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An update on Florida's Artificial Reefs: recent deployments and trends[1]

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Abstract

Artificial reefs are materials humans place on the sea floor to mimic effects of natural reefs. Artificial reefs can have benefits to sea life and humans alike and are one of the most popular and publicized marine habitat enhancement actions. A lot of Floridians visit artificial reefs every year—to fish, dive, snorkel, or boat around. As artificial reefs maintain high popularity and funds continue to be directed at marine habitat creation, the number of artificial reefs is increasing around the state. One of the challenges in describing the function and impact of artificial reefs is that artificial reefs themselves are evolving. They are changing in design and over time as reef structures are encrusted with organisms and/or are subjected to storms and shifting sands. As reef designs are changed, expectations shift, and advances in research and monitoring allow us to learn more about them. This publication provides an update of Florida's recent artificial reef activities. It is focused on new deployments, designs and monitoring objectives, that have taken place from 2015–2021. The publication should help management agency personnel and outreach and education professionals better understand recent trends in artificial reef priorities from around the state. It should also help stakeholders, like fishing and diving clubs, monitoring programs, and local artificial reef planners and coordinators by sharing information learned across counties.

Introduction

Artificial reefs are human-made or -sourced materials that are placed on the sea floor (Lindberg and Seaman 2011). When deployed intentionally, their purpose is typically to increase the amount of structural habitat in a way that will benefit fish populations and humans (Becker et al. 2018). In general, artificial reefs can benefit fish populations if they provide more or better-quality places for fish to feed, reproduce, or seek refuge. Additional information about the ways that artificial reefs can affect fish populations will be covered in a future publication. Artificial reefs generally can help people by creating new fishing, snorkeling, or diving locations, which all can increase recreational opportunities and economic activity within a region. More information about ways artificial reefs can affect people in general can be found here.

Florida has over 3,800 approved and published public recreational artificial reefs in permitted areas within state and federal waters adjacent to its shores (described here). This is in addition to those that are constructed as mitigation (to offset environmental impacts), for other purposes (e.g., bridges, shore protection structures, navigation aids and rock disposal sites), unpublished artificial reefs (e.g., research reefs), and accidental (e.g., shipwrecks) or illegally placed (e.g., non-permitted disposed materials or illegal structures like spiny lobster casitas).

To properly quantify the number of public recreational reefs, we must first agree on what counts as a reef. For this publication, an "individual reef" refers to those listed in the Florida Fish and Wildlife Conservation Commission (FWC) database, found here. The FWC generally defines a single reef as either a single, large structure (like a vessel), or one or more groups of smaller materials, like concrete or rocks, deployed within approximately 150 feet of each other. For example, a single "reef" might include six different piles of limestone that are placed more than 150 feet from the next closest artificial reef structure.

There are several additional terms that help describe and count artificial reefs (please see Glossary). A **permit area** is a designated area of the sea floor that is approved for artificial reefs. **Patch reefs** are either individual reefs or groups of individual reef structures that are at least 150 feet from their nearest neighbor. Patch reefs are also usually the counting unit of reefs used by FWC. This means that when the numbers of reefs are given for the state or region, they are referring generally to the number of patch reefs, rather than the number of reef structures. (**Reef structures** are the individual materials, for example, concrete, metal, vessels/barges, rocks, or reef modules. **Reef modules** are a specific type of reef structure purposefully designed for use as artificial reefs.) This publication will use FWC's system and counting unit: for

our purposes here, a single patch reef or a very large individual structure (like a submerged ship or airplane) counts as one reef.

Developing artificial reefs usually starts at the local grassroots level, often by interested citizens and fishing or dive clubs coordinating with local marine advisory boards and their local government. For example, a number of counties actually have a designated County Artificial Reef Manager or Coordinator. These local people work in coordination with the state management agency, FWC, which often provides technical assistance and state and federal grant funding opportunities. Often, these different actors work together to plan and permit reefs, secure funding, obtain and gather donated reef materials, employ marine contractors to put the reefs in the water, and then (ideally) monitor how they affect humans and ecosystems. Florida's artificial reef program continues to grow, with over 900 reefs deployed in the last seven years (2015–2021) alone. While artificial reefs can be a favorite choice among many interested in marine hard-bottom habitat restoration, deployment and design strategies are important considerations when assessing overall benefit to either fishers or fish populations. Understanding recent changes and trends in how and where these reefs are deployed is important to guide management agencies as they plan for the future. As individual counties or stakeholder groups design future reef deployments, we hope this compilation will help in guiding that process through a description of recent additions and trends in Florida's artificial reef program at both state and regional levels.

Statewide Summary

From 2015 through 2021, the number of artificial reefs in Florida's coastal waters has increased substantially compared to prior years. Most of these new reefs have been deployed using funds related to the Deepwater Horizon oil spill. Specifically, Natural Resource Damage Assessment (NRDA) funds have allocated over $10 M in the last five years for northwest Florida, with an additional $10 M anticipated to be appropriated starting in fall 2021. Significant additional Deepwater Horizon Oil Spill funds have also been appropriated during this period for artificial reef construction through the Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act (RESTORE). Some of this funding is received directly by specific Florida counties, while other amounts are distributed to or through the FWC as part of FWC's state-wide artificial reef program. From 2015–2021, FWC has documented deployments of over 900 reefs. Nearly all of these were patch reefs, with an average patch reef size of about 1,245ft^2, and a total of over 25,000 individual structures (e.g., a rock pile, reef module, or similar). These numbers illustrate two trends: (1) there has been a substantial increase in the numbers of artificial reefs, especially in waters adjacent to northwest Florida over the 2015–2021 period, and (2) most of these new reefs consist of designed modules.

The increasing popularity of designed modules may be owing to their relative ease of deployment, as well as the businesses that have developed to supply them. Most of the patch reefs deployed during 2015–2021 were made up of designed modules. These are prefabricated structures made primarily of concrete designed specifically for use as artificial reefs. Often these reef modules are purchased from contractors who can build them in many shapes, sizes, and designs. As more contractors develop diverse reef modules, they have become one of the most consistently available reef material type. Placing multiple reef modules in a grouping then becomes one of the easier means of building patch reefs.

Another state-wide trend from 2015–2021 has been increasing interest in deploying artificial reefs in areas closer to shore. It is believed this may have multiple benefits. Shallow, nearshore reefs increase accessibility for people who may not have access to offshore vessels or dive gear. This is especially true for those reefs that are very close to shore, advertised as **snorkel reefs**. These are intended as much to provide recreation to those viewing nature as to increase fishing access. Another potential advantage of shallow reefs is that they may help focus fishing effort towards species that are less threatened by overharvest or towards individuals less susceptible to high release mortality. For example, shallower reefs may allow fishers to target species like sheepshead, grunts, and smaller snappers rather than gag grouper and red snapper, which are generally found in deeper water, have historically been overfished, and experience higher release mortality due to barotrauma. A final potential conservation benefit of shallower reefs (when properly sited and designed) is the idea that they may provide better habitat, shelter, and growth potential for juvenile fish. The survival of juvenile fish depends on their density (how many small fish there are; more information about that can be found in EDIS FA222 here). During this stage of life, called "recruitment," greater habitat availability can increase the number of fish that survive to be adults. These shallower artificial reefs may be used as successful recruitment habitat by smaller fish, provided they are not caught by fishers or natural predators.

The specific numbers, types, and approaches to enhancing artificial reefs in Florida varies through time as well as regionally. This variation is partly because of differing availability of funds, materials, and suitable reef sites (locations for placing reef patches and/or structures). It is also an effect of location, since the Florida coastline varies so much in terms of depth, currents, water clarity, other human uses, and existing natural reef areas. Below we give brief, region-specific summaries of artificial reef work.

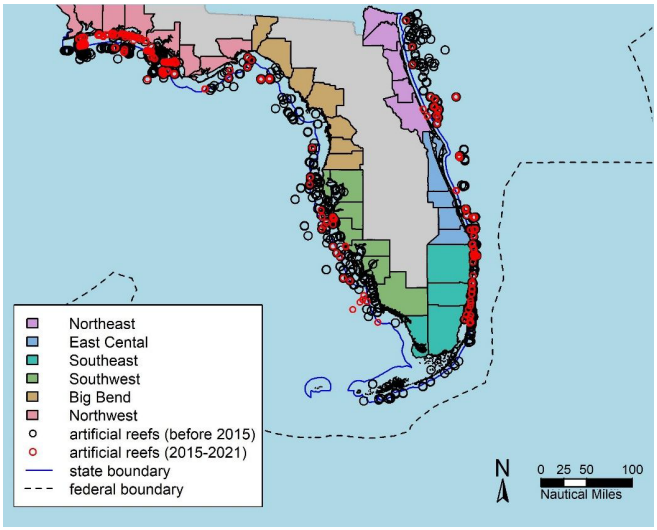

Figure 1. Florida's artificial reefs, overall and since 2015, by region. The different colored counties show the different regions of the state, and the open circles show artificial reef locations. Black circles show reefs deployed prior to 2015, and red circles show those deployed 2015–2021. The thin blue line shows the outer extent of state waters (9 nautical miles on the Gulf coast and 3 nautical miles on the Atlantic coast), and the dashed line shows the outer extent of federal waters. Note that the symbols for artificial reef are not to scale; they are much larger than the actual reef footprints. Thus, while the figure seems to indicate near continuous coverage of artificial reefs along the Florida coastline, artificial reefs make up an exceedingly small proportion of the ocean floor adjacent to Florida.
Credit: Lisa Chong

Northeast Florida

The northeast Florida region includes Nassau, Duval, St. Johns, Flagler, and Volusia counties. The water depth drops off steeply here, and most artificial reefs are 6–30 miles offshore, but within 50–130' of water. From 2015–2021, this region of Florida deployed 54 new reefs, with the most (49) in Volusia County due to dedicated local county appropriations (Table 2). Two especially notable reefs deployed in 2018 were the vessels the Lady Philomena and the Tug Everglades, sunk 250 apart and with two piles of concrete culverts to create one large area attractive to divers. Also, during this period, Volusia County constructed the first artificial reefs deployed in state waters off northeast Florida. These two new nearshore reefs are located less than 1 mile off the beach in state waters for fisheries management purposes (state waters on Florida's Atlantic coasts < 3 miles from shore). Locating these reefs in state waters is sometimes attractive to fishers because they avoid federal water harvest closures, such as those affecting red snapper. However, if these state-water reefs do allow for greater harvest, this may eventually affect harvest season length in future years.

East Central Florida

East central Florida includes Brevard, Indian River, St. Lucie, and Martin counties—an area well-known for the protected, shallow-water inshore areas of the Indian River Lagoon and Mosquito Lagoon. But the region also boasts popular near-shore and offshore fishing and diving opportunities. From 2015–2021, 50 reefs were deployed in this region, with the most (27) in St. Lucie County (Table 3). Most reefs were secondary (used) concrete, modular reefs, or less often, vessels. Most counties in this region have focused specifically on deep-water, offshore reefs targeted towards providing improved recreation to primarily recreational fishers. One of the challenges facing this region is finding and retaining adequate staging areas—places where artificial reef materials can be gathered, cleaned, and kept on land before they are deployed into the water. Finding and securing usable, long-term siting areas that have good access by road and to the water is difficult, especially in locations where coastal real estate is so valuable.

Southeast Florida

This region of Florida includes Palm Beach, Broward, Miami-Dade, and Monroe counties, and it has seen a diversity of artificial reef work from 2015–2021. Most of the new reefs have been deployed in Palm Beach (47) and Miami-Dade (46) counties (Table 4). The last permitted artificial reef in Monroe County was the 2009 sinking of the Vandenberg, a decommissioned military vessel over 500 feet long and 17,000 tons. As with many locations, one of the recent trends in southeast Florida has been using many individual reef modules in the reef siting areas. Recently, a newer type of artificial reef module called a **reef dart** has been utilized. Reef darts are tall, thin, pole-like structures intended to be deployed in deep waters (100–500') to attract aggregating sportfish like grouper, snapper, jacks, and other deep water and pelagic species. Palm Beach and Broward Counties are notable for their work deploying artificial reefs emphasizing artwork—such as metal sculptures added to vessels prior to sinking (the Lady Luck (2016) and Okinawa (2017) are two examples of this) or concrete sculptures deployed in the shape of marine life and mermaids deployed off Palm Beach County. In Miami-Dade County, one of the most notable reef projects was to construct piles of concrete and limestone boulders to replace the popular but decaying "bug light" navigation structure off Key Biscayne. This was a steel tower that attracted baitfish and fishers seeking live bait for offshore fishing. This diversity of reefs (traditional block, reef darts, art-centric reefs for diving, and bait reefs) is notable and should allow understanding return on investment for different types of reefs, so long as there is appropriate monitoring. Good underwater visibility with many dive operators provides for strong ecotourism

across the region. Notable challenges off the southeast region include implementing detailed pre-deployment mapping to avoid natural reef habitats and selecting contractors capable of managing strong currents and operating in deep water.

Southwest Florida

The southwest region of Florida spans Hillsborough and Pinellas counties south to include Manatee, Sarasota, Charlotte, Lee, and Collier counties. Most of these counties have only a few reef siting areas but have also made new deployments during the 2015–2021 period. The counties with the greatest number of recent reefs are Collier (40) and Sarasota (29) (Table 5). One trend in southwest Florida includes the addition of several memorial reefs that mix art and commemoration to create diving "destinations" (Pinellas County Veterans Reef, Charlotte County Jeff Steel Memorial Reef). Like other regions, southwest Florida has also increased their number of shallow-water, inshore reefs. Southwest Florida has recognized some of the challenges to adding additional reefs, including finding appropriate staging areas and organizing annual reef clean-ups to remove debris that inevitably collects on these sites (e.g., old anchors, fishing line, nets). Like most other developed coastal regions in Florida, finding staging areas with access to deep water (for loading barges) is difficult. Reef clean-ups are increasingly important to keep reefs free of marine debris that could threaten divers or sea life. Several have been scheduled in Manatee County.

Big Bend Florida

The region including Jefferson, Taylor, Dixie, Levy, Citrus, Hernando, and Pasco counties had the fewest reefs added from 2015–2021 (23) (Table 6). However, the area is also known for abundant natural habitat, including sea grass, oyster reefs, and natural hard bottom. Most of the recent deployments in this region have occurred off Taylor County, including additions to the Steinhatchee Fisheries Management Area and Buckeye Reef. The remainder of reefs in this region were deployed in Hernando County, which created four new reefs in the last seven years. In this region, as in much of the state, counties are increasingly interested in shallow, inshore, and snorkeling reefs. Citrus, Pasco, and Dixie Counties are also all actively working to reauthorize and expand existing permitted areas, as well as identify new permitted areas further offshore (40+ miles offshore) for offshore reef fish anglers.

It is worth noting that this region of the state has some of the most expansive natural hard bottom area, as well as relatively low human population density. The latter may mean demand in these counties is lighter, while the natural hard bottom (and sea grass) can limit the places available for reef siting areas.

Northwest Florida

The northwest Florida region encompasses the Panhandle, including Wakulla, Franklin, Gulf, Bay, Walton, Okaloosa, Santa Rosa, and Escambia counties. This region has received many artificial reefs associated with NRDA, FWC, and private funding. A huge portion of this funding was directly attributed to the proximity of and impact to NW Florida due to the significant economic harm caused by the loss of recreational fishing opportunities resulting from the extended saltwater fishery closures established during the Deepwater Horizon oil spill in 2010 (Carroll et al., 2016). From 2015–2021, over $10M has been used to fund 429 patch reefs, the majority of which have been comprised of prefabricated reef modules located in state waters (within 9 miles of land on the Gulf coast of Florida). The most reefs have been added to Bay County (199) and Escambia County (186)—and again, many of these reefs contain multiple individual modules. And while not included in the FWC Artificial Reef list, Okaloosa County is notable for being the first county in the state of Florida to deploy a deep-water **Fish Aggregating Device** (FAD). Around the world, FADs are used to attract pelagic fish species such as tuna, mackerel, jacks, cobia, etc., rather than reef species. To date, four FADs have been placed in Okaloosa waters. Other notable deployments off northwest Florida include deployment of snorkeling reefs off public beach access points of Escambia, Santa Rosa, Okaloosa, and Walton Counties. Deployed in high energy areas at depths less than 20 feet, these 4-disc concrete modules are mounted on pilings jetted 15 feet into the sand and are popular with snorkeling beach goers and kayakers.

Summary

Across the state, many new artificial reef deployments occurred between 2015–2021. There are notable differences across regions, with the majority of new reefs occurring in the northwest region, and more than 50% of new reefs statewide deployed by the top three counties (by reefs deployed)—Bay, Escambia, and Okaloosa counties. This northwest region was more impacted by the Deepwater Horizon oil spill and received substantial funding associated with that disaster. Other important trends seen statewide include the diversification of reef design. Increasingly, reefs are being deployed with a specific use in mind—whether diving attractions aimed at art appreciation, deep water reef darts deployed to attract certain fish for fishers, or accessible snorkel reefs to create habitat and attract people. Because reefs are so widely diverse and specialized, it is essential that scientists, managers, and stakeholders planning to deploy a new reef specify their objectives for that reef. This is a notable departure from more "opportunistic" reef development that has dominated historical artificial reef deployments in Florida.

Possibly the most wide-spread artificial reef trend is the interest in shallower artificial reefs. Nearly every region is considering or has already deployed such shallow reefs. It should be noted that "shallow" can be a somewhat imprecise term when it comes to reefs. For example, some "shallower" reefs on Florida's Atlantic coast are in fact state water reefs and are in depths of greater than 50 feet. Whereas other shallow reefs, especially along the Gulf coast, are shallow enough to be accessed by swimming or from kayaks. Especially these shallow reefs provide access to more than just fishers, and many of the reefs are described as "snorkel" reefs. The shallow reefs may also be frequented by different fish species, providing harvest opportunities for species that are typically subject to less fishing pressure.

One of the consistent challenges with artificial reefs is appropriate monitoring. Despite researchers, FWC managers, and other stakeholders emphasizing this need, the lack of clear common standards for what to monitor and how, and the lack of funding and personnel to do the monitoring, has resulted in a lot of unknowns about how artificial reefs affect fish and fishers alike (FWC 2003; Bortone 2011; Becker et al. 2018). This is problematic, especially because of the potential for artificial reefs to increase fishing harvest rates and lead to the need for more comprehensive spatially explicit stock assessment modeling and in some cases more restrictive management (Karnauskas et al. 2017). Future efforts to fund and deploy new artificial reefs may want to prioritize those that include clear objectives and design considerations as well as long-term monitoring efforts.

Glossary

Permit areas—the area of the ocean floor that is approved for artificial reefs (including patch reefs and/or individual reef structures).

Patch reef—the unit that is used to count total reefs, and which is defined as an individual structure or an aggregation of structures that is at least 150 feet from another patch reef.

Reef structure—the individual structures placed on the sea floor. Reef structures are defined in terms of what that material is (e.g., concrete, rock) and how it is organized (e.g., rubble, reef module, etc.).

Reef module—Reef modules are prefabricated reef structures. They are not repurposed materials but are manufactured specifically to be artificial reefs.

Reef dart—a specific type of reef module used in deep-water artificial reefs. A reef dart is a tall, pole-like structure intended to attract schooling deep-water and pelagic reef fish like snowy grouper, cubera snapper, and jacks.

Bait reef—a specific type of reef structure intended to attract baitfish for the purposes of making it easier for anglers to catch these fish to use as live bait for offshore angling trips.

Memorial reef—a specific type of reef structure that is intended to commemorate people or events, and usually mixes art with structure.

Snorkel reefs—shallow, near-shore reefs that are intended to provide utility to those who can access from shore and may not have access to SCUBA gear.

Fish Aggregating Device (FAD)—typically incorporate floating structures anchored to the bottom and surface and/or midwater structures intended to attract both baitfish and more pelagic species like billfish, mackerels, cobia, tripletail, etc.

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Table 1. Total numbers of new reefs by region from 2015–2021. Asterisk (*) denotes that 2021 is not complete and totals may increase.

Year	Region					
	Northwest	Big Bend	Southwest	Southeast	East Central	Northeast
2015	25	4	41	17	2	14
2016	104	7	9	19	24	7
2017	88	3	15	10	5	0
2018	157	0	8	15	6	14
2019	133	1	9	8	8	7
2020	52	8	7	27	4	11
2021*	46	0	4	9	1	1
Totals 2015–2021	*605*	*23*	*93*	*105*	*50*	*54*

Table 2. Artificial reefs added to thenortheast region of Florida 2015–2021.

County	New Reefs 2015–2021
Duval	3
Flagler	0
Nassau	1
St. Johns	1
Volusia	49

Table 3. Artificial reefs added to the east central region of Florida 2015–2021.

County	New Reefs 2015–2021
Brevard	5
Indian	5
Martin	13
St. Lucie	27

Table 4. Artificial reefs added to the southeast region of Florida 2015–2021.

County	New Reefs 2015–2021
Broward	12
Miami-Dade	46
Monroe	0
Palm Beach	47

Table 5. Artificial reefs added to the southwest region of Florida 2015–2021.

County	New Reefs 2015–2021
Charlotte	4
Collier	40
Hillsborough	0
Lee	6
Manatee	11
Pinellas	3
Sarasota	29

Table 6. Artificial reefs added to the Big Bend region of Florida 2015–2021.

County	New Reefs 2015–2021
Citrus	0
Dixie	0
Hernando	4
Levy	0
Pasco	0
Taylor	19

Table 7. Artificial reefs added to the northwest region of Florida 2015–2021.

County	New Reefs 2015–2021
Bay	199
Escambia	186
Franklin	15
Gulf	0
Okaloosa	96
Santa Rosa	31
Wakulla	31
Walton	47

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