31-N seepage management (Browder et al. 2005, FDEP 2013). These projects focus on four important stressors: altered freshwater inflow, input of toxicants and pathogens, altered input of solids and nutrients, and physical changes in structures.
Monroe County: Florida Keys

The Florida Keys are a 210-km-long (130 mi) archipelago on the southern edge of Florida (Fig. 7.3). The region is encompassed by the Florida Keys National Marine Sanctuary. Additional protected regions in the Sanctuary include Key West National Wildlife Refuge (NWR), Great White Heron NWR, National Key Deer Refuge, and Crocodile Lake NWR, as well as several state parks and aquatic preserves. Beginning near the border of Miami-Dade and Monroe counties, a series of sounds are found between the mainland and the primary tract of the Florida Keys. These sounds are all semienclosed and have low tidal amplitude and minimal exchange with other water bodies. The shoreline in these areas is mostly lined with mangroves. The lack of freshwater input and poor water circulation makes these sounds largely inhospitable to oysters. Oysters in the Everglades and Florida Bay are described in Chapter 6.

Continuing south, the middle and lower Florida Keys are a mix of hardened shorelines, mangroves, and occasional sandy beaches. Sources of fresh water include small amounts of terrestrial runoff, including runoff from watering lawns. Salinity is too high to support extensive populations of the eastern oyster, but they are occasionally found on hardened shorelines or mangrove prop roots (Mikkelsen and Bieler 2000). Several species of non-reef-building oysters are present in the Florida Keys, including two other species within the family Ostreidae: the root oyster (*Crassotrea rhizophorae*) and the crested oyster (*Ostrea stentina*) (Mikkelsen and Bieler 2000). The morphology of these oysters is plastic, as they often develop around their settlement substrate. The root oyster has a straighter and more elongate hinge than does the eastern oyster, as well as an elongate muscle scar. The crested oyster has a series of fine marginal teeth, lacking in both *Crassotrea* species, and a lighter muscle scar (Mikkelsen and Bieler 2007). The other most common oyster in the Keys is the scaly pearl oyster (*Pinctada longisquamosa*), which can at times be abundant in seagrass meadows. Other oyster species present include the sponge oyster (*Ostrea permollis*), Atlantic pearl oyster (*Pinctada imbricata*), black-lipped pearl oyster (*Pinctada margaritifera*), Atlantic wing oyster (*Pteria colymbus*), glassy wing oyster (*P. birundo*), tree oysters (*Isognomon alatus, I. bicolor, and I. radiatus*), hammer oyster (*Malleus candeanus*), frond oyster (*Dendostrea frons*), threaded oyster (*Teskeyostrea weberi*), and foam oysters (*Hyotissa mcgintyi, H. byotis, and Neopycnodonte cochlear*) (Mikkelsen and Bieler 2000, 2007).
Threats to Oysters

Reef-building eastern oysters are rare in this region, largely as a result of suboptimal salinity regimes. The threats to oysters listed here are therefore restricted to those areas (namely Biscayne Bay) that are known to have hosted significant oyster reefs in the past.

- **Altered hydrology:** The hydrology of Biscayne Bay has been significantly altered by intense urbanization and the construction of drainage canals, which has decreased sheet flow through coastal wetlands and natural creeks. Water management canals preclude natural coastal flow and deliver large pulses of sediment-rich water through few large canals. Such canals allow rapid delivery of water that is often hypoxic and contaminated with urban runoff (SFWMD 1995). Additionally, the canals are generally steep-walled and linear, so their shorelines offer little habitat value. Restoration of minimal flows to the many mangrove-lined tidal creeks around the bay would enhance their chances of supporting small oyster communities (Meeder et al. 2001).

- **Isolated populations:** The survival and resilience of any remaining oyster populations are of concern due to their isolation from other oyster populations and vulnerability to continued urban development (Arnold et al. 2008). Biscayne Bay oysters are isolated from other oyster reefs on the southeast coast of Florida; the closest significant population of oysters is in the Lake Worth Lagoon, in Palm Beach County.

- **Habitat loss:** The coast of Broward County and northern Biscayne Bay is heavily developed, and much of the natural shoreline has been replaced by seawalls and other structures. Oyster reefs have directly faced habitat loss as a result of dredging and hardened shorelines.

- **Sea-level rise:** Sea-level rise is another contributor to the high salinity of Biscayne Bay. Sea-level rise will continue to suppress freshwater influence in the bay, such that brackish conditions may be completely eliminated in the bay except for waters adjacent to managed drainage canals. Sea-level rise may also result in increased submergence times, which would limit the intertidal exposure time for oysters that offers them refuge from predation, pests, and disease (Bahr and Lanier 1981). Increased submergence times as a result of sea-level rise, along with increasing salinity, lead to greater susceptibility to predation, pests (e.g., the boring sponge *Cliona celata*; Carroll et al. 2015), and pathogens (Shumway 1996).

- **Harmful algal blooms:** Harmful algal blooms have been tied to pollution from fertilizers, animal wastes, and increased soil erosion, all conditions that exist in south Florida watersheds. Toxins from cyanobacteria blooms have been detected in both Biscayne Bay and Florida Bay (Brand 2010).

Mapping and Monitoring Efforts


**Historical oyster distribution study**

Meeder et al. (2001) completed a study to identify tidal creek sites along western Biscayne Bay that were appropriate for restoration of freshwater discharge. Site selection was based on evidence of past oyster populations (determined by presence of oyster shell in sediments), and salinity targets were based upon physiological requirements of oysters.

**FWC baseline mapping and monitoring**

In the winter of 2005–2006, FWC and Golder Associates surveyed oyster distribution in the Sebastian River, Saint Lucie Estuary, Lake Worth Lagoon, and Biscayne Bay using a real-time kinematic global positioning system (RTK GPS) (Gambordella et al. 2007). Oyster reefs were identified using earlier oyster maps, helicopter aerial surveys, and sounding lines. Few live oysters and no oyster reefs were found in Biscayne Bay, so no oyster maps were produced for the bay.

**Comprehensive Everglades Restoration Program oyster monitoring**

Oysters were monitored as part of the CERP Restoration Coordination and Verification (RECOVER) program by FWC from 2005–2007 (RECOVER 2007, Arnold et al. 2008, Parker et al. 2013). Monitored basins included the Saint Lucie Estuary, Loxahatchee River, Mosquito Lagoon, Sebastian River, Lake Worth Lagoon, Biscayne Bay, and Tampa Bay (Arnold et al. 2008). Metrics included spatial and size distribution of oyster populations, physiological condition, disease frequency, and rates of reproduction, recruitment, growth, and survival in south Florida estuaries (RECOVER 2007). Too few oysters were present in Biscayne Bay for systematic density surveys. Most oysters existed as rare inhabitants...
oyster larvae. If oyster larvae are present, the placement of suitable substrate might allow settlement and rebuilding of oyster populations. If no larvae are present, transplanting of live oysters from the nearest suitable population, likely Lake Worth Lagoon, may be required. Small-scale efforts should be implemented before broader, large-scale efforts are planned.

Works cited


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**General references and additional regional information**

Biscayne National Park: http://www.nps.gov/bisc/index.htm

Biscayne Aquatic Preserves: https://floridadep.gov/rcp/aquatic-preserve/locations/biscayne-bay-aquatic-preserves

South Florida Multi-species recovery plan: http://www.fws.gov/verobeach/listedspeciesMSRP.html

South Florida Water Management District: http://www.sfwmd.gov/

CERP Biscayne Bay Coastal Wetlands: http://www.evergladesrestoration.gov/content/bbrrct/minutes/2015_meetings/071515/BBCW_Project_Status.pdf

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**Regional contacts**

Kara Radabaugh, Florida Fish and Wildlife Conservation Commission, kara.radabaugh@myfwc.com

Steve Geiger, Florida Fish and Wildlife Conservation Commission, steve.geiger@myfwc.com

Ryan Moyer, Florida Fish and Wildlife Conservation Commission, ryan.moyer@myfwc.com