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Oyster Integrated Mapping and Monitoring Program Report for the State of Florida

KARA R. RADABAUGH, STEPHEN P. GEIGER, RYAN P. MOYER, EDITORS

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Cover photograph: An eastern oyster (*Crassostrea virginica*) reef in St. Petersburg, Florida. Photograph by Kara Radabaugh.

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An assortment of oysters on red mangrove (*Rhizophora mangle*) prop roots in the Ten Thousand Islands, Florida. Photo credit: Kara Radabaugh.

Summary of the Oyster Integrated Mapping and Monitoring Program

The Oyster Integrated Mapping and Monitoring Program (OIMMP) began as a joint effort between the Coastal Wetlands and Molluscan Fisheries research programs at the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute in St. Petersburg, Florida. OIMMP is based on the framework established by the Seagrass Integrated Mapping and Monitoring (SIMM) program (http://myfwc.com/research/habitat/seagrasses/projects/active/simm/) and the Coastal Habitat Integrated Mapping and Monitoring Program (CHIMMP) (http://myfwc.com/research/habitat/coastal-wetlands/projects/chimmp/), which rely upon a network of ecosystem experts to assemble regional summaries of mapping and monitoring data. The main objective of OIMMP was to build and maintain a collaborative network of stakeholders with interest in mapping and monitoring Florida's oyster habitats in order to identify the status of and management priorities for oysters and their habitats.

OIMMP workshops were held at the Guana Tolomato Matanzas National Estuarine Research Reserve in 2017 and 2018 and the Fish and Wildlife Research Institute in 2019 to bring together oyster researchers and managers from across the state. During these workshops, attendees gave presentations on oyster mapping and monitoring activities and made recommendations for future mapping, monitoring, and management of oyster resources. See http://ocean.floridamarine.org/OIMMP for detailed proceedings and outcomes of the OIMMP workshops.

Attendees of the 2017 workshop developed the regional boundaries for the chapters in this report, and many attendees also volunteered to contribute their expertise as coauthors. Additional regional coauthors were added based on need and personal recommendations (see below for a list of all regional contributors). Due to the collaborative nature of this report, the style, content, and level of detail varies among chapters based upon regional data availability, range of participating organizations, and expertise of the contributing authors.

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See Appendix for affiliation abbreviations.

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Restored oyster reef in the Mosquito Lagoon. Photo credit: Linda Walters.

Executive Summary

Oysters provide a variety of critical ecosystem services to coastal communities in Florida. They improve water quality and clarity as they filter feed, lessen shoreline erosion, and provide a habitat or food source for a wide variety of birds, fish, and invertebrates. Oysters are commercially valuable as a harvested food source, and historically their shell has been mined extensively for construction material. The eastern oyster (*Crassostrea virginica*) is the only reef-building oyster in Florida and forms both subtidal and intertidal reefs. Numerous other species of non-reef-building oysters are less frequent. This report focuses primarily on the eastern oyster, because it is the most abundant oyster in Florida and because it is important as both a keystone species and an ecosystem engineer.

The survival of an oyster reef depends on its shell budget, which is its rate of shell deposition from new oyster growth relative to the rate of shell loss. The rate of growth is limited by basic biological functions of living oysters (rates of growth and reproduction), while the rate of loss is a function of both biotic (e.g., predation, competition) and abiotic (e.g., salinity, temperature, pH) factors that can affect both living oysters and the shells of deceased oysters. Rates of bioerosion, chemical degradation, dissolution, and burial affect the length of time the dead shell remains on a reef as viable settlement substrate. The optimum salinity range for eastern oysters is 14 to 28, although they can temporarily tolerate salinity extremes from 5 to 40. Oysters have decreased growth and reproduction at low salinity and can quickly suffer high rates of mortality under freshwater conditions. While oysters can physiologically tolerate high salinity for extended periods of time, in such conditions they are more vulnerable to marine predators, disease, and parasitism. Tolerance of high or low salinity is significantly diminished at high temperatures, which oysters frequently encounter in Florida. Climate change and sea-level rise further alter the frequency and severity of temperature and salinity stress.

Many Florida estuaries have lost 80–90% of the oyster reefs that were present before human development. Altered surface-water flow is one of the major threats to oyster reefs today, as channelization or other mechanisms that concentrate stormwater runoff reduce salinity to levels less than those optimal for oyster survival, growth, and reproduction. Hydrologic alterations, coupled with freshwater withdrawal, also starve downstream areas of freshwater flow, resulting in increased salinity that makes oys-

ters more vulnerable to predation and disease. Significant losses to oyster reefs have occurred due to anthropogenic activities including dredge-and-fill construction, harvesting without substrate replacement, and, in the past, shell mining. Oyster populations must also cope with water pollution, competition with invasive species, sedimentation, and accelerated erosion due to boat wakes. Many of these stressors are increasing as Florida's human population grows. The decline in the Florida oyster population has led to small and often isolated populations spread across Florida's estuaries. Although the long-term and large-scale ramifications of this decline are not well studied, the isolation of these small populations can limit genetic diversity and connectivity between estuaries.

Oyster harvesting is permitted in Florida within designated shellfish harvesting areas. The Florida Department of Agriculture and Consumer Services (FDACS) regulates the opening and closure of these harvesting areas based on health risks to consumers. Both FDACS and the Florida Fish and Wildlife Conservation Commission (FWC) monitor the waters in these shellfish harvesting areas for bacteria, red tide, and chemical pollutants. FWC reports commercial harvesting yields, which have had mandatory reporting since 1986. Historically 90% of the state's harvests originated from Apalachicola Bay in Franklin County; however, harvests from Apalachicola Bay (and consequently statewide harvests) have declined significantly since the 2012–2013 collapse of the bay's fishery.

Large-scale oyster reef mapping relies primarily on georeferenced multispectral or hyperspectral imagery with in situ ground truthing to verify mapping accuracy. Reefs are identified by patterns of color, texture, and shape, but reef identification can be confounded if oysters are intermixed with algae, mud, seagrass, or rubble. Oysters that grow on mangrove roots or seawalls are generally not included in mapping efforts because they are hard to see in aerial imagery. These oysters nevertheless contribute significantly to the oyster population in an estuary. Subtidal reefs can be mapped with side-scan or multibeam sonar or videography with simultaneous acquisition of global positioning system (GPS) data, but ground truthing is necessary to verify the presence of live oysters. Subtidal oyster mapping is complicated by murky water, variable water depth or shallow water, limited benthic relief, and oyster reefs co-occurring with multiple benthic habitats such as seagrass beds and hardbottom. Oyster maps in Florida generally focus on a specific region or estuary. FWC and the Oyster Integrated Mapping and Monitoring Program have compiled available oyster maps across the state, creating the most comprehensive map to date of oyster distribution in Florida (http://geodata.myfwc.com/datasets/oyster-beds-in-florida). This map identifies more than 7,920 ha (19,580 ac) of live oysters, yet gaps remain, and further mapping efforts are needed in several areas.

Oyster monitoring in Florida is conducted by a number of agencies and organizations with a variety of objectives, such as determining the efficacy of hydrologic restoration, the health of oyster fisheries, or the success of restoration efforts, as well as general ecological assessments. While methods used in monitoring programs may vary widely, commonly measured parameters include water quality (salinity, dissolved oxygen, and temperature), reef area, reef height, oyster density, degree of tidal emersion, and oyster size–frequency distribution.

The chapters in this report summarize mapping and monitoring programs for oyster reefs in each region of Florida. Content of each chapter includes a general introduction to the region, location-specific threats to oyster reefs, a summary of selected mapping and monitoring programs, and recommendations for oyster management, mapping, and monitoring. Regional figures include the FWC compilation of oyster maps, FDACS shellfish harvesting areas, and oyster harvesting data from 1951 to 2017.

Through the process of compiling this report and from feedback provided at the OIMMP workshops, several needs and recommendations were identified for Florida oysters:

Management priorities and recommendations

- Manage freshwater flow to mimic natural flow, avoiding rapid salinity changes and prolonged exposure to salinity extremes.
- Add shell and other materials to combat substrate limitation due to extensive harvesting, dredging, or past shell mining. Place substrate on firm sediments to prevent its sinking, and determine ideal locations based on current hydrologic conditions rather than historic reef extent.
- Create and implement a comprehensive oyster fishery management plan that takes into account climate change, variable oyster fishing effort, shell budgets, annually variable freshwater input, and widespread anthropogenic changes in order to prevent overfishing or loss of substrate.
- Replace or supplement hardened shorelines with living shorelines to create habitat and facilitate habitat migration upslope as sea level rises.
- Maintain genetic connectivity of oyster populations between estuaries across the state by rebuilding or maintaining stable oyster populations in all estuaries where they naturally occur.

Mapping priorities and recommendations

- Fill remaining mapping gaps in the Panhandle (Pensacola, Choctawhatchee, and St. Andrew bays), Big Bend and Springs Coast (Apalachee Bay and subtidal oysters), Everglades, and Indian River Lagoon (outside of its major tributaries).
- Complete regular mapping efforts every 5–7 years. Oyster extent is dynamic due to urban development, variable freshwater flow, and changing freshwater management, so maps should be updated regularly.
- Map all oysters, including subtidal oysters and oysters on mangrove roots and seawalls.
- Determine historical extent of oyster reefs to facilitate decision making regarding targets for future reef extent.
- Differentiate between live and dead sections on oyster reefs to track mortality or dead margins on live reefs over time.

Monitoring and research priorities and recommendations

- Conduct standardized and long-term monitoring across multiple estuaries to facilitate comparisons among oyster populations.
- Determine genetic diversity, life history, and habitat characteristics of high-salinity oyster reefs to determine why certain oyster populations survive in high salinity while others are decimated by predators and disease.
- Quantify oyster size structure of oyster populations. Shell height in an oyster population can provide a snapshot of reef resilience because large oysters are disproportionately important to reproductive output and shell budgets.
- Make high-frequency autonomous measurements of temperature and salinity near established oyster reefs in order to capture extreme events such as freshwater pulses, temperature extremes, and hypoxic conditions.