Update to the
Atlantic States Marine Fisheries Commission

Profiles of State Artificial Reef Programs and Projects

July 2021

Bluestriped grunt, French grunt, porkfish, schoolmaster, yellowtail snapper and other reef fish at the bow section of Joe's Tug located six miles south of Key West, FL at a depth of 65 feet. Joe's Tug was a 90 foot steel tugboat prepared and deployed as an artificial reef on January 21, 1989. Photo credit: Keith Mille, FL FWC.

Atlantic Artificial Reef Summary Information

PERMITTED SITES

In federal waters	168
In offshore state waters	80
In inshore state waters	89
Total	337

NUMBER OF MITIGATION REEFS

at least 38

AVERAGE ANNUAL OPERATING BUDGET*

$458,852

* For some states this is the operational budget, for others it is the annual construction materials budget.

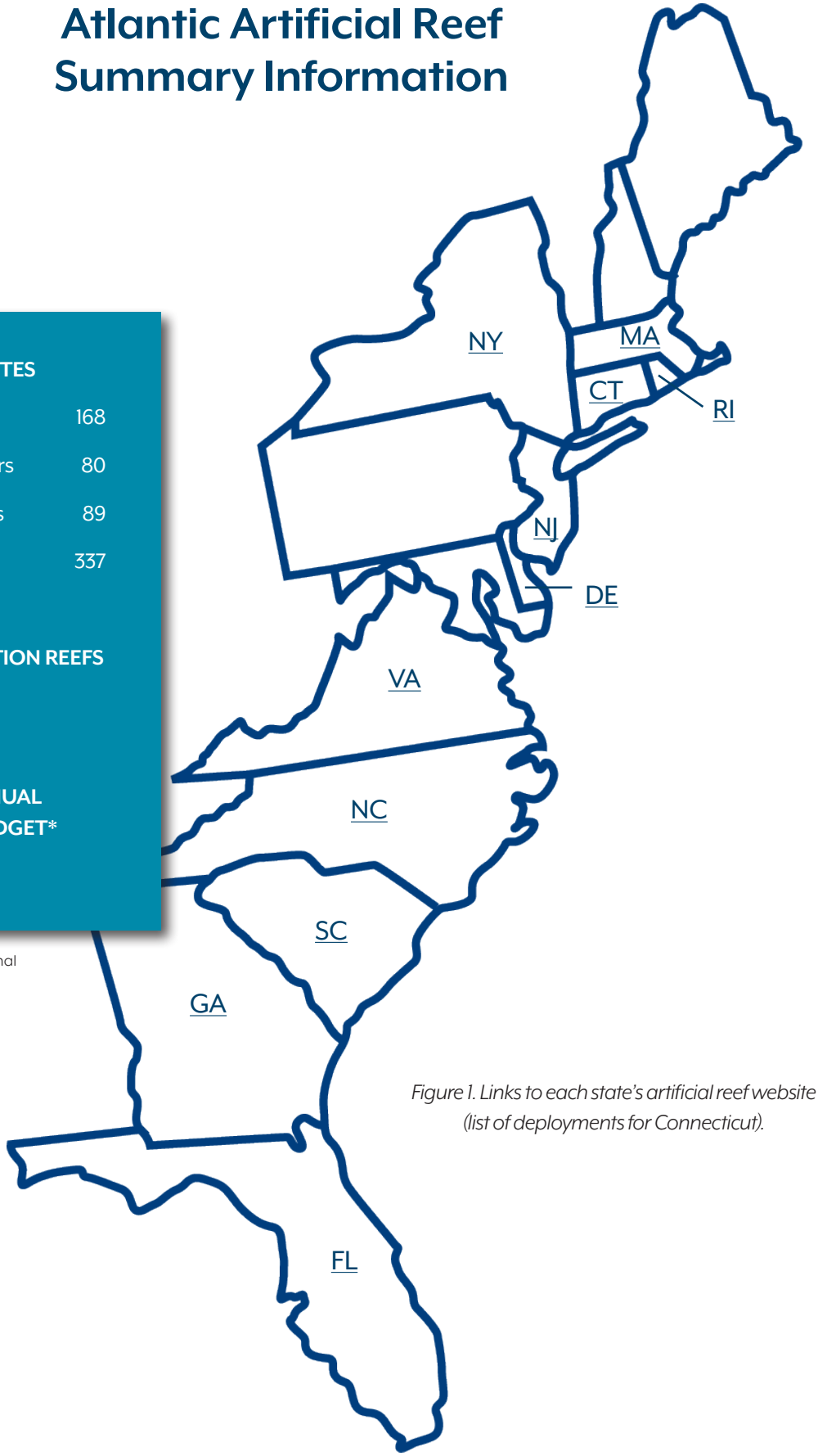

Figure 1. Links to each state's artificial reef website (list of deployments for Connecticut).

Introduction

In 1988, the Atlantic States Marine Fisheries Commission published *A Profile of Atlantic Artificial Reef Development*, which featured profiles for each state's artificial reef program (ARP, see appendix for list of abbreviations and acronyms). In the 30+ years since its release, many states have expanded their programs; deployed a variety of artificial reefs (ARs) using best management practices for construction, materials, and siting; and have monitored sites for use – both by fishers and divers, as well as by marine life. This publication is an update to the 1988 profiles, providing summary information on each state's program, as well as featuring some reefing highlights over the last three decades.

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Massachusetts

MASSACHUSETTS ARTIFICIAL REEF PROGRAM OVERVIEW	
ARTIFICIAL REEF DETAILS	
Number of Permitted Sites	5 (all in offshore waters)
Number of Mitigation Reefs	2
PROGRAM DETAILS	
Artificial Reef Management Authority	Massachusetts Division of Marine Fisheries (MA DMF)
Average Annual Operating Budget	$10,000
State Artificial Reef Plan	*https://www.mass.gov/media/9591/download*
Reef Coordinator	Mark Rousseau; *Mark.Rousseau@mass.gov*
Shellfish Reef Program Contact (separate from the ARP)	Jeff Kennedy; *Jeff.Kennedy@mass.gov*
Artificial Reef Website, with list of deployments	*https://www.mass.gov/service-details/artificial-reefs*
State Reef Publications	*https://www.mass.gov/media/9596/download*
Research Collaborations	*https://www.tandfonline.com/doi/pdf/10.1080/00288330909510001*

The Massachusetts ARP was formalized in 2008 with the completion of the Massachusetts Marine Artificial Reef Plan. The MA DMF Fisheries Habitat Program oversees all ARP developments. Prior to 2008, artificial reefing activity in Massachusetts consisted of a series of ad-hoc deployments for research pilot projects or mitigation. Four of the five Massachusetts permitted reef sites are less than 25 years old. The Dartmouth reef in Buzzard's Bay was created in 1997 using Reef Balls by the University of Massachusetts as a pilot research project. The Sculpin Ledge reef in Boston Harbor is a 1999 mitigation project designed using concrete terrace structures to address subtidal habitat loss at Spectacle Island resulting from the capping of a landfill using "Big Dig" project fill. The Boston Harbor HubLine reef was constructed in 2006 as mitigation for hard bottom habitat impacts resulting from the installation of the HubLine natural gas pipeline between Boston and Salem. The Harwich Reef in Nantucket Sound was created in 2016 using concrete recycled from the demolition of the local high school. The Harwich reef was a collaborative effort with the local charter boat captains and was the first reef project funded using revenue from Massachusetts Recreational Saltwater Fishing License sales. This is a recreation-only reef, with all commercial fishing activity prohibited through regulation enacted in 2016. The permit remains open to accept additional materials in the future.

Permits for the Yarmouth reef, Massachusetts' oldest AR originally created in 1978, were reissued in 2016 to allow additional material to be deployed in vacant areas of the 125-acre site. In 2019, derelict concrete navigation buoy moorings were donated and deployed by the United States Coast Guard (USCG), with additional USCG deployments expected in the future. Additionally, 2,000 cubic yards of granite and concrete were added to the site, using funding by Massachusetts Department of Fish and Game's In-lieu Fee Mitigation Program to pay for deployment.

The Massachusetts ARP is currently focused on addressing three programmatic bottlenecks to help position the program for sustained success: permitting new sites, acquiring free materials, and securing funding for future

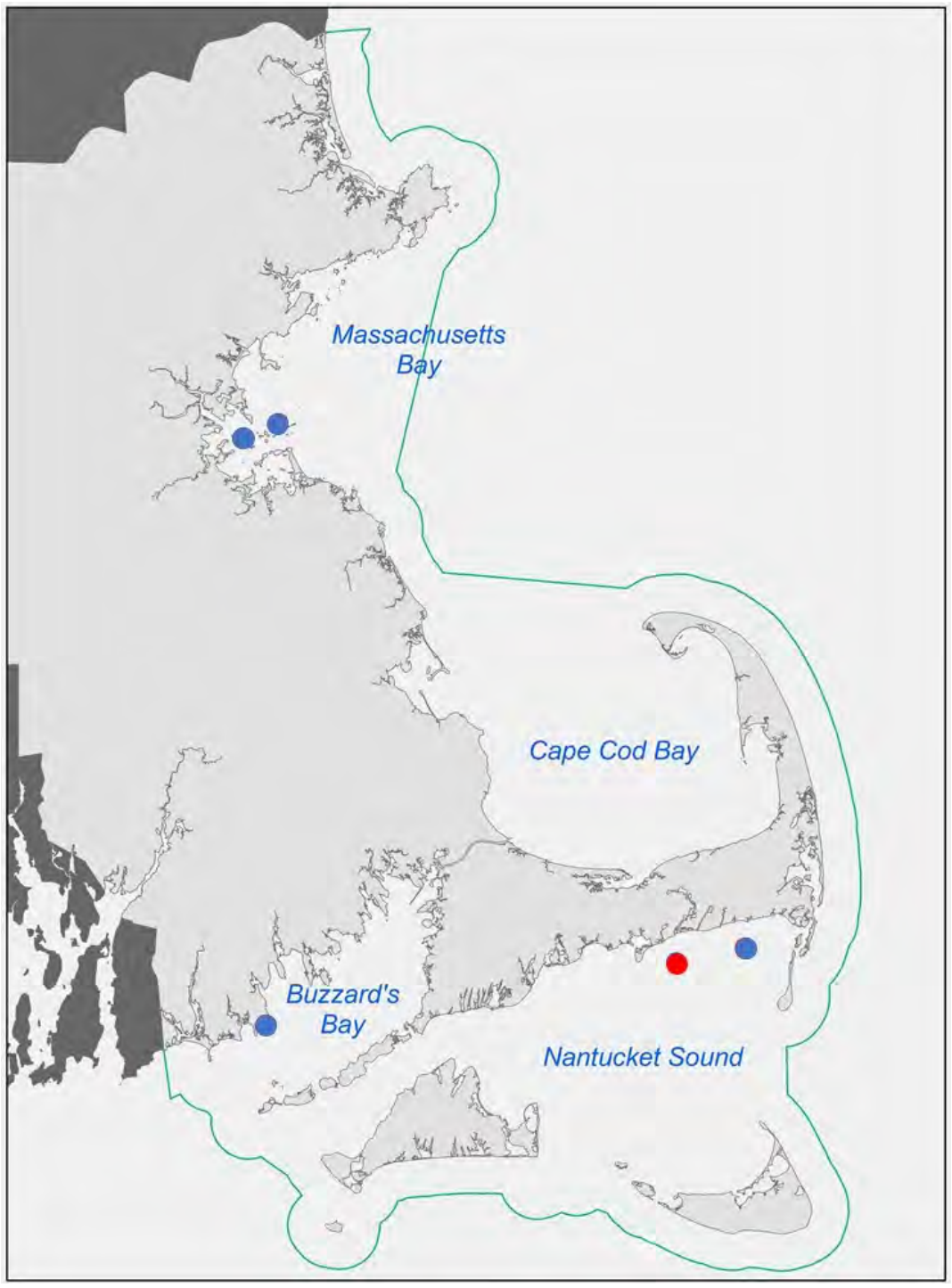


Figure 2. ARs in Massachusetts. Red circles indicate reefs placed before 1988, and blue circles indicate reefs placed after 1988.

deployments. Progress on ARP development is limited by the availability of funding and dedicated staff. A part-time coordinator oversees the ARP and utilizes staff from other programs to conduct reef-associated activities. Collaborations with local communities and other state agencies are utilized to secure free materials and to obtain new permits. All Massachusetts reef sites have established stations for collecting long term monitoring data, including acoustic monitoring of fish and bottom temperature data collection, to take advantage of ongoing efforts from other MA DMF projects to assist with reef monitoring.

PROGRAM HIGHLIGHTS

Completion of the Massachusetts Artificial Reef Plan in 2008 formally established guidance to direct future artificial reefing activities in Massachusetts. Dedicated funding for the program is limited for site selection and monitoring, requiring program staff to build on collaborative efforts with local and state agencies to secure materials of opportunity and funding for deployments. Despite these limitations, the ARP continues to make strides building reefs, siting new reef sites to permit, securing new materials of opportunity, and researching and monitoring existing reef sites.

Figure 3. USCG Vessel Oak deploying derelict concrete navigational aid "sinkers" on the Yarmouth Reef in Nantucket Sound. Photo credit: Mark Rousseau, MA DMF.

Harwich Artificial Reef

Massachusetts's newest AR is the Harwich Reef in Nantucket Sound, deployed in 2016. The project was a collaborative effort between the Town of Harwich and MA DMF. The first deployment of materials consisted of 1,600 cubic yards of concrete rubble obtained from the demolition of the Old Harwich High School, deployed to create patch habitat arrays across a 10-acre site. MA DMF enacted a regulation prohibiting all commercial fishing activity on the reef site and within a 100-meter perimeter buffer zone. The regulation makes this the first and only reef site in Massachusetts dedicated exclusively to recreational saltwater fishing. The reef is very popular within the local community. The permit remains open to allow for the deployment of additional materials to the site.

Figure 4. Deployment of materials to the Harwich Artificial Reef site. Photo credit: Mark Rousseau, MA DMF.

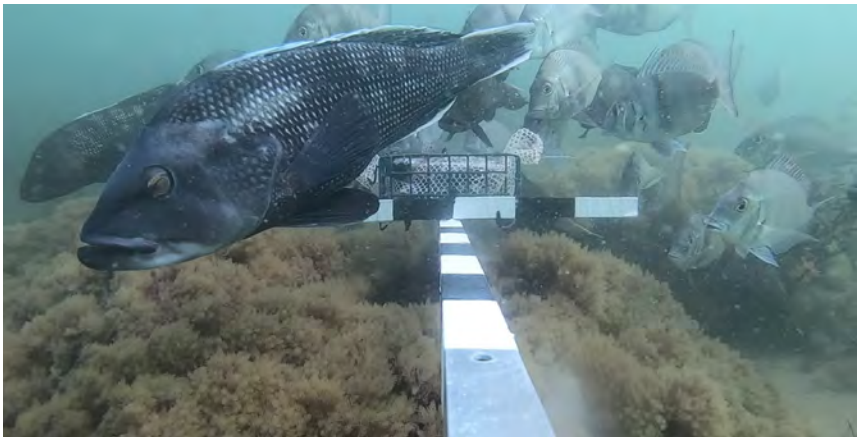


Figure 5. BRUV Research in Nantucket Sound. Photo credit: Simonetta Harrison, MA DMF intern/NEU.

Figure 6. Collaborative monitoring in Nantucket Sound with the Cape Cod Salties and NEU graduate intern. Photo credit: Mark Rousseau, MA DMF.

Monitoring

MA DMF utilizes ARs as long-term monitoring stations to track movement of radio tagged finfish and horseshoe crabs using acoustic receivers, and for the collection of time series bottom temperature data in jurisdictional waters. Temperature data collection dates back to 2006 on some AR locations. MA DMF also conducts periodic sidescan sonar surveys of reef sites to verify material placement and stability. An Underwater Visual Census (UVC) survey using divers collects data on the HubLine mitigation reef in Boston Harbor annually to document long-term successional changes to both native and invasive species on AR habitat compared to nearby natural, hard structured habitats. The UVC survey has been completed every July since 2006. In Nantucket Sound, a 2019 study using Baited Remote Underwater Video Stations (BRUVS) compared reef productivity of the Yarmouth and Harwich ARs, Massachusetts' oldest and newest ARs. Species richness, diversity, abundance, and age structure of economically important demersal fish species were compared to fish aggregations on nearby natural reefs and sand bottom habitats. The study identified an increase in abundance of reef-associated species with increases in reef age. Future research on reefs in Nantucket Sound will utilize BRUVS to assess structured habitat connectivity to determine appropriate spacing of new reefs to existing reefs and natural structured habitats. To complete AR monitoring studies, MA DMF has relied on volunteer services of recreational sport fishing clubs and graduate student interns to assist MA DMF's monitoring efforts, particularly in Nantucket Sound. In 2019, collaborations to complete BRUV research on Nantucket Sound reef sites included a Northeastern University's (NEU) Three Seas Program graduate intern and several members of the Cape Cod Salties who donated vessel time to MA DMF.

Site Selection

The success of the Harwich reef deployment in 2016 generated significant demand for the permitting of additional reef sites in Massachusetts. In 2017, MA DMF began assessing potential AR locations in structure-limited areas of lower Cape Cod Bay. To identify potential sites, information about existing benthic conditions was collected in three distinct phases: sidescan imaging acoustic surveys, underwater camera groundtruth imaging, and SCUBA diver transect monitoring. Over 12,000 acres of bottom were surveyed in four distinct locations using sidescan sonar. Survey locations were ranked based on absence of structure, proximity to structure, and ideal bathymetric conditions. With the assistance of an NEU graduate intern, over 300 sediment photos and more than 5,000 linear feet of diver transect data were collected and analyzed to identify five potential new reef locations in lower Cape Cod Bay. If permitted, the five sites identified in Cape Cod Bay will double the number of ARs in Massachusetts jurisdictional waters.

Material Acquisition

Reef sites with open permits are a desirable option for government agencies looking to donate suitable materials of opportunity for reefing as a means to recognize cost savings for large-scale infrastructure improvement projects when disposal debris can meet MA DMF reefing materials requirements. MA DMF is working with the Massachusetts Department of Fish and Game and the Massachusetts Department of Transportation to secure free materials of opportunity from large transportation upgrades such as the Massachusetts South Coast Railway Improvement project. Over 1,000 cubic yards of granite from more than 60 culvert and bridge infrastructure upgrades along the rail line have been donated to the MA DMF reef program for reefing. With no funding immediately available for material deployments, MA DMF has secured a temporary lease from the New Bedford Marine Commerce Terminal for staging the donated granite until deployment funding is secured. Additionally, MA DMF is collaborating with the USCG Stations Newport and Woods Hole to receive derelict navigation aid moorings, known as sinkers, to reef sites in Nantucket Sound. The USCG delivers and deploys materials to areas on the reef designated in advance by MA DMF at no cost to the state.

Future reef deployments will focus on barge loading of materials from coastal construction projects, with direct delivery to reef sites. In order for this to be a successful, economically feasible option, MA DMF will be required to maintain several open reef permits in several locations.

Figure 7. Lower Cape Cod Bay sites selected for permitting. Image credit: Kristen Schmicker, MA DMF intern/NEU.

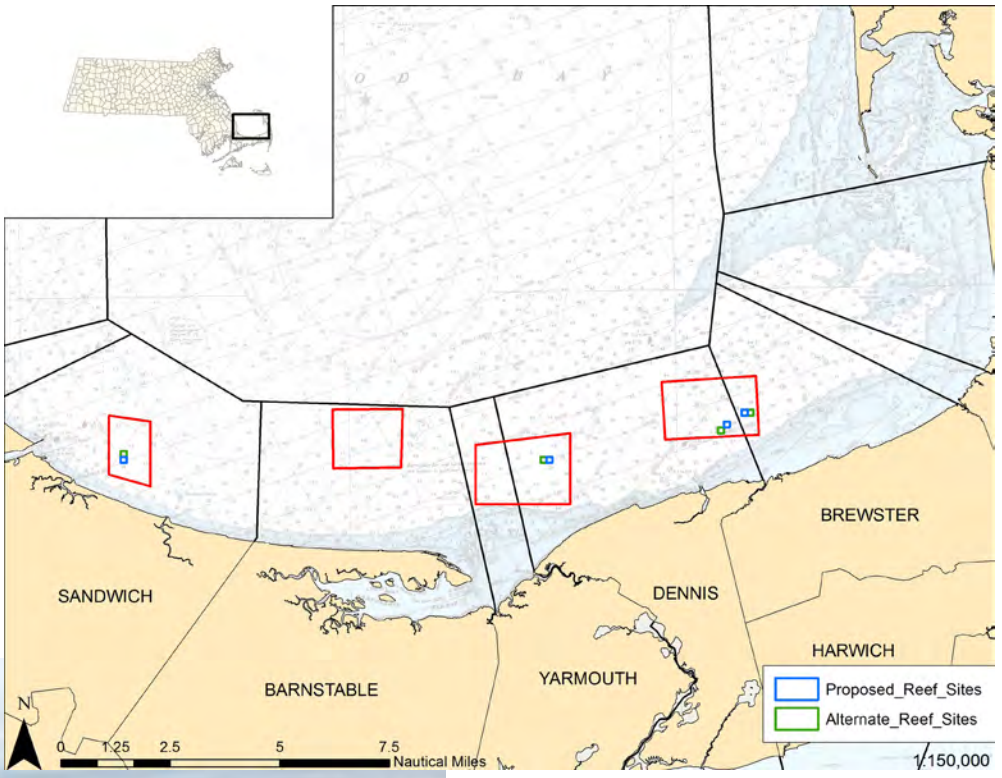


Figure 8. Material from the MA Department of Transportation South Coast Railway Project stored at the Clean Energy Center's Marine Commerce Terminal in New Bedford. Photo credit: Mark Rousseau, MA DMF.

Rhode Island

RHODE ISLAND ARTIFICIAL REEF PROGRAM OVERVIEW	
ARTIFICIAL REEF DETAILS	
Number of Permitted Sites	3 (in offshore waters); 4 (in inshore state waters)
Number of Mitigation Reefs	1
PROGRAM DETAILS	
Artificial Reef Management Authority	New England Fishery Management Council, Rhode Island Department of Environmental Management Division of Marine Fisheries (RI DMF)
Average Annual Operating Budget	$10,000
State Artificial Reef Plan	No official state plan, reviewing the current guidelines for artificial reef planning
Reef Coordinator	Patrick Barrett; *Patrick.Barrett@dem.ri.gov*
Shellfish Reef Program Contact (separate from the ARP)	Eric Schneider; *Eric.Schneider@dem.ri.gov* Patrick Barrett; *Patrick.Barrett@dem.ri.gov*
Artificial Reef Website, with list of deployments	*http://www.dem.ri.gov/programs/marine-fisheries/surveys-pubs/habitat.php*
Research Collaborations	Sheehy, D. 1976. Utilization of artificial shelters by the American lobster (*Homarus americanus*). Journal of the Fisheries Research Board of Canada 33: 1615-1622. Sheehy, D.J. 1982. The use of designed and prefabricated artificial reefs in the United States. Marine Fisheries Review 44(6-7): 4-15. Castro, K.M., J.S. Cobb, R.A. Wahle & J. Catena. 2001. Habitat addition and stock enhancement for American lobsters, *Homarus americanus*. Marine and Freshwater Research 52(8): 1253-1261.

ARs were first deployed in Rhode Island waters during the early 1970s. During this time there was no state sponsored ARP, but the state supported research projects undertaken by the University of Rhode Island (URI) to investigate the use of pre-fabricated concrete modules as a tool to increase species specific abundance in otherwise unstructured benthic marine habitat (i.e. sand bottom). Specifically, this work focused on determining if ARs can be used as a tool to increase the carrying capacity of lobsters in areas devoid of natural shelter. The results suggested that these species-specific modules were readily occupied by lobster and can significantly increase the abundance of lobster at certain locations (Sheehy 1976). These lobster modules were the only ARs on record in Rhode Island at the time of the ASMFC's 1988 Profile on Artificial Reef Development. Findings from this work provided promising results and garnered the state's interest in ARs as a fisheries management tool. However, AR planning and development did not expand until the late '90s.

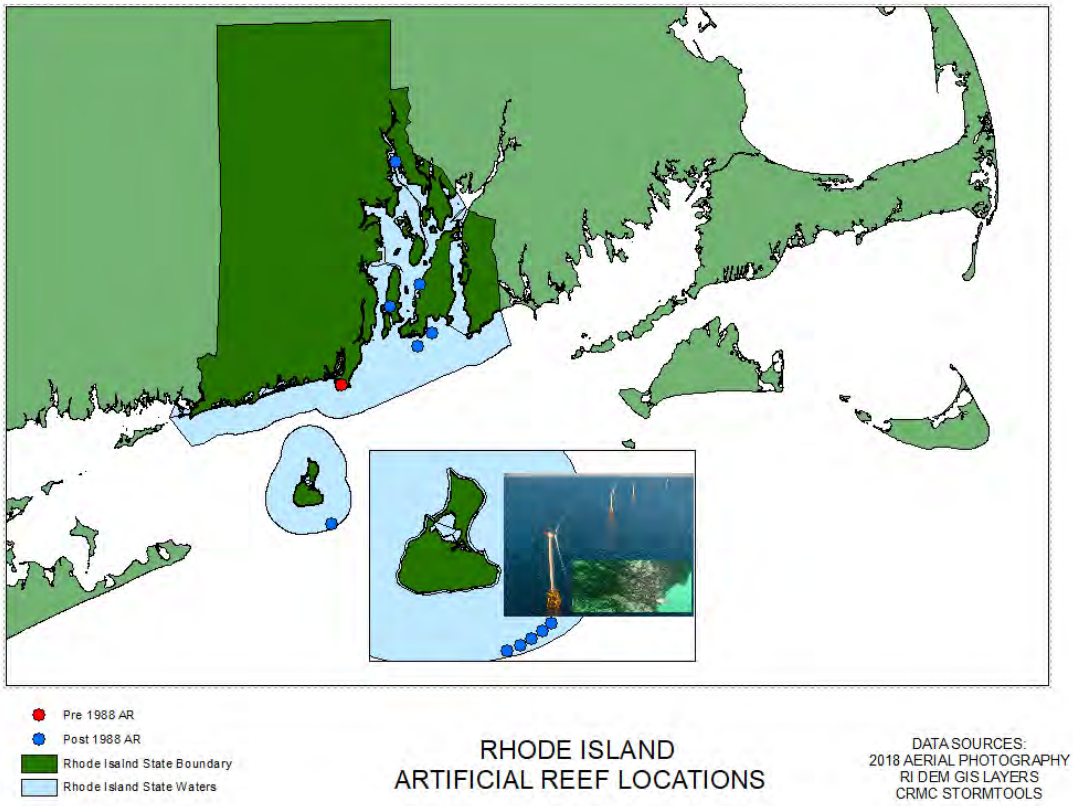


Figure 9. ARs in Rhode Island. Red circle indicates reefs placed before 1988, and blue circles indicate reefs placed after 1988.

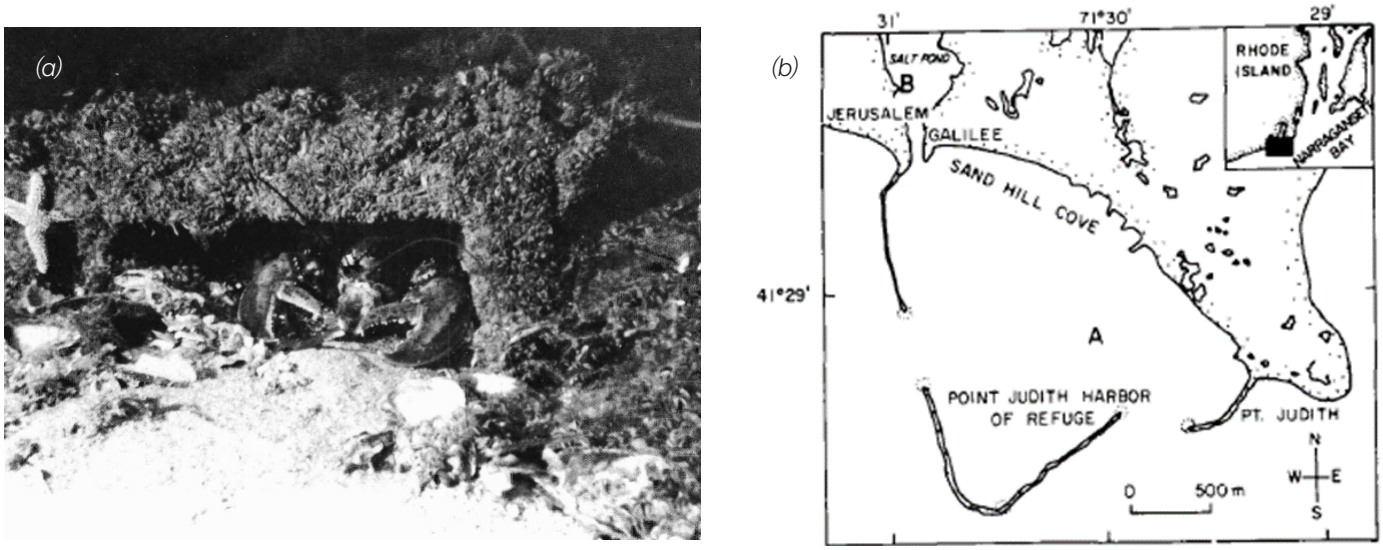


Figure 10. (a) Lobster occupying two-piece single-chamber shelter, and (b) map of lobster module enhancement areas as cited in Sheehy 1982 and 1976 respectively.

In 1997, a second AR project conducted by the URI was developed with the same purpose of improving the stock of American lobster. Instead of pre-fabricated modules, this deployment consisted of six reefs split into two grades of cobble stone (10-20 cm and 20-40 cm) deployed off the western side of Jamestown, near Dutch Island (Castro et al. 2001). Castro found that the ARs increased the abundance of adult lobsters relative structured and unstructured habitat controls. The success of these two reefs provided the state with more confidence that the implementation of ARs can be used as a successful management tool. Not too long after, ARs returned to Narragansett Bay as part of a mitigation measure taken by the U.S. Navy post remediation of the McAllister Point Landfill. From 1955-1970s,

the McAllister Landfill accepted all waste from the Newport Naval Station. In 1989, the landfill, in conjunction with other sites on the base, were included on the Environmental Protection Agency's (EPA's) National Priority List. As a post remediation mitigation measure, specifically post-dredging of the nearby marine sediment, the U.S. Navy was required to conduct post-eelgrass restoration and AR enhancement work at the sites dredged and backfilled during the remediation work. While some projects arise out of a necessity to react, others arose more opportunistically.

In 2003, the Rhode Island Department of Transportation (DOT) started to plan the removal of the Old Jamestown Bridge that was closed after the completion of the Jamestown-Verrazano Bridge in 1992. Since the bridges spanned the east passage of Narragansett Bay, Rhode Island was presented with a unique opportunity to repurpose this old bridge material as an AR, which proved to be a more cost effective option than landfill disposal. The demolition of the Old Jamestown Bridge began in 2006 and with funds acquired by the Rhode Island DOT from the Federal Highway Administration, the state was able to construct two ARs, Gooseberry Island and Sheep Point Reef, in nearshore waters off the coast of Newport. In addition to the recycled bridge materials (i.e., concrete slabs, rebar, concrete rubble) these ARs were improved by cryptic habitat units that enhanced vertical relief and protected juvenile and cryptic fishes.

Figure 11. The through truss span of the Old Jamestown Bridge, just before it hits the water following the first controlled explosive demolition in 2006. Photo credit: RIDOT.

Currently, there is no official ARP but a draft guideline for AR planning in Rhode Island was developed by Rhode Island Division of Marine Fisheries (RI DMF) in conjunction with a 2013 permit application for a reef ball project in estuarine waters. The project permit was withdrawn but the document and AR site suitability analysis stands as the most up to date plan for AR enhancement in the state. This work is currently being reviewed and considered for potential improvements in order to adopt into an official plan state plan.

Currently, all habitat restoration falls under one of two programs, either the Shellfish Restoration Program or the Fish Habitat Enhancement Program. AR work is conducted under the Fish Habitat Enhancement Program consisting of a couple members of the state's Habitat Team. Since last year, the RI DMF Habitat Team has continued to monitor essential fish habitat (EFH) such as oyster reefs, eelgrass, and kelp, in addition to siting potential locations for AR work. Over the last four years the team, in collaboration with The Nature Conservancy, has been using a combination of monitoring techniques (e.g. multi gear surveys, benthic video monitoring, and dive surveys) to determine suitable locations for fish habitat enhancement projects in the Upper Narragansett Bay and Providence River. This research has led to the first permitted AR project specifically aimed towards enhancing fish habitat since 2006. Deployment of the Sabin Point AR project was completed in October 2019.

PROGRAM HIGHLIGHTS

Jamestown Bridge Artificial Reef Project

Gooseberry Island and Sheep Point reefs were completed in August 2007. The main goal of the work was to enhance inshore, flat sandy bottom habitat, with more complex structure with the understanding that these improvements to the benthic structural complexity will likely result in increased fish biomass, juvenile fish abundance, and provide additional recreational fishing and SCUBA diving opportunities in Rhode Island. These reefs were constructed in 65-85 feet of water on sandy, unstructured, habitat, and surveyed via transect methods on SCUBA. In addition to these materials, cryptic habitat units were deployed and hauled at various intervals to measure the colonization of cryptic and juvenile finfish species.

Figure 12. Cryptic habitat units prior to be deployed. Photo credit: Natasha Pinckard.

Sabin Point Artificial Reef Project

The goal of this project is to enhance fish abundance at a site, which currently provides fishing access but supports a moderate-low fish abundance. This work aims to enhance the size and abundance of targeted species (e.g. scup, tautog, black sea bass), as well as support juvenile fish and prey species by adding structure to relatively featureless bottom habitat to a location in close proximity to a local fishing pier. The project site has been carefully chosen to balance the goal and objectives of the project while taking into consideration the environmental constraints, logistics of implementation, and competing uses. This is the first AR project since 2006, and the first AR to use Reef Balls in Rhode Island.

Figure 13. AR being deployed at Sabin Point. Photo credit: Grace Kelly, ecoRI.

Artificial Reef Productivity Monitoring

As AR work continues to grow in Rhode Island, DMF is looking to identify the best monitoring methods to evaluate the success of their AR work. DMF will be using the Sabin Point project as a pilot study for the use of Reef Balls in Rhode Island waters, as well as to identify monitoring guidelines for future AR projects. DMF is also interested in determining the relative habitat value produced by creating ARs in the bay, both from a biological and social standpoint. DMF intends to utilize a dive transect monitoring protocol that is designed to sample common algae, invertebrates, and fish species to monitor changes to AR habitats over time. From this work they will establish fish habitat linkages by comparing productivity estimates on AR in relation to sand flat controls, and other important finfish habitats (e.g. oyster reefs, kelp, eelgrass). In addition to the biological surveys DMF is also interested in conducting recreational angler interviews to see how perception of the park, and the fishing opportunity, has changed at Sabin Point since the creation of the AR.

Connecticut

CONNECTICUT ARTIFICIAL REEF PROGRAM OVERVIEW	
ARTIFICIAL REEF DETAILS	
Number of Permitted Sites	1 (in inshore state waters)
Number of Mitigation Reefs	1
PROGRAM DETAILS	
Artificial Reef Management Authority	Connecticut Department of Energy and Environmental Protection (CT DEEP), Fisheries Division, Marine Fisheries Program
Average Annual Operating Budget	$0
Reef Coordinator	David Molnar; *David.Molnar@ct.gov*
Shellfish Reef Program Contact (separate from the ARP)	David Carey; *David.Carey@ct.gov*
List of deployments	*https://www.nfwf.org/sites/default/files/finalreportsl/1401.13.039429-final_report.pdf*

ARs were first deployed in Connecticut waters in 2014. During this time there was no state sponsored AR program, but the state authorized research projects undertaken by Sacred Heart University (SHU) to investigate the use of pre-fabricated concrete modules "Pallet Reef Balls" and native vegetation as a tool to decrease erosion of intertidal sediments and restore intertidal wildlife habitats. Specifically, this work focused on determining if ARs can be used as a tool to reduce wave action and stabilize the shoreline, subsequently aiding in marsh grass restoration and species recolonization. The results suggested that wave energy has been reduced and sedimentation has increased (NFWF 2018).

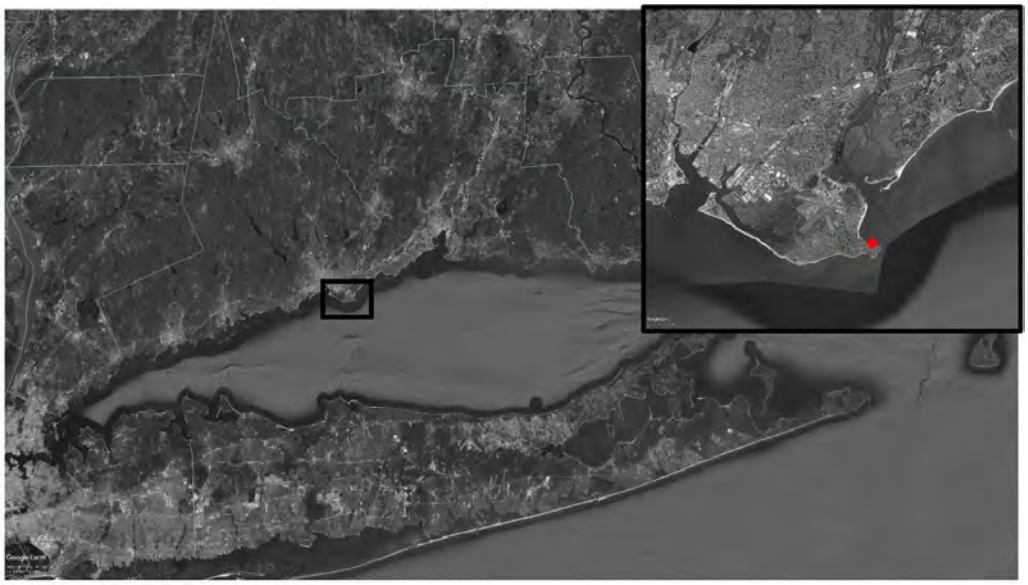


Figure 14. AR in Connecticut. Red circle indicates reef placed in 2014.

PROGRAM HIGHLIGHTS

Stratford Point Living Shoreline Project

Figure 15. Precast concrete reef balls called Pallet Balls being deployed at the Stratford Point Living Shoreline in 2014. Photo credit: CT DEEP.

Stratford Point was formerly owned by Remington Gun Club for 50 years and was used as a gun firing range, subsequently leading to lead pollution in the intertidal shoreline from the bullets. DuPont acquired the land and conducted remediation efforts in the early 2000s to remove the pollution, however, in the process, the cleanup disturbed the intertidal habitat. In 2011, Dr. Mattei, Professor at SHU, became involved in Stratford Point's ecological system.

Pallet Balls were installed at Stratford Point Living Shoreline in May 2014. The main goal of the work was to protect coastal shorelines from storm-generated erosion (NFWF 2018). The deployment of 64 Pallet Balls helped improve the benthic habitat, serving as substrate for marine organisms such as juvenile finfish, oysters, barnacles, algae, sponges, clams, snails, and crabs. The installation of smooth cordgrass (*Spartina alterniflora*) helped the establishment of a fringe marsh and provided additional wave attenuation. These reefs were constructed during low tide, approximately 18 meters seaward of the mean high water elevation. As part of the project, and per requirements of the state's Certificate Permission, subsequent monitoring of abiotic and biotic data was collected for five years to determine if the living shoreline was successful in terms of increasing coastal resilience over time. Presently, the attenuation of wave energy has been reduced by 30% and within the first year of the installation, 15 cm of sediment accreted landward of the Pallet Balls (NFWF 2018).

Funding for this project was provided by U.S. Army Corps of Engineers (USACE) Connecticut In-Lieu Fee Program ($250,000), Connecticut Institute for Resilience and Climate Adaptation (CIRCA) Matching Funds ($91,000), and Long Island Sound Futures Fund ($115,198). The leading stakeholders involved in this project are SHU professors, DuPont, Connecticut Audubon Society and National Audubon Connecticut, AECOM (formerly URS) and CIRCA.

Reference

National Fish and Wildlife Foundation (NFWF). "Final Programmatic Report Narrative" 23 Dec. 2019, *http://www.nfwf.org/finalreports1/1401.13.039429-final_report.pdf*

Figure 16. The living shoreline project consisted of an artificial reef and intertidal marsh. Reef balls are located approximately 18 meters seaward of the mean high-water elevation. Photo credit: CT DEEP.

New York

NEW YORK ARTIFICIAL REEF PROGRAM OVERVIEW	
ARTIFICIAL REEF DETAILS	
Number of Permitted Sites	3 (in federal waters - 2007 acres); 5 (in offshore waters - 1,321 acres); 4 (in inshore waters - 61 acres)
Number of Mitigation Reefs	0
PROGRAM DETAILS	
Artificial Reef Management Authority	New York State
Average Annual Operating Budget	$750,000
Artificial Reef Plan	*https://www.dec.ny.gov/docs/fish_marine_pdf/dmrreeffsgeis.pdf*
Reef Coordinator	Christopher LaPorta; *Christopher.LaPorta@dec.ny.gov*
Shellfish Reef Program Contact (separate from the ARP)	Debra Barnes; *debra.barnes@dec.ny.gov*
Map of deployments	*https://www.dec.ny.gov/outdoor/71702.html*
Artificial Reef Website	*https://www.dec.ny.gov/outdoor/7896.html*

The New York State Department of Environmental Conservation (NYSDEC) ARP was established in 1962 to enhance and restore fisheries habitat as part of New York State's Marine Fisheries Management Program and provide additional fishing and diving opportunities.

A Generic Environmental Impact Statement and Plan for the Development of Artificial Reefs in New York's Marine and Coastal District (GEIS/Reef Plan) was written by NYSDEC in 1993 to establish programmatic guidelines and goals and to secure permits authorizing the construction, repair and maintenance of ARs in both New York and adjacent federal waters.

The GEIS/Reef Plan was updated through the completion of a Supplemental GEIS/Reef Plan (SGEIS). The SGEIS was completed in 2020 and addressed the advancements in science and knowledge surrounding AR development and the programmatic questions raised in the 1993 GEIS. The SGEIS will be an integral part of the ARP's path forward toward significantly increasing overall reef area through the expansion of existing sites and the creation of new sites.

The ARP maintains 12 reef sites in New York's Marine and Coastal District including eight sites in the Atlantic Ocean, two in Great South Bay and two in Long Island Sound. All but one site (Twelve Mile Reef) were permitted prior to 1988 (see map). Reef sites are strategically positioned in proximity to major inlets for increased boating access.

Program compliance and performance monitoring of the sites is conducted through aerial surveys, SCUBA, bathymetric surveys, remote operated vehicle (ROV), trap surveys, and contracted biological monitoring surveys. Supplemental monitoring information is also received through volunteer angler and diver surveys.

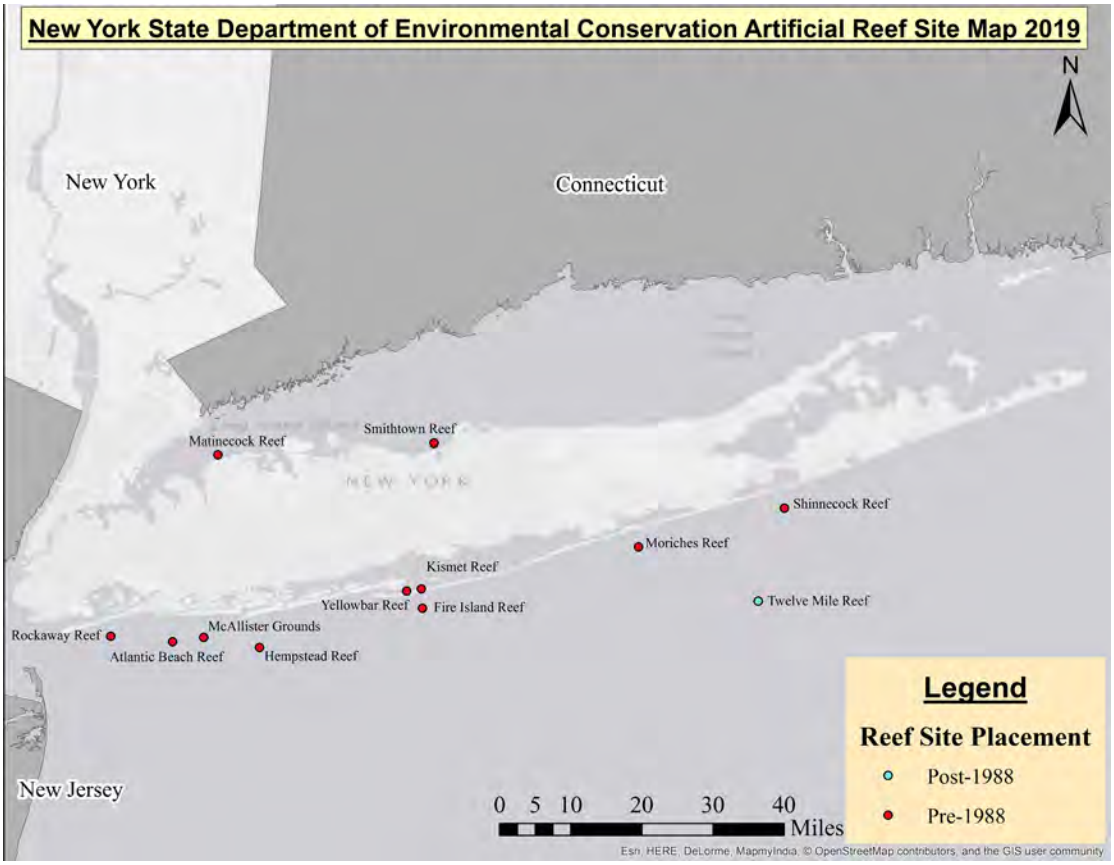


Figure 17. ARs in New York. Red circles indicate reefs placed before 1988, and blue circles indicate reefs placed after 1988.

Materials of opportunity are utilized to create patch reefs on ARP sites. Reef building materials that have been used include, but are not limited to, rock (dredged and jetty), concrete (pipes, blocks, slabs, bridge decking, rubble), steel (vessels, barges, pipe, buoys, automobile bodies), wood (drydocks, barges, vessels) and tires. A majority of these materials were used because of their abundance and availability. Over time performance monitoring determined which materials proved to have superior reef building characteristics (stability and durability) for sustained use. Car bodies and tires are no longer used by the ARP due to their poor performance as reef material. In the past other available and abundant materials such as wood (barges and vessels) have been predominantly replaced by the significantly more stable and durable rock and steel.

Historically, the ARP had no dedicated budget to acquire, prepare and deploy materials on its sites. Some project and monitoring funding has been secured through the New York State Environmental Protection Fund.

A majority of deployed materials have been acquired through ARP partnerships. Federal agencies, such as the USACE and the National Marine Fisheries Service (NOAA Fisheries) have donated reef building materials ranging from large volumes of dredge rock to steel fishing vessels.

Other partnerships with construction companies have produced large volumes of material (concrete and steel) from demolition projects where reefing was more economically feasible than alternate disposal methods. Additional reef building collaborations were forged with local fishing clubs and saltwater angler based organizations (Fisherman and Fishing Line magazines) through specific reef site sponsorship.

Perhaps the most significant challenge encountered by the New York ARP has been the increased value of and preparation cost for reef building materials that were once readily available and commonly used. A key factor has

been the exorbitant increase in scrap steel value making acquisition of steel vessels, barges, and pipes among other steel products onerous due to greater scrapping value.

PROGRAM HIGHLIGHTS

Atlantic Beach Reef

The most significant ARP material deployment was the result of a successful partnership with New York District USACE during an ongoing New York Harbor Channel Deepening Project. This project produced large volumes of dredged bedrock from New York Harbor to allow deep draft vessels access to the Port of New York. The partnership was a "win-win" for the USACE, who aquatically recycled large volumes of disposal material, and the ARP who gained large volumes of high-quality reef building material at no cost.

Figure 18. Atlantic Beach Reef line of boats. Photo credit: NYSDEC.

Reef placements occurred from 1998 through 2001 producing over 200 deployments yielding approximately 600,000 cubic yards of rock. To date this is the largest patch reef created in ARP history located on the Atlantic Beach Reef.

After blasting and dredging, the rock was loaded into hopper barges and towed to a series of designated target coordinates on the Atlantic Beach Reef for deployment. The rock drops created an extended patch reef that defines the northern boundary of the site easily located by the large number of vessels frequenting it.

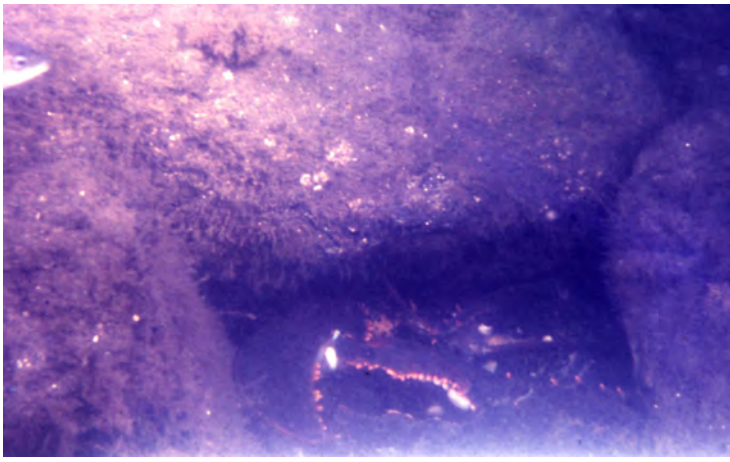
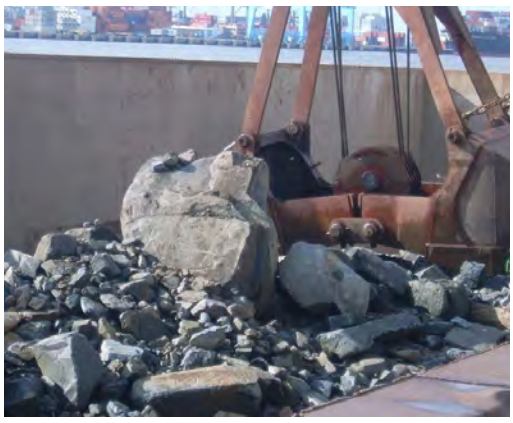


Figure 19. Lobster in rocks. Photo credit: NYSDEC.

The Atlantic Beach Reef "rockpile" remains one of the most popular and frequented destinations to date as is evidenced by the photo of the "rack-line" of boats enjoying the fishing and diving opportunities this massive patch reef offers.

SCUBA monitoring of this large reef has documented a considerable number of large interstitial spaces that could easily house a "double-digit" lobster or tautog!

Figure 20. Rocks for the Atlantic Beach Reef. Photo credit: NYSDEC.



Moriches Anglers Reef

The largest vessel deployed by the New York ARP began its life as a 167-foot steam freighter. The vessel currently known as The Boat went by many prior monikers such as Philip J, SS Newport, Boulogne Sur Mer, and Bad Bob's Big Boat before going to its final resting place on the Moriches Anglers Reef.

The original steam freighter was gutted and converted into the floating Four Star French Restaurant SS Newport that was berthed in Newport Harbor, Rhode Island for 10 years. When the SS Newport fell on hard times it was sold and converted into its final incarnation as the floating Nightclub Bad Bob's Big Boat berthed in Newport Harbor for 20 years. Bad Bob's Big Boat had a colorful reputation as an upper-class destination but eventually declined and became a hangout for rowdy crowds. Over time the Newport City Council issued an eviction notice for the vessel and eventually a settlement spelled out terms for The Boat's removal from Newport Harbor. The last owner of The Boat was a SCUBA diver who was familiar with the New York ARP. He contacted the ARP and offered to donate the vessel. The vessel's dimensions of 167-feet long, 27-foot beam, and 25-foot keel made it a good candidate for reefing.

Figure 21. The Boat (a) before reefing and (b) under water. Photo credit: NYSDEC.

Local divers have reported that The Boat rests on its keel in 70 feet of water on the Moriches Anglers Reef. The large voids and open decks of The Boat have been documented to hold large numbers of tautog, black sea bass, and scup. This patch reef remains one of the more popular diving destinations of the New York sites due to its size.

The project was sponsored by the local fishing club The Moriches Anglers who adopted the Moriches Anglers Reef because many club members frequented the site to fish and dive. Over time members of the club created the not for profit organization Moriches Offshore Reef Fund (MORF) that was ultimately responsible for improving over half the reef site with patch reefs primarily in the form of steel vessels and barges preferred by club members. MORF's long-term sponsorship of the Moriches Anglers Reef has been the most successful single site sponsor partnership with the New York ARP to date.

Governor Cuomo's Reef Initiative/Tappan Zee Bridge

Demolition of the Tappan Zee Bridge and the resulting opportunity to "aquatically recycle" materials to reduce landfill burden produced significant changes for the ARP. Starting in 2018 Governor Andrew Cuomo's Artificial Reef Initiative (Reef Initiative) rejuvenated the ARP through the provision of resources, acquisition and deployment of unprecedented volumes of surplus reef building materials located throughout New York. Materials were received from the following state agencies: New York Power Authority (NYPA), New York Thruway Authority (NYTA), New

Figure 22. The deployment of the steel bridge/miter gate/pontoon sculpture off the "slip and slide." Photo credit: NYSDEC.

York Department of Transportation (NYDOT) and New York Canals Corporation (NYCC). The New York City (NYC) Department of Transportation, National Grid (NAGD) and the USACE also contributed materials to the Reef Initiative.

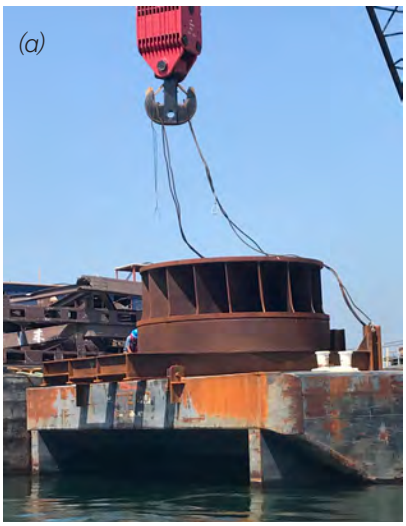
The concerted multi-agency Reef Initiative effort resulted in the first ever deployment of materials onto all 12 New York reef sites from 2018 through 2019 totalling nearly 100 individual patch reefs.

Materials recycled through the Reef Initiative included surplus NYCC steel vessels and barges, NYPA and NAGD power producing equipment (steel rotors and turbines), NYDOT concrete and steel bridge and highway demolition materials and NYTA steel trusses and concrete supports and decking from Tappan Zee Bridge. All materials were either transported over land or via waterways (Erie Canal and Hudson River) to New York's Coastal Marine District for deployment.

One Reef Initiative project of interest was the result of a marine contractor who used a variety of NYCC materials to create a steel sculpture. The sculpture design was made from various steel parts (miter gate, lift bridge section and pontoons) welded together with the understanding that greater surface area and increased profile are important characteristics for reef building success. The fabricated sculptures produced large surfaces of attachment for marine colonizers with increased conduit for water flow resulting in enhanced shelter and foraging opportunities for various reef-associated species.

In addition to the imaginative reef material design, a new method of material deployment was devised and named the "slip-and-slide." This method employed large spare steel I-beams welded together to form a movable base. The sculptures and other reef materials (70-ton steel turbine runners) were placed on this base for overboard deployment. A large crane was used to control lifting of the onboard section of the "slip-and-slide" until the materials literally slipped off and over the side of the barge.

Figure 23. The 70-ton steel turbine (a) on deck and (b) being deployed. Photo credit: NYSDEC.



New Jersey

NEW JERSEY ARTIFICIAL REEF PROGRAM OVERVIEW	
ARTIFICIAL REEF DETAILS	
Number of Permitted Sites	14 (in federal waters); 4 (in offshore state waters)
Number of Mitigation Reefs	0
PROGRAM DETAILS	
Artificial Reef Management Authority	New Jersey Division of Fish and Wildlife (NJDFW) ARP
Average Annual Operating Budget	$180,000 plus donations
Reef Coordinator	Peter Clarke; *Peter.Clarke@dep.nj.gov*
Artificial Reef Website	*https://www.nj.gov/dep/fgw/artreef.htm*

In 1984, NJDFW initiated its ARP with permitting through USACE in order to develop a hard-bottom habitat that is beneficial to marine life. This permitting provided the development of an AR system with standardized oversight using best environmental practices. NJDFW started with four reef locations: the Sea Girt Reef off Monmouth County, the Garden State North and Garden State South reefs off Long Beach Island in Ocean County, and the Atlantic City Reef off Atlantic County. By 1994, the network increased to include a total of 14 permitted reef sites ranging from Sandy Hook to Cape May. An additional reef was added in 2005, with two more added in 2017, bringing the total to 17 reef sites covering 7.8%, or 35 square miles, of seafloor managed by NJDFW at present. With over 4,300 deployments made over the 17 reef sites, 91% of the total permitted area is still undeveloped. Four of the reef sites are located inside of the three-mile state waters territory, while the remaining 13 sites are in federal waters (see map of ARs above). New Jersey has one estuarine reef site located in the Delaware Bay.

Historically, ARs have been constructed out of a wide range of materials, but recently they have been limited to three material types: steel, rock, and concrete. Steel is generally acquired as ex-fishing vessels, barges, tug boats, army tanks, and subway cars that are no longer considered suitable for their intended use. Rock is often provided through many river and port deepening projects and consists of the largest quantity of material encountered during the project period, preferably larger than a basketball and frequently bigger than a car. Concrete typically originates from bridge decommissioning projects, old piers and pilings, road culverts, and other pre-cast material. Rather than these materials going to recycling, NJDFW is able to repurpose them to create new underwater habitat. All material is inspected for suitability before it is deployed. If determined fit for deployment, it is cleaned and prepared using the best environmental practices.

PROGRAM HIGHLIGHTS

Monitoring

Currently, NJDFW is conducting an independent fixed gear reef survey on three reef sites within the New Jersey reef network. This project was initially a collaborative effort with Rutgers University for years one through three and is now conducted entirely by New Jersey. Sampling includes three seasons consisting of five-week sampling events equating to a total of 15 weeks of trap hauls per year. Reefs sampled include Sea Girt, Manasquan Inlet, and Little

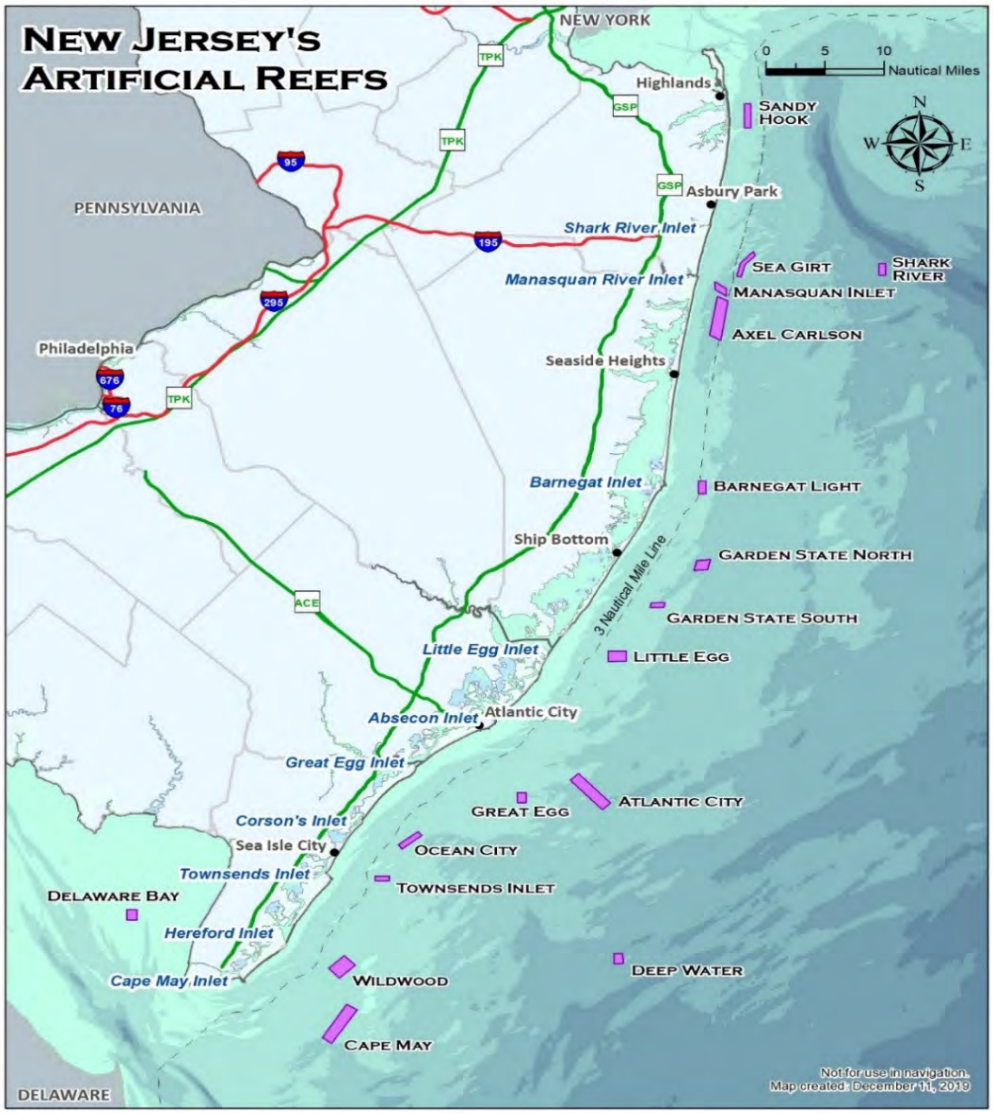


Figure 24. ARs in New Jersey. The 17 reef sites are depicted in purple shaded symbols, four occur in state waters (0-3 nm), 14 are in federal waters (3-200 nm). The gray dotted line indicates the state waters boundaries.

Egg Inlet reefs. Measurements include the initial absence of marine life and evaluating the rate of presence as fish species develop on the material, enumerating species as development occurs, weighing and measuring all species collected. Sampling techniques include video recordings, side scan sonar, and fixed gear with bottom temperature monitoring.

Funding

The NJDFW ARP receives funding through two sources. The operating budget for staff salaries and fringe/indirect benefits including monitoring and supplies averaged over five years is roughly $180,000 of Sport Fish Restoration Funds. All funds for material acquisition, preparation, and deployment are supplied by outside sources from sport fishing clubs and environmental advocacy groups.

Recent Deployments

In 2019, the New Jersey ARP performed eight deployments; these included two Reef Ball deployments on the Ocean City Reef; three barges on the Townsends Inlet Reef; two Caisson Gates, one on the Atlantic City Reef, the second on the Cape May Reef; and a concrete bridge rubble deployment on the Townsends Inlet Reef. In total, material deployed in 2019 equaled roughly 5,000 cubic yards of new habitat.

Delaware

DELAWARE ARTIFICIAL REEF PROGRAM OVERVIEW	
ARTIFICIAL REEF DETAILS	
Number of Permitted Sites	5 (in federal waters); 9 (in inshore state waters)
Number of Mitigation Reefs	2: USACE Mitigation Reef and Public Service Electric and Gas reef deployment funding
PROGRAM DETAILS	
Artificial Reef Management Authority	Delaware Division of Fish and Wildlife (DE DFW); permitting under USACE (federal waters) and Delaware Division of Water, Wetlands and Subaqueous Lands Section (state waters)
Average Annual Operating Budget	$600,000 plus additional funding for large projects.
Reef Coordinator	Jeff Tinsman; *Jeffrey.Tinsman@delaware.gov*
Artificial Reef Website	*https://dnrec.alpha.delaware.gov/fish-wildlife/fishing/artificial-reefs/*
List of deployments	*http://www.dnrec.delaware.gov/fw/Fisheries/Documents/2015-16%2DELAWARE%20REEF%20GUIDE.pdf*

Delaware was the last state along the Atlantic coast between New York and Texas to initiate a state-sponsored reef program, with development starting in 1995. Most of Delaware's salt water access is along Delaware Bay and most reef sites (8 of 14) are estuarine. Delaware uses materials of opportunity such as concrete products and retired vessels as reef materials. Concrete piles deployed from an anchored barge are stable after initial settling and provide a high profile. All types of concrete are very durable, gaining strength over time. Delaware Bay provides foraging and breeding habitat for tautog and juvenile habitat for black sea bass, as well as seasonal habitat for flounder, triggerfish, scup, spadefish, croaker and a variety of pelagic types. The cost of production of donated concrete products is used to provide the required 25% match for federal Sport Fish Restoration funding. Match from concrete donations is more than enough to match the cost of the concrete deployment and excess can be used for vessels and other materials which do not generate match. Since December 2017, Delaware has been receiving rock from the Delaware Main Channel deepening project. Both bedrock and glacial rock have been placed on sites four, six and seven in Delaware Bay. To date, more than 2.1 million tons of granite have been placed on these sites. Benefits go beyond enhanced fishing as this habitat should enhance the growth and survival of estuarine-dependent juvenile black sea bass. Black sea bass are not harvested in Delaware Bay, but at ocean sites after they recruit into the recreational size category (12.5 inches). Delaware's ocean sites are the resting place for retired vessels of various sizes as well as non-traditional materials like retired NYC subway cars. Black sea bass, tautog and summer flounder are most commonly caught on these sites. Delaware uses a variety of monitoring efforts to characterize various aspects of the reefs. Periodic sidescan sonar surveys are used to ensure permit compliance for materials deployed and remaining stable on the reef. Diver sampling of the invertebrate community can be used to estimate the food resources available to fish, compared with the natural bottom. A randomized aerial flight survey estimates fishing effort on each site and these data are used to estimate the economic value of the reef program to the coastal economy of the tristate region, about $7 million/year in recent years. Delaware does not use state employees, prison, or volunteer labor to operate the program, but contracts with a marine contractor. For many years the reef program operated with annual projects. In 2018, DE DFW switched to

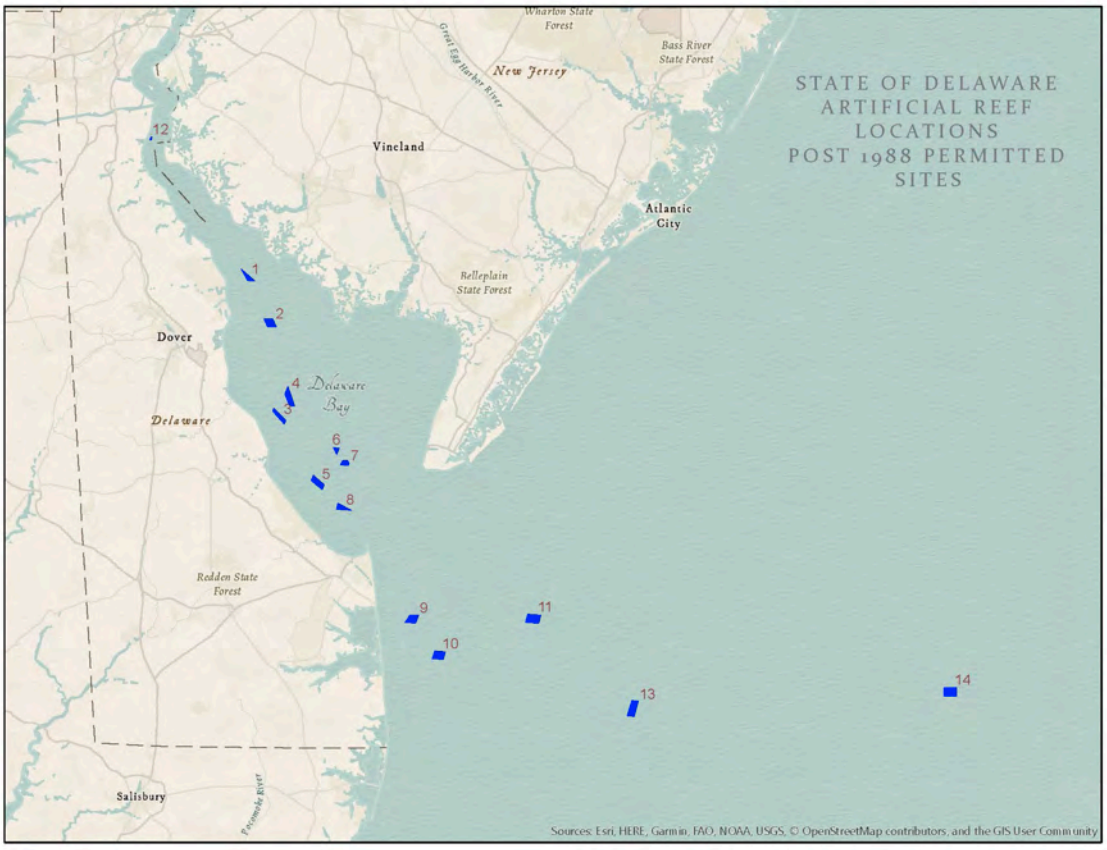


Figure 25. ARs in Delaware. All were permitted post-1988.

a five-year federal aid project and issued a request for proposals (RFP) seeking a marine contractor to do all concrete work, and to find, purchase, prepare, clean, tow, and deploy mutually agreed upon vessels. Each vessel just requires an addendum to the five year contract, which runs concurrent with the federal aid project. This five year format allows more time to generate match, which must be used in the project segment in which it is generated and the five year contract for the reef contractor eliminates the repetitious need to write a new contract for each project. With a steady funding source and a contractor dedicated primarily to reef work, Delaware has one of the most active reef programs along the Atlantic coast.

PROGRAM HIGHLIGHTS

Use of Non-traditional Materials

Reef materials should be thought of as having common characteristics, like stability, durability and being non-toxic. Materials not stable are subject to moving off the permitted site in storms. Materials not durable enough to last decades would be hard to justify the cost of deployment. Toxic materials will harm the environment. All of Delaware's usual materials, like concrete and steel ships, meet these criteria. When something different is offered it should be judged against these measures. In 2001, NYTA was retiring about 1,500 1960s vintage subway cars, painted red and nicknamed "Redbirds." These contained small amounts of non-friable asbestos, making remediation and recycling prohibitively expensive, so they were offered to the Atlantic coast reef programs. Delaware was able to effectively make the argument that asbestos was not an issue in the marine environment, and by comparison to a few Southeastern Pennsylvania Transit Authority cars surviving on a New Jersey reef site, that stability and durability were adequate. Delaware held a public meeting with National Oceanic and Atmospheric Administration (NOAA) and EPA representatives and local and regional environmental groups invited in order to educate the interested public. In the end, there was no opposition, and Delaware became the first of five states to accept cars, and did so early enough to make the project viable. After two rounds of deployments (2001-2003 and 2007-2009) Delaware accepted 1,329 cars

and Site #11 (Redbird Reef) went from bare bottom to fully developed. This is one of the most successful of Delaware's reef projects. A huge amount of reef material was deployed at no cost to the program in a short amount of time. The value of the donation of effort to clean the cars and barge them to Delaware was over $8 million and this provided match for other reef projects for 15 years.

Three State Effort (Delaware, New Jersey, and Maryland) to Sink the Retired Destroyer Arthur W. Radford

In early 2009, the U.S. Navy announced that they would make a retired 653 foot Spruance-class destroyer (Arthur W. Radford) available to the reefing community. This opportunity was rumored by 2006 and allowed time for planning and preparation. Delaware and New Jersey reef personnel got permission to tour the vessels, docked in Philadelphia. The states invited a marine contractor to join in order to get an idea of preparation costs and the volume of non-ferrous metals onboard, which would mitigate costs. Delaware had two deeper water reef sites permitted in 2006, to accommodate the vertical profile of a destroyer. These sites were selected to be nearly equidistant from Indian River Inlet (Delaware); Cape May, New Jersey; and Ocean City, Maryland. With joint development by three states as a goal, the sites were named Del-Jersey-Land Inshore (135 feet deep) and Offshore (190 feet deep). Delaware, being the permit holder was the lead agency. Delaware had to change its policy of not accepting title until after sinking, in order to comply with the U.S. Navy's policy of always transferring title to a state. This situation necessitated that the ARP deal with the State Insurance Commissioner regarding liability insurance. This was paid by the state with no cost to the Delaware ARP. In order to meet the rigorous application schedule, the three states had to tour the vessels again, advertise for a marine contractor and include them in the tour, issue an RFP to interested contractors, review and rank the proposals, then submit the winning bid with our application for the vessel to the U.S. Navy. There was much back and forth prior to the awarding of the vessel, including preparing an EFH Assessment. In June 2010, the Radford was moved to a private dock in the Philadelphia Navy Yard for preparation and the title passed to Delaware. One of DE DFW's goals was to show that properly done, large vessel projects need not take nearly a decade to complete, or cost $5-10 million, as has been the case with some other large vessel projects in other locations in the past. In our case, the Radford was sunk on August 10, 2011, 15 months after Delaware accepted title. Cost was less than $1 million, shared between Delaware, New Jersey, Maryland and the U.S. Navy. It is the longest vessel ever reefed in the Atlantic. Delaware was able to make this project work because they had an adequate reef site previously permitted; the vessel was docked in Philadelphia, minimizing the cost of towing; and it was relatively clean, having been built toward the end of the polychlorinated biphenyl (PCB) era. The contractor, American Marine Group, was a dedicated, experienced group specializing in reef development and intimately familiar with the Best Management Practices for preparing vessels for reefing. They performed all tasks from clean-up to creating diver safe spaces to towing and sinking, rather than sub-contracting many tasks.

A Great, Once in a Generation Windfall from Another Project

During the 1990s when reef development was just getting underway, the USACE was in the planning stages of deepening the Delaware Main Navigational Channel from 40 to 45 feet in depth to accommodate the upstream passage of more modern, deeper draft commercial vessels and to keep Delaware River ports (Wilmington, Delaware; Philadelphia, Pennsylvania and Trenton, New Jersey) competitive with other East Coast ports. Delaware Bay and the lower reaches of the river are all fine sediments, but as you approach upstream ports, two types of rock are encountered: bedrock which is blasted to the 45 foot depth profile, and large glacial boulders buried in sand. This rock is separated from fine sediment and small rocks and loaded by clamshell dredge into a hopper barge. A tug transports the barge to the permitted site where the rock is discharged at identified target locations. Rock placement continued until the required clearance above structure, generally 15 feet at bay sites, was approached. From December 2017 until March 2019, more than two million tons of rock were placed on these three sites. In that short time span, over 90% of the materials on the Delaware reef sites had become natural rock. Delaware may receive additional rock in the future from maintenance dredging of the spur channels. Based on the volume of the material, the fact that it was delivered at no cost to the reef program, and that it has promise to enhance black sea bass juvenile habitat, this project ranks very high as one of Delaware's best.

Virginia

VIRGINIA ARTIFICIAL REEF PROGRAM OVERVIEW	
ARTIFICIAL REEF DETAILS	
Number of Permitted Sites	5 (in federal waters); 18 (in inshore state waters)
Number of Mitigation Reefs	0
PROGRAM DETAILS	
Artificial Reef Management Authority	Virginia Marine Resources Commission (VMRC) under permits from the USACE
Average Annual Operating Budget	$69,520
Reef Coordinator	Alicia Nelson; *Alicia.Nelson@mrc.virginia.gov*
Shellfish Reef Program Contact (separate from the ARP)	Andrew Button; *Andrew.Button@mrc.virginia.gov*
Artificial Reef Website	*https://webapps.mrc.virginia.gov/public/maps/artificial_reefs_list.php*
Map of Deployments	*https://webapps.mrc.virginia.gov/public/maps/artificial_reefs.php*

Virginia became formally involved in AR development in 1972 with the acquisition of six surplus World War II Liberty Ships, under Public Law 92-402. Virginia was awarded six ships, and VMRC was deemed as the state's authorized recipient for these vessels, which were sunk at two offshore reef sites (Parramore Reef and Triangle Reef). In the 1980s Virginia began acquiring its own reef permits. Initially, permits in Virginia were held by private organizations, but were eventually turned over to VMRC over concerns with liability and financial responsibility for wash ups. Additional reefs were developed through a siting plan written as part of a three-year AR study, conducted for VMRC, by Old Dominion University (ODU). This siting plan was largely responsible for the present system of bay AR sites. VMRC now holds USACE construction permits for 18 bay and five ocean reefs. Three of these reefs: Back River, Gwynn Island, and Wachapreague were initially permitted to ODU for use as test sites. They were turned over to VMRC after the conclusion of the study. Additional sites were chosen with considerations based on the recommendations of the three year study and after reviewing such factors as water depth, existing users, bottom type, and distance to ramps and other facilities. Input was gathered from the sport fishing community, both by ODU and by the ARP, before making final site selection decisions. The most recent reef site was permitted in 2006. No new locations are planned at this time. Instead, the ARP has focused on providing updated material to the existing 23 locations within the ARP.

The current ARP is constrained by loss of the majority of the annual funding and all dedicated AR personnel over the last 10 years. The ARP exists almost entirely on donations of material from local construction programs, and is exploring partnerships with local fishing clubs and organizations for targeted deployments near popular fishing areas.

When material is offered for donation, VMRC staff inspect the material prior to deployment for compliance with USACE and EPA regulations. The most common reason for rejection is crumbling pieces or exposed rebar which

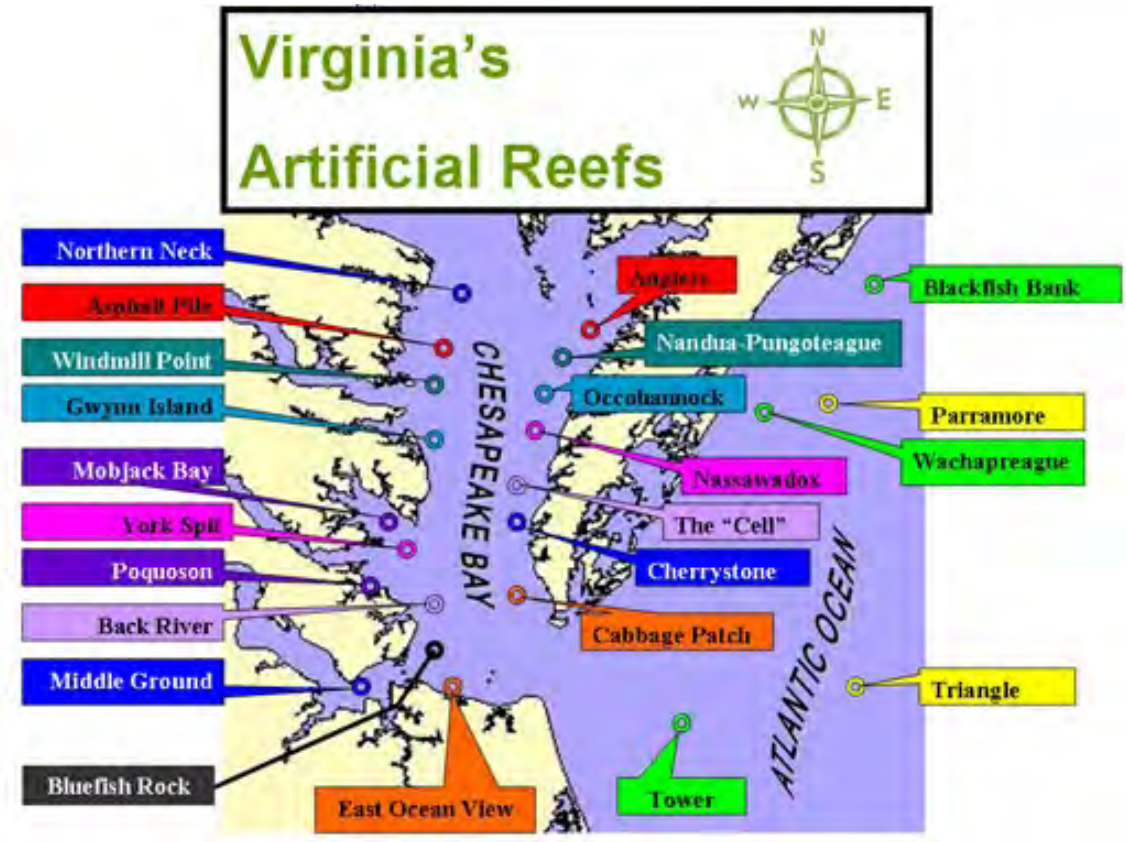


Figure 26. ARs in Virginia.

can be trimmed. VMRC staff is present for deployments and verifies the location and clearances of the materials deployed. Occasionally, the program receives donations by the U.S. Navy and local USCG of armored cable or concrete block.

Despite the reduced capabilities of the program in recent years, VMRC has focused on providing the deployment information in a more efficient way to the angling public. Beginning in 2017, new material locations were mapped using an online interactive mapping system and mobile application. These new interactive maps allow users to pinpoint GPS locations, zoom in and out of map features, and get metadata (such as date placed and amount of material) for each new deployment. Where available, previous deployment sites were incorporated into the new system.

PROGRAM HIGHLIGHTS

In 2016 and 2017, the Virginia ARP was very active due to multiple large deployments of bridge material from the replacement of the Lesner Bridge in Virginia Beach.

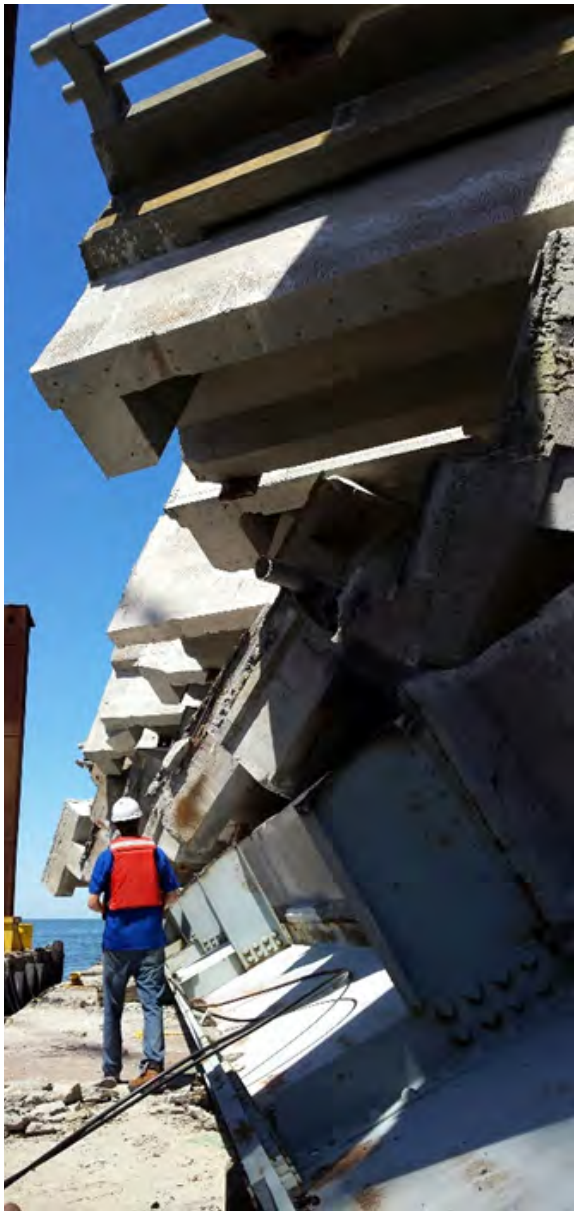
Permits for the bridge replacement required donation of usable materials to the ARP. Including this requirement early in the process simplified the donation. ARP staff met with representatives from McLean Contracting Company prior to demolition to clarify the donation process, choose sites (and backup sites) within the permitted locations, and to agree on protocol for material inspection and deployment.

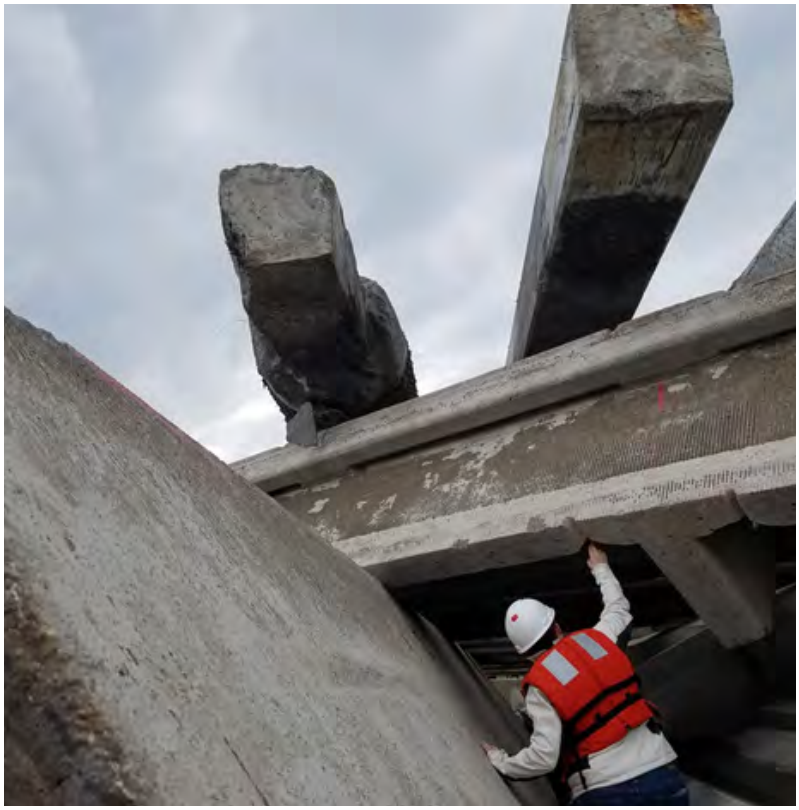
As the demolition progressed, VMRC staff had to be available to inspect material and monitor deployments in a timely manner so that construction would not be delayed. The material consisted of concrete girders, pieces of deck, pile caps, columns, and footings. Pre-deployment inspections were performed on every loaded barge

of material. The most frequent issue found was protruding rebar, which was trimmed from the material prior to deployment. Planning around weather conditions was difficult, as the VMRC observation vessel is smaller and less able to handle the conditions than most of the construction vessels.

Two preferred sites were chosen for the materials, one on each side of the Chesapeake Bay. This was done to provide options for the deployment teams based on wind and wave conditions on the scheduled days of activity. Most of the material (almost 10,000 tons of concrete) was placed at the Cabbage Patch Reef, while several deployments were placed at Blue Rock Reef when weather conditions were more favorable there. In total, over 13,000 tons of material from the Lesner Bridge replacement were deployed to ARs in the Chesapeake Bay.

While this type of deployment is entirely dependent on local construction projects, it is the most frequent type of the deployment for the Virginia ARP. There are several upcoming construction projects in the area that include plans to donate any usable material to the ARP. Despite the sporadic availability of large-scale construction projects, the number of bridge and other large construction projects in the areas surrounding the Chesapeake Bay provide a large resource in potential material for the ARP.





(left) Figure 27. Adam Kenyon (VMRC) inspects pieces of Lesner Bridge being donated by the McClean Construction Company to the Cabbage Patch Reef (2017). Photo credit: VMRC.

(above) Figure 28. Alicia Nelson (VMRC) inspects pieces of Lesner Bridge being donated by the McClean Construction Company to the Cabbage Patch Reef (2017). Photo credit: VMRC.

Figure 29. Deployment of Lesner Bridge material to the Cabbage Patch by McClean Contracting Company (2017). Photo credit: VMRC.

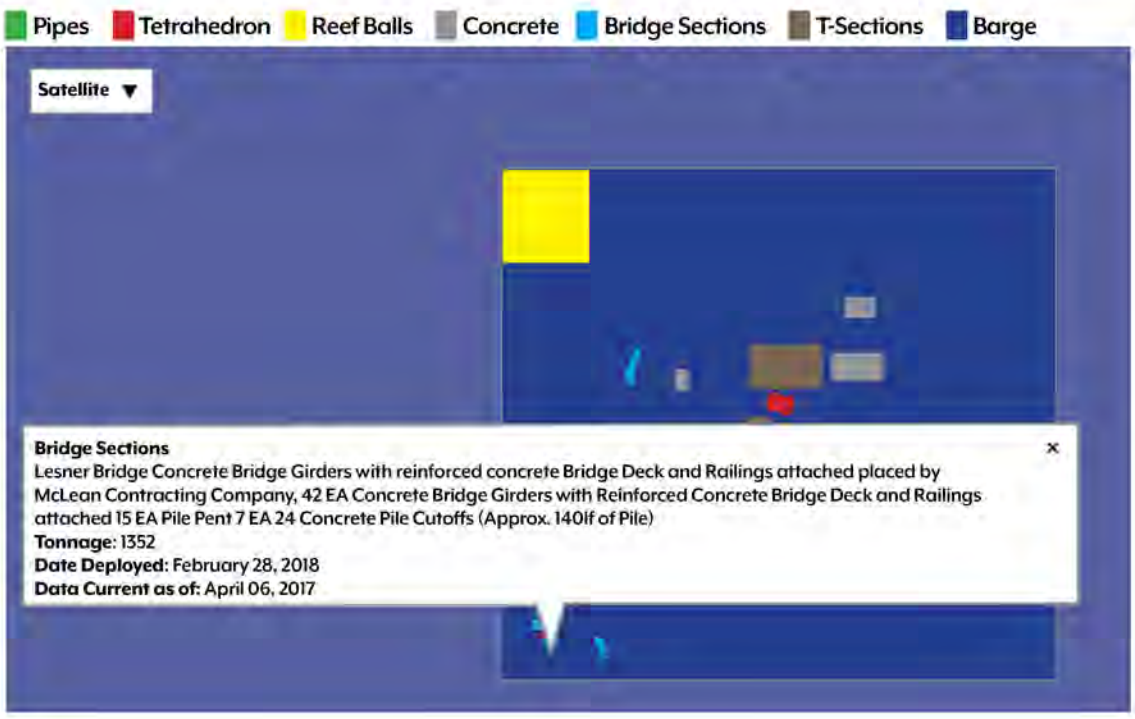


Figure 30. Interactive mapping tool for Virginia ARs. Image credit: VMRC.

North Carolina

NORTH CAROLINA ARTIFICIAL REEF PROGRAM OVERVIEW	
ARTIFICIAL REEF DETAILS	
Number of Permitted Sites	30 (in federal waters); 13 (in offshore state waters); 25 (in inshore state waters)
Number of Mitigation Reefs	0
PROGRAM DETAILS	
Artificial Reef Management Authority	North Carolina Division of Marine Fisheries (NCDMF)
Average Annual Operating Budget	$1,869,000
State Artificial Reef Plan	*http://portal.ncdenr.org/c/document_library/get_file?uuid=d7dddb18-f546-48c8-98d1-4cc43016ed2a&groupId=38337*
Reef Coordinator	Jordan Byrum; *Jordan.Byrum@ncdenr.gov*
Shellfish Reef Program Contact (separate from the ARP)	Jason Peters; *Jason.Peters@ncdenr.gov*
Artificial Reef Website	*http://portal.ncdenr.org/web/mf/artificial-reefs-program*
State Reef Publications	*http://portal.ncdenr.org/c/document_library/get_file?uuid=24160156-4b96-49e6-9126-4fa488b49cbb&groupId=38337*
Map of Deployments	*https://ncdenr.maps.arcgis.com/apps/webappviewer/index.html?id=3b27e8594cb6444c88b5525bf763aa55*

Since 1988 the North Carolina ARP has permitted and constructed 17 offshore reefs and 20 inshore ARs. These reefs have been distributed throughout the four major bays on the North Carolina coast and in each major sound. Various donated and pre-fabricated materials have been deployed on offshore and inshore reefs in efforts to create cost-effective habitat, such as recycled concrete, boat molds, and aircraft. Deployment locations and material types have historically been led by partnering groups with less focus on biological impact or material suitability. Monitoring of these materials for stability and longevity has limited the accepted material types to concrete structures and steel vessels, as all other types are susceptible to movement and quick deterioration.

In recent years, changes to legislation surrounding fishing license revenues have resulted in a large budget for materials and deployment for the ARP. This has enabled the ARP to regularly construct large projects offshore and continue to annually build small inshore reefs. In fall 2019, NOAA Fisheries issued a long-awaited programmatic Section 7 consultation, which evaluated the ARP's impact to protected species. This increase in funding and streamlined permitting process have expedited reef building in North Carolina. Planning of ARs is now aimed at maximizing the habitat value through material comparison with nearby natural reefs, planned longevity, and strategic methods of creating complex vertical structure.

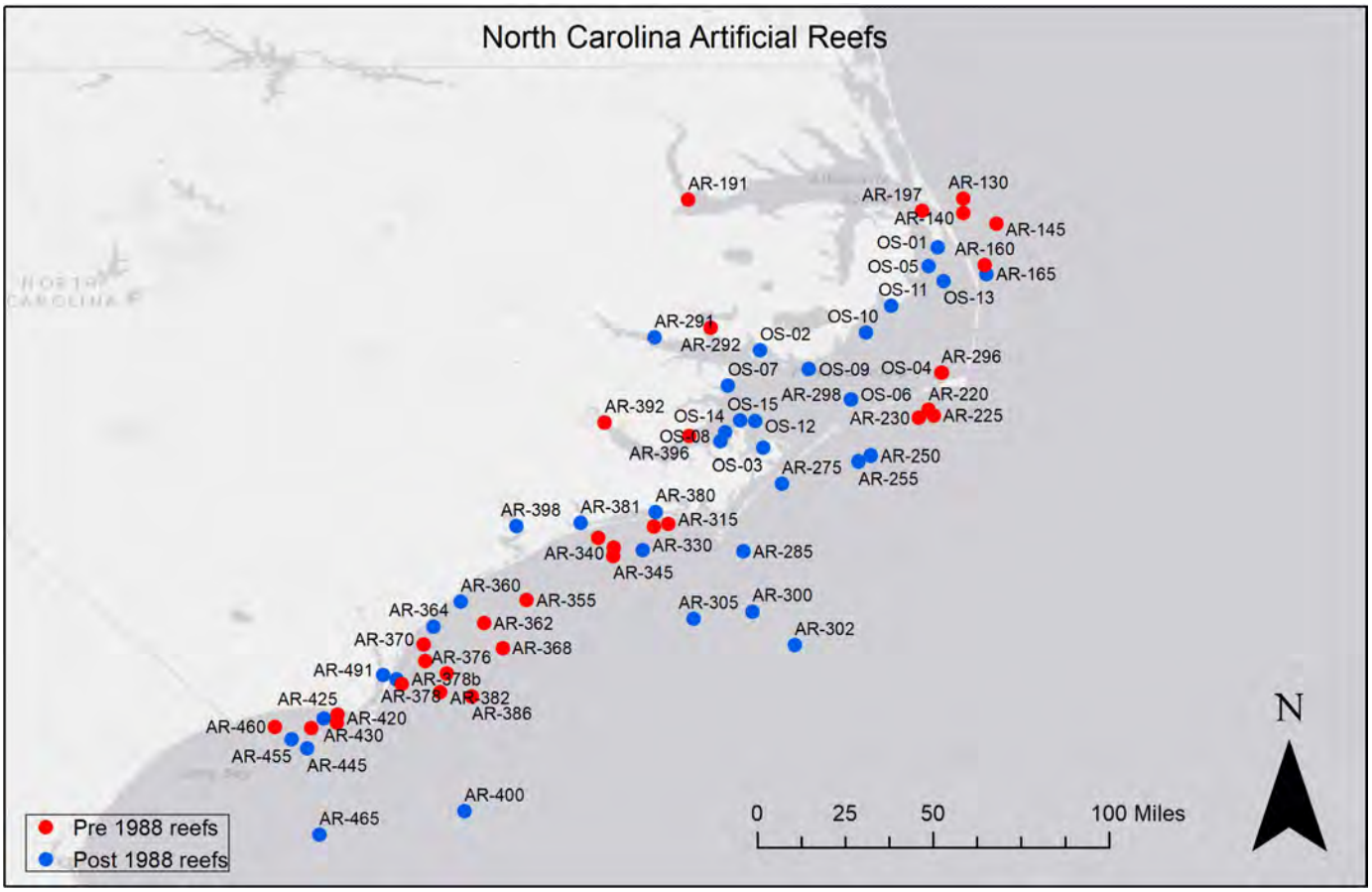


Figure 31. ARs in North Carolina. Red circles indicate reefs placed before 1988, and blue circles indicate reefs placed after 1988.

The ARP has conducted several projects on ocean reefs recently. Annual deployments of Eternal Reef Balls occur at AR-360, just offshore of Topsail Island. This is the result of a partnership between NCDMF and Eternal Reefs. The ARP also sank a 100 foot class tugboat, Fort Fisher, at AR-320 in September 2018. Almost 700 Reef Balls have been poured to be deployed at AR-250 and AR-255 off Ocracoke and AR-368 off Wilmington alongside a 180-200 foot class vessel. The construction of these sites was planned for early 2020 and is the second year of a four-year budget designated for reef material purchase, transportation, and deployment grant. Purchasing for a reef construction project is also in process at AR-165 off the Outer Banks using state funding secured by the Outer Banks Anglers Club. During late spring 2019, demolition of the Herbert C. Bonner Bridge over Oregon Inlet began. This bridge connected the islands of the Outer Banks and has recently been replaced with a new bridge. The old bridge is being disassembled and deployed at four nearby offshore reef sites: AR-130, AR-140, AR-145, and AR-160, totaling around 80,000 tons of concrete bridge material. As of November 2019 the project was around 50% complete.

In 2018, the ARP constructed two new inshore reefs, AR-380 and AR-381 in Bogue Sound. Both reefs are accessible by small boats or kayaks. AR-380 was constructed using 96 bay balls, and AR-381 used 50 NCDMF designed reef units. Each of these reefs were constructed with a division-owned vessel. Planning and purchasing for reef construction is underway for AR-197, located north of Roanoke Island, and will also be constructed using division-owned vessels.

The ARP continues to utilize a dedicated mapping vessel to survey all new reef enhancements and prospective sites. ARs are also monitored via SCUBA for material condition and by water quality sondes for seasonal

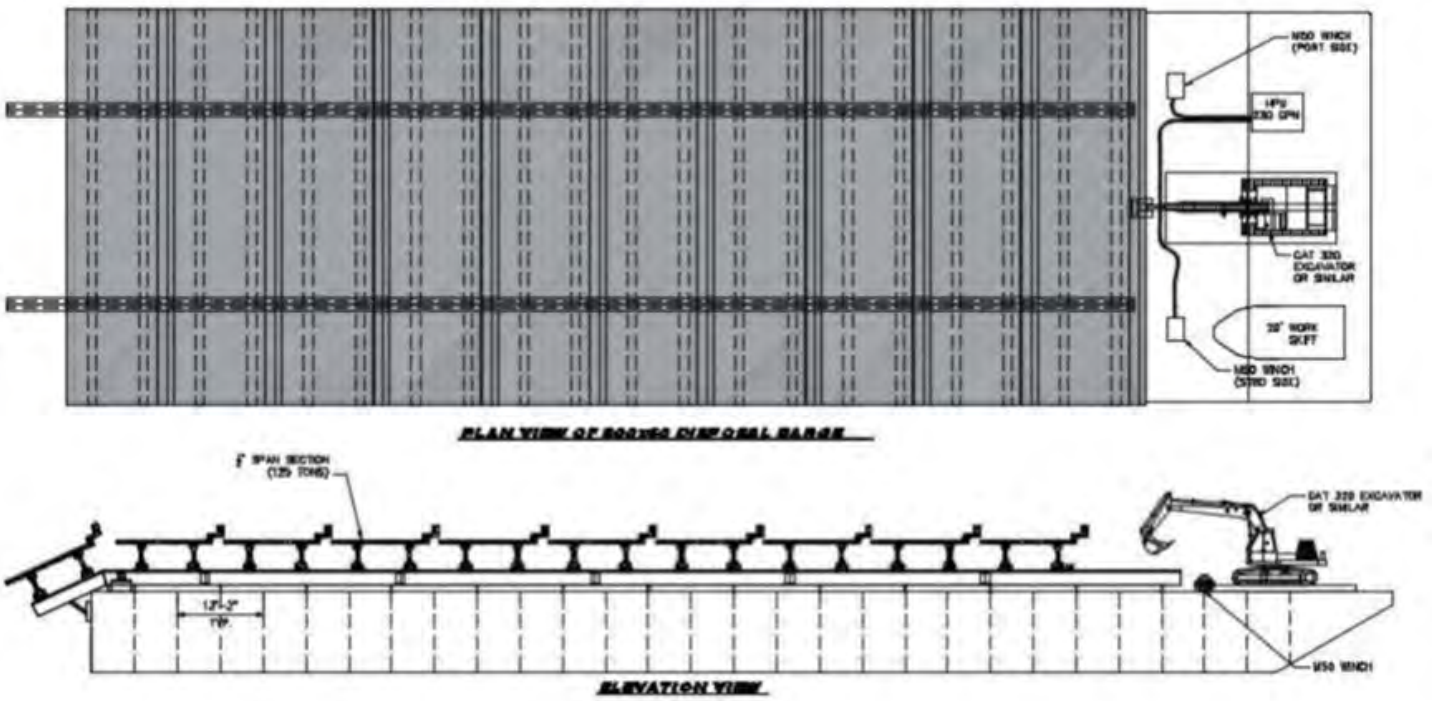


Figure 32. Blueprint from PCL Construction showing the deployment barge loaded with bridge material. Image credit: NCDMF.

changes in water quality. In early 2018, a new buoy system was implemented on all estuarine reef sites. These new buoys are small and can be serviced by outboard-powered vessels rather than a large self-propelled barge.

PROGRAM HIGHLIGHTS

In early 2016, construction of a new bridge over Oregon Inlet on North Carolina's Outer Banks began. This project was the culmination of efforts between numerous contractors, state and federal agencies, local groups, and municipalities. After completion of the new bridge, the old bridge was scheduled for demolition. This was anticipated to produce approximately 80,000 tons of concrete that would cost millions to crush and transport to landfills for disposal. Because of a well-maintained relationship with the North Carolina Department of Transportation (NCDOT), the NCDMF ARP was included in these discussions. Through coordination between NCDOT, their contractor, and NCDMF, a plan was developed to dispose of the bridge material on four ARs located offshore of Oregon Inlet.

As the permit holders, a major concern for the ARP included routine issues of accuracy of deployment within AR boundaries and avoidance of pre-existing reef material. The bridge material is loaded onto 250-foot barges with around 1,500 tons of material per barge. These are towed offshore by a tugboat. The material is seated on a set of rails fitted with hydraulic cylinders used to push the bridge pieces off. Maneuverability and fine-scale positioning of a barge under tow are somewhat limited, particularly in the ocean. In order to provide the highest likelihood of successfully placing materials in the desired area, deployment areas were designated as roughly 40 acres.

In order to ensure materials are deployed in the correct location and meet vertical clearance requirements, NCDMF staff are typically on-site for all deployments. Due to moving shoals and no regular maintenance dredging, Oregon Inlet is particularly dangerous and unpredictable. Decisions regarding reef deployments often are made with little advance notice. Deployment of bridge material is restricted by the tugboat's ability to

navigate the inlet with the barge. The lack of regular schedule, long travel distance from NCDMF office, and concerns about marginal weather in smaller NCDMF vessels made on-site monitoring challenging. To alleviate concerns about monitoring deployments, NCDMF is instead using Automatic Identification System (AIS) tracking software to monitor the tugboat and barge. The software allows for real-time monitoring of the deployment vessel's location with accuracy within the minute, as well as visualization of the deployment boxes within each reef.

As of November 2019, bridge deployments were just over 50% completed, all occurring well within the permitted boundaries and with very little outside of the designated deployment areas. Sidescan and bathymetric surveys were conducted after about 35% of deployments were completed. These confirmed the AIS tracking records of the deployments remaining in or very near deployment boxes, and all material remaining within each reef boundary. Continual sidescan and bathymetric surveys will be conducted at completion intervals. The project is estimated to be completed by spring or summer 2020.

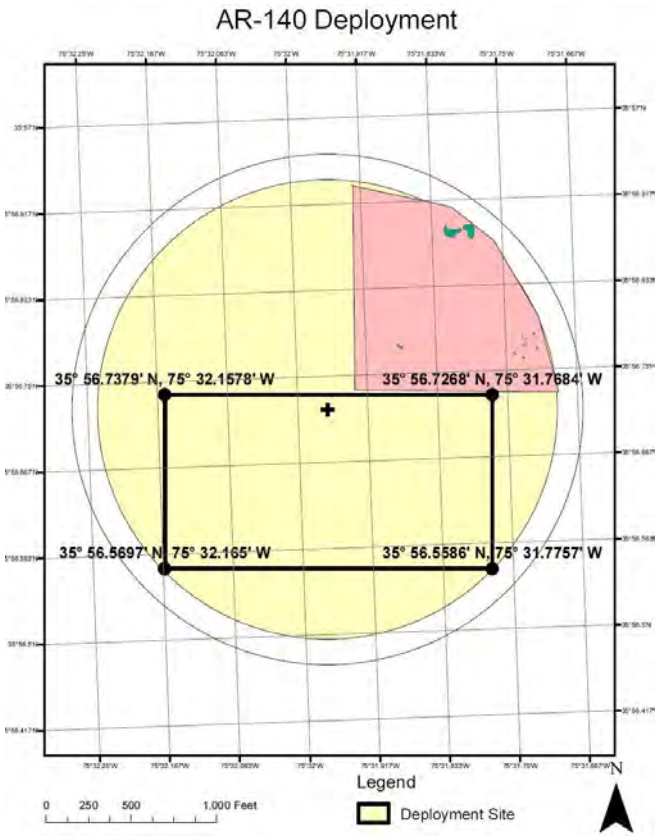


Figure 33: Deployment Plan for AR-140. Image credit: NCDMF.

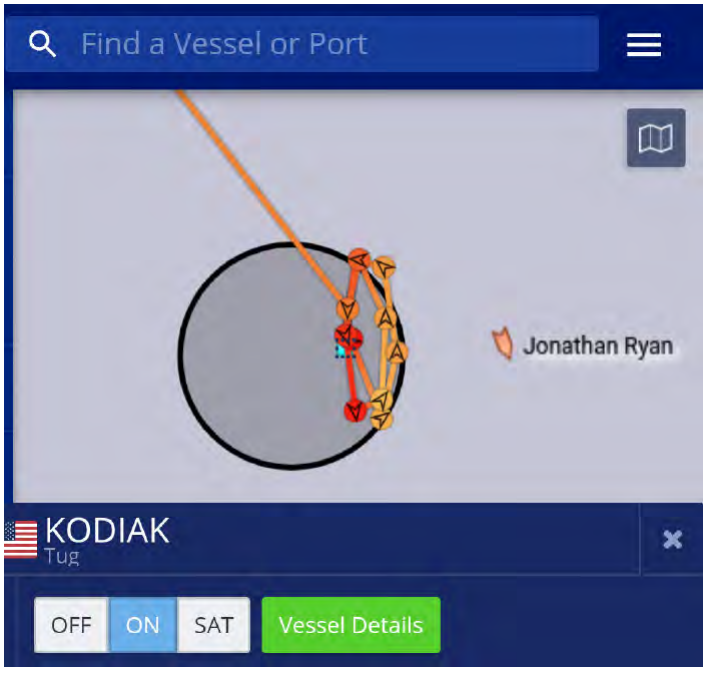


Figure 34: AIS Tracking of Deployment Barge on AR-160. Image credit: NCDMF.

Figure 35: Sidescan imagery of AR-140 bridge deployments. Image credit: NCDMF.

South Carolina

SOUTH CAROLINA ARTIFICIAL REEF PROGRAM OVERVIEW	
ARTIFICIAL REEF DETAILS	
Number of Permitted Sites	35 (in federal waters); 9 (in offshore state waters); 3 (in inshore state waters)
Number of Mitigation Reefs	0
PROGRAM DETAILS	
Artificial Reef Management Authority	South Carolina Department of Natural Resources (SCDNR)
Average Annual Operating Budget	$500,000
Reef Coordinator	Robert Martore; *MartoreB@dnr.sc.gov*
Shellfish Reef Program Contact (separate from the ARP)	Ben Dyar; *DyarB@dnr.sc.gov*
Artificial Reef Website	*http://saltwaterfishing.sc.gov/artificialreef.html*
List of Deployments	*http://www.dnr.sc.gov/artificialreefs/docs/ReefGuide2015.pdf*

The South Carolina Marine Artificial Reef Program (SCMARP) was created in 1973 to enhance recreational fishing and diving opportunities in the state's coastal waters and to enhance marine and estuarine fishery stocks by increasing the amount of productive hard bottom habitat on the ocean bottom. Initially, SCMARP was minimally staffed with state-supported personnel, but had no dedicated funds to support reef construction activities. ARs were constructed solely through donated materials and services or through funds specifically appropriated for individual projects. Reef construction activities were, as a consequence, sporadic, with little long-term planning or coordination. Prior to 1988 there were 23 AR sites in South Carolina estuarine and offshore waters constructed primarily of surplus materials.

In 1991, the state enacted the Recreational Fisheries Stamp Program (now the Saltwater Recreational Fisheries License Program) whereby anglers were required to purchase a license to fish in saltwater off the coast of South Carolina. A portion of the funds raised was dedicated to finance the SCMARP. With the addition of dedicated funding AR construction expanded considerably across the state. To better manage this anticipated growth, the SCDNR drafted the South Carolina Marine Artificial Reef Management Plan (1991). The plan outlines appropriate materials for use in reef construction, cleaning protocols for surplus materials, and provides long-term planning goals for equitable distribution of reef sites and materials across all coastal counties. SCMARP currently maintains 47 AR construction sites along approximately 160 miles of coastline. These sites range in location from estuarine creeks to as far as 50 miles offshore. Each manmade reef site consists of a permitted area ranging from several thousand square yards to as much as 24 square miles. A total of approximately 40 square miles of coastal and open ocean bottom has been permitted. The increase in number of permitted reef sites is not the only measure of growth for the program. Since introduction of the Recreational Fisheries Stamp Program the average number of yearly deployments on these sites has risen from less than six per year to 16.

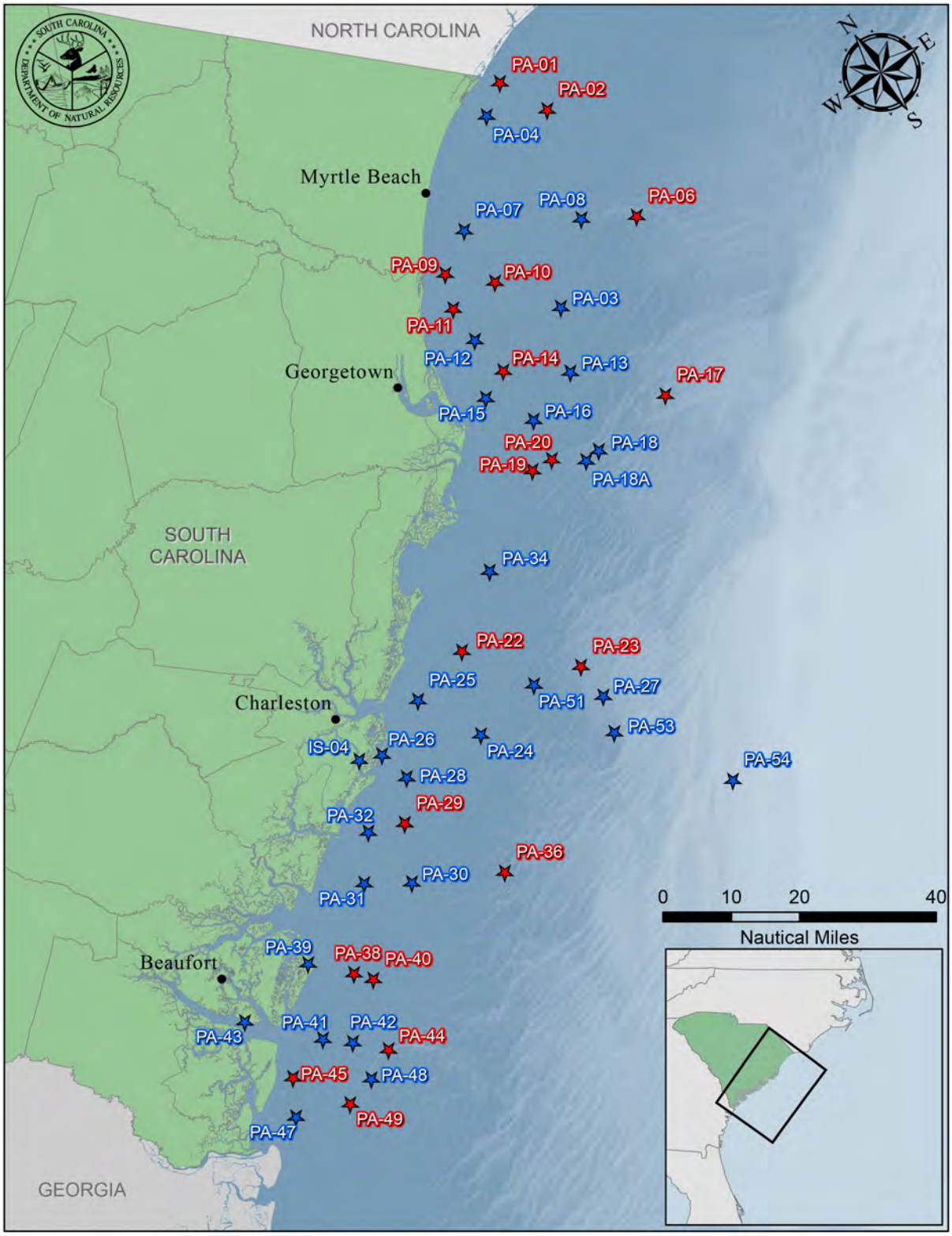


Figure 36. ARs in South Carolina. Red indicates reefs placed before 1988, and blue indicates reefs placed after 1988.

Since adoption of the Artificial Reef Management Plan, materials used in reef construction on South Carolina reefs have been much more highly regulated. Donated surplus items such as car and truck tires and automobile bodies were commonly used on the state's first ARs. Decades of observations of these materials has shown their limited value as long lasting reef structure, therefore, these items are no longer allowed for use in the SCMARP. Concrete structures, both surplus and designed, are currently the most commonly used materials in reef building. Surplus materials like culvert pipe or concrete junction boxes are usually donated to the SCMARP. Construction of designed structures are either contracted out or built in-house. SCMARP has designed, built, and tested over a dozen different designs of concrete reef habitat modules. Tens of thousands of these units have been placed on all reef sites across the state. Steel-hulled vessels are the next most commonly utilized material on South Carolina ARs. Hundreds of vessels ranging in length from 40-460 feet have been deployed on all reef sites across the state including barges, tugboats, freighters, trawlers, landing craft, as well as army and naval ships.

PROGRAM HIGHLIGHTS

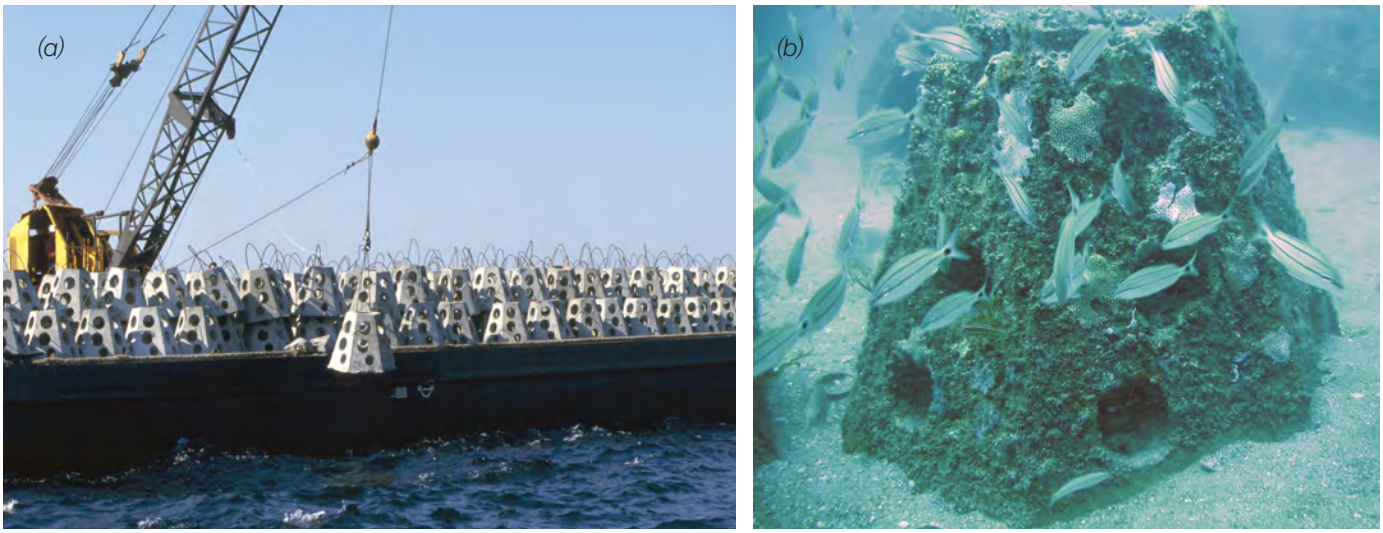


Figure 37 a and b. The design of concrete cones made by SCDNR allows stacking on a barge so that hundreds of units can be deployed at one time. Photo credit: SCDNR.

In addition to reef construction, SCMARP is responsible for monitoring and research activities on all South Carolina reef sites. SCMARP utilizes sidescan and hull mounted sonar, aerial surveys, and SCUBA to monitor colonization of reef materials, development of fish assemblages, and structural stability of reef materials. Past research projects have included examining heavy metals and PCBs in organisms found on ARs, feeding habits and trophic relationships of fishes on ARs, succession and biodiversity, and development of invertebrate assemblages. SCMARP is currently looking at the effect of invasive lionfish on ARs. To help better determine utilization patterns on ARs, acoustic receivers have been placed on numerous reef sites along South Carolina's coast to detect the presence of fish implanted with radio tags. They continue to show the seasonal presence of highly migratory species from as far away as Massachusetts and Florida, as well as local migrants (inshore to offshore) like sturgeon.

Many reef construction projects off South Carolina are conducted with assistance from outside organizations. From 1997-2014, SCMARP carried out joint reef building projects with the South Carolina Army National Guard. The Guard provided materials and assisted with de-militarization and cleaning of those materials while the state permitted all reef sites, provided permanent marker buoys on the sites, and conducts all follow up monitoring and underwater surveys. To date over 500 armored military vehicles, 250 steel shipping containers, and approximately 35,000 tons of concrete have been deployed through this cooperative program, creating over 1,120,000 cubic feet of new reef habitat. Nearly every AR site off South Carolina has received material from this project.

Figure 38 a and b. Armored personnel carriers are deployed on a South Carolina AR site. Photo credit: SCDNR.

Over the past decade, SCMARP has deployed numerous steel-hulled vessels with the assistance of the Coastal Conservation Association (CCA) of South Carolina. A typical project would involve reef program personnel identifying an appropriate vessel, coordinating either vessel purchase or donation, and arranging a contractor for cleaning, preparation, and towing of the vessel. Total costs would then be split between the SCMARP and CCA. Vessels procured through this partnership include barges, shrimp trawlers, landing craft, and tugboats. The long-term goal of this joint venture is to place smaller vessels on near-shore reefs and larger vessels on deeper reefs off each of South Carolina's coastal counties and, eventually, place CCA-sponsored material on every reef site off the state.

Figure 39. Two CCA sponsored 106-foot long tugboats sunk on 100-foot deep South Carolina ARs. The (a) General Oglethorpe and the (b) Grace McAllister. Photo credit: SCDNR.

To better manage the use of permitted manmade reefs in offshore waters and to ensure their long-term viability the SCDNR has, through the South Atlantic Fishery Management Council (SAFMC), obtained special management zone (SMZ) status for 29 of the 35 permitted reef sites located in federal waters (the remaining, newer sites are now also under consideration by the SAFMC for SMZ status). Fishing on those reef sites granted SMZ status is restricted to hand-held hook and line gear and spearfishing (without powerheads) and take is limited to the current recreational

bag limits. In 2014 the program began construction of a first-of-its-kind deep-water (>300 feet) AR marine protected area (MPA) with the goal of creating spawning habitat for deep-water snapper and grouper species and protecting spawning stocks. To create structures of sufficient size to be effective as reef material in 300 feet of water items such as steel I-beams, cell phone towers, 40-foot long container boxes, and a surplus derrick crane were welded to the decks of two 260-foot barges to create vertical structures nearly 100 feet in height. Subsequently, a 170-foot long steel bridge truss, also welded to the deck of a barge, was added to the site named the Charleston Deep Reef, creating the first AR MPA in the nation. Since creation of this protected reef site two of SCDNR's experimental ARs, originally permitted to examine the feasibility and possible benefits of establishing no-take manmade reefs solely for the purpose of stock and habitat enhancement, have been granted Spawning SMZ status by the SAFMC. Like the Type II MPAs in deeper water, fishing for or possessing species from the Snapper-Grouper Management Unit is prohibited within these areas. South Carolina now has three ARs deployed and maintained exclusively for the protection and enhancement of its reef fish fisheries resources.

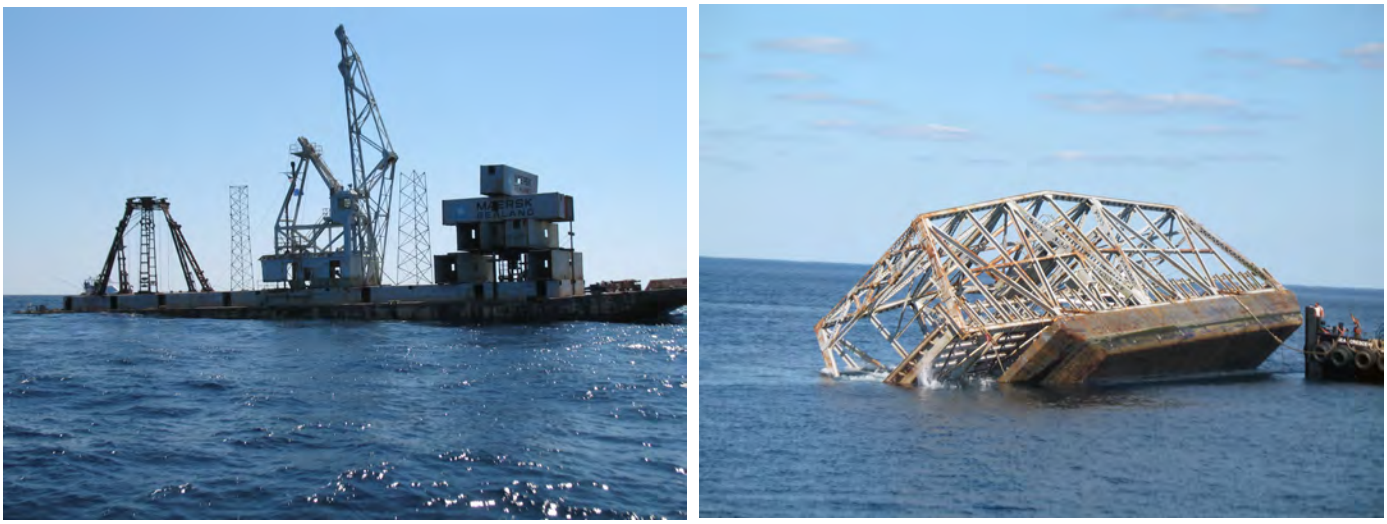


Figure 40. Barges with added profile and a steel bridge truss welded to a deck barge were used to create the Charleston Deep Reef Marine Protected Area. Photo credit: Robert Martore, SCDNR.

Figure 41. Warsaw grouper on the Charleston Deep Reef MPA. Photo credit: NOAA ROV footage, 2016.

Georgia

GEORGIA ARTIFICIAL REEF PROGRAM OVERVIEW	
ARTIFICIAL REEF DETAILS	
Number of Permitted Sites	28 (in federal waters); 3 (in offshore state waters); 15 (in inshore state waters)
PROGRAM DETAILS	
Artificial Reef Management Authority	Georgia Department of Natural Resources (GADNR), Coastal Resources Division under permits from the USACE and Georgia Coastal Marshlands Protection Act
Reef Coordinator	Paul Medders; *Paul.Medders@dnr.ga.gov*
Artificial Reef Website	*https://coastalgadnr.org/HERU*
Map of Deployments	*https://coastalgadnr.org/sites/default/files/crd/Reefs/Reef%20Booklet%202016%20Update%20%28Edited%205-24-17%29.pdf* *https://coastalgadnr.org/sites/default/files/crd/Reefs/InshoreReef-Web.pdf*
State Reef Publications	*https://coastalgadnr.org/HERU/downloads*

The Offshore Artificial Reef (OAR) Project in Georgia began in 1970 under the authority of the Georgia State Game and Fish Commission and is currently administered by GADNR's Coastal Resources Division (CRD). In the mid-1980s as inshore saltwater fishing's popularity grew in Georgia, so did anglers' desire for additional fishing sites. The CRD responded with Sport Fish Restoration, state, and private funds, to establish an Inshore Artificial Reef Enhancement Project.

The GADNR OAR Project is currently funded through federal dollars from the U.S. Fish and Wildlife Service's Federal Aid in Sport Fish Restoration Program. Historically, state funding was limited during the 1980s, although some budget increases were afforded sporadically during the 1990s and beyond through occasional legislative appropriations. Following the licensing of recreational fishermen in Georgia's marine waters in 1998, funding for the OAR Project increased and stabilized. In recent years additional funding has been generated for marine habitat enhancement through the sale of specialty license plates. The first projects funded through this revenue source are in progress.

Items used for AR enhancement in Georgia are typically materials of opportunity. For example, in 2015, the CRD deployed approximately 400 concrete transmission line poles and bases donated from the Georgia Power Corporation, the Georgia Transmission Corporation at AR F.

In 2018, the CRD deployed ~3,000 tons of concrete and metal materials, as an enhancement to AR DRH. The size of this deployment was only possible through the support of a numerous partners. This included funding from Federal Aid in Sport Fish Restoration, the Sapelo Saltwater Fishing Club, CCA of Georgia, and the Building

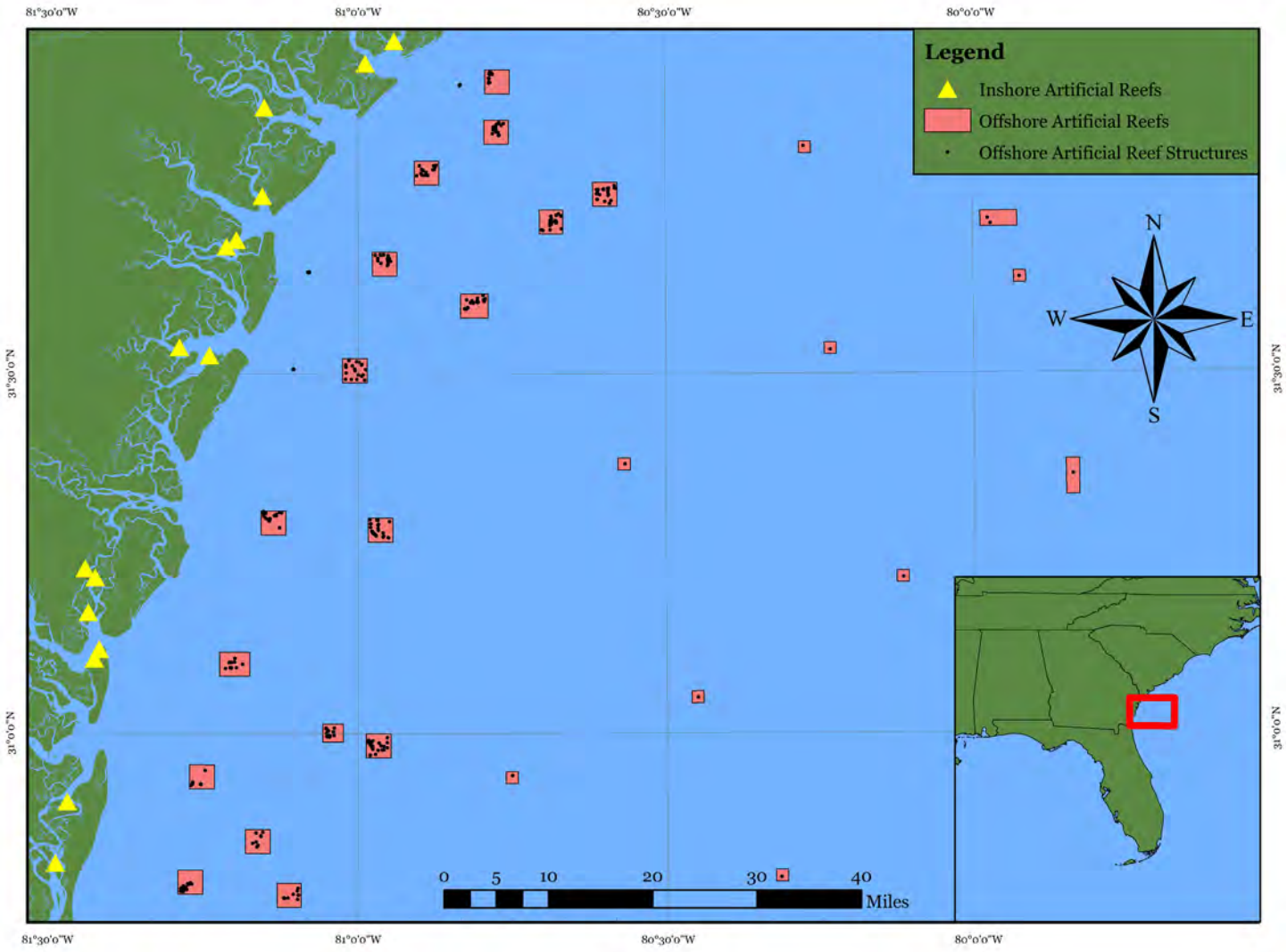


Figure 42. ARs in Georgia.

Conservation Trust – CCA's National Habitat Program – as well as the donation of materials from the City of Brunswick, Georgia and Claxton Poultry Company.

Partnerships also provide opportunities to acquire materials that are not normally available such as subway cars. Through a multi-year partnership with NYTA the CRD has deployed total of 182 subway cars, the most recent of which was a deployment of 44 cars at reef JY in 2009.

Florida

FLORIDA ARTIFICIAL REEF PROGRAM OVERVIEW	
ARTIFICIAL REEF DETAILS	
Number of Permitted Sites	48 (in federal waters); 38 (in offshore state waters); 10 (in inshore state waters)
Number of Mitigation Reefs	32
PROGRAM DETAILS	
Artificial Reef Management Authority	The FWC ARP provides financial and technical assistance to local coastal governments, nonprofit organizations, and universities to develop and monitor ARs. ARs must be deployed in designated permitted areas that are regulated by the USACE and must also meet additional Department of Environmental Protection (DEP) permit requirements in state waters.
Average Annual Operating Budget	$600,000
Reef Coordinator	Keith Mille; *Keith.Mille@myfwc.com*
Shellfish Reef Program Contact (separate from the ARP)	Katie Konchar; *Katie.Konchar@myfwc.com*
Artificial Reef Website	*https://myfwc.com/fishing/saltwater/artificial-reefs/*
Map of Deployments	*http://myfwc.maps.arcgis.com/apps/View/index.html?appid=4675e1db32ac43a9a4308e757965d17d%20%20*
State Artificial Reef Plan	*https://myfwc.com/media/4889/flarstrategicplan2.pdf*

The FWC Division of Marine Fisheries Management administers a state ARP that was legislatively created in 1982. In November 2003, the FWC adopted a state Artificial Reef Strategic Plan developed by an advisory board of interested stakeholders. The plan listed several goals of the ARP to ensure that ARs are utilized to benefit Florida's economy and fisheries, while also being incorporated into research projects to obtain a better understanding of how ARs impact the ecological function of an area. Over the last 37 years, Florida has distributed more than $26 million in state and federal funds to local coastal governments, non-profit organizations and state universities for AR-related activities. Florida tracks ongoing AR deployments using patch reef designations, which is defined as any material within 150 feet of each other. Of the greater than 3,600 artificial patch reefs that have been constructed and deployed offshore of Florida: 38% are secondary-use concrete materials, 33% are prefabricated concrete modules, 15% are vessels/barges, 8% are metal, 4% are boulders, and 2% are other materials. Each year, approximately 140 patch reefs are added in Florida waters.

The ARP allocates federal funds from the U.S. Fish and Wildlife Service Federal Aid in Sport Fish Restoration Program through an annual grant cycle, which is awarded to applicants based on a suite of criteria. The funds available for this program have been steadily funded for the past decade, providing funding for typically seven to eight construction projects and two to three monitoring projects annually. Competition for grant funds is high due to rising AR deployment costs and the lack of available material, so the total funding requested through the grant

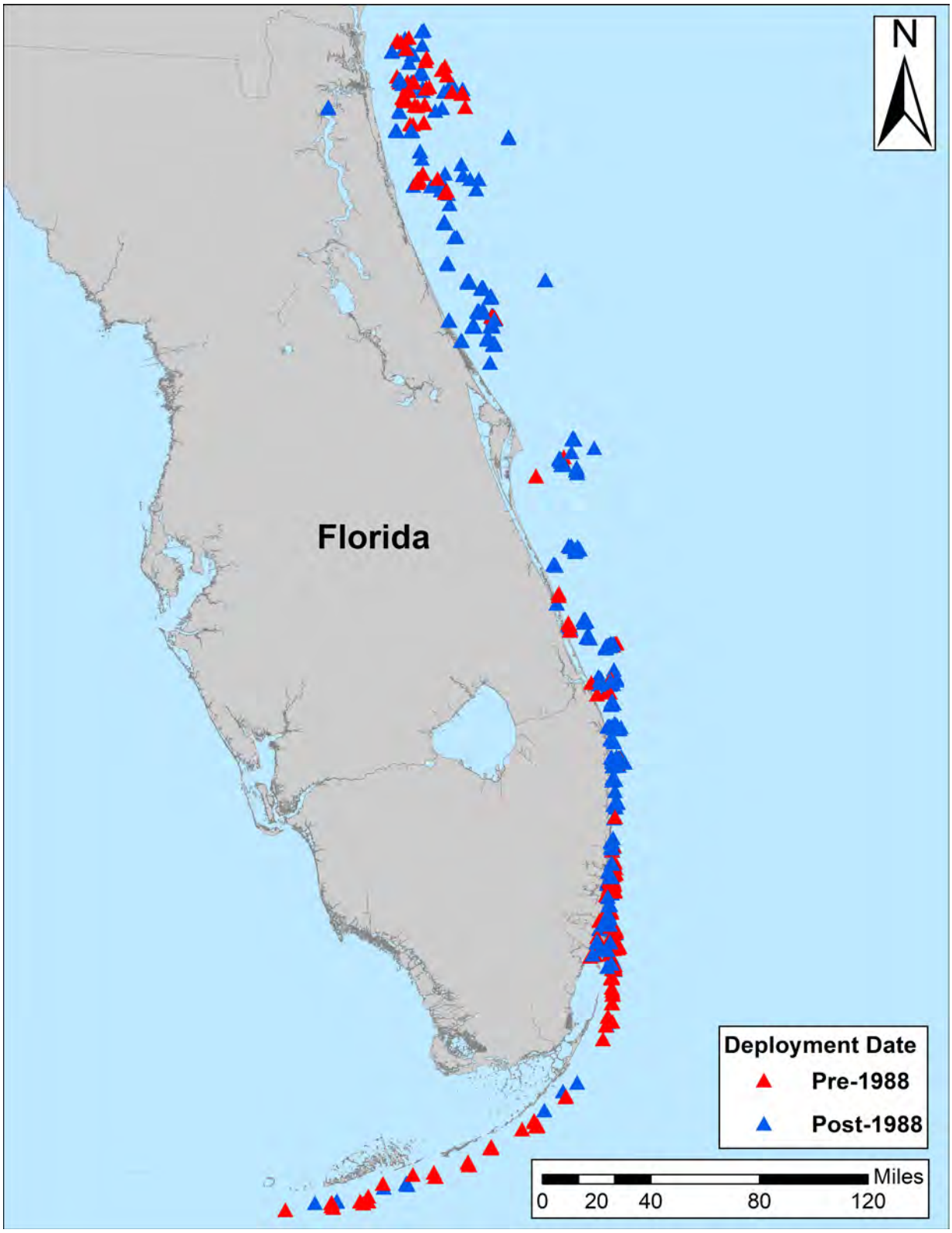


Figure 43. ARs on the east coast of Florida. Red triangles indicate reefs placed before 1988, and blue triangles indicate reefs placed after 1988.

program is typically double the available funds. In addition to managing annual grant awards, the FWC ARP also conducts fish censuses, sidescan sonar mapping, material evaluation, and other monitoring activities. These activities are conducted in-house by small team within the ARP, which consists of an environmental administrator, two permanent fishery biologists and one temporary fishery biologist. The information gained from these monitoring activities is used to evaluate the change in fish community spatially and temporally, impacts from environmental perturbations (e.g. hurricanes, red tide, etc.), and durability of various AR material. One of the current monitoring projects being conducted by FWC staff is using underwater hydrophones to record boat noise in proximity to ARs to quantify and compare boater visitation rates at different reef sites. FWC also recently funded another project that will evaluate the difference in permit (*Trachinotus falcatus*) spawning aggregation behavior and fishing mortality at natural and AR sites in the Florida Keys. These monitoring projects are examples of how the FWC ARP selects specific projects for funding to help achieve AR and fisheries management objectives.

In addition to grant management and monitoring, another important role of the FWC ARP is to provide opportunities for stakeholders to discuss issues related to AR management. The FWC ARP and Florida Sea Grant organize regional AR workshops every two years, and a statewide AR summit every five years. These venues provide an opportunity for a diverse group of stakeholders (e.g. county managers, fishers, non-profit organizations, researchers, etc.) to disseminate information regarding AR best practices, new research findings, and future challenges for AR development in Florida.

PROGRAM HIGHLIGHTS

With over 3,600 AR patch reefs state-wide, Florida has a diverse assemblage of AR habitats between the Atlantic Ocean, Gulf of Mexico, and estuarine regions throughout the state. Recent trends include an increase in the use of concrete module ARs, including more requests for artform ARs (e.g. statues), and an increase in efforts for more purpose-built ARs to provide habitat to satisfy fisheries management objectives. Large steel vessels continue to be popular and deployed statewide despite rising costs to prepare and deploy. Large bridge demolition projects continue to comprise the greatest tonnage of AR deployments overall, while use of secondary-use concrete such as concrete culverts and manholes are in decline due to lower availability from an increase in concrete recycling. The use of ARs as mitigation to offset impacts from beach nourishment or ship groundings continues, with advancements in material design such as the ability to be used as nursey areas for reef-building corals. The following paragraphs spotlight three recent projects off southeast Florida.

Palm Beach Reef Darts

During 2017, Palm Beach County worked with one of the oldest recreational fishing clubs in Florida (Palm Beach Fishing Club) to design a "reef dart" module that uses concrete power poles to create an array of high relief features to attract grouper and pelagic fish species. Ultimately, the Palm Beach Fishing Club wants to focus on building deepwater reef habitat to attract snapper and grouper species at depths greater than 400 feet. There have been three deployments of this module type as of 2019, so the long-term success of this module type is still unknown. The first version of the reef darts was deployed offshore Palm Beach in a depth of 105 feet. Post-deployment dives observed that several of the poles had snapped during deployment upon impact to the seafloor, and the reef darts were placed too far apart (>100 feet). The reef dart design was upgraded with a reinforced power pole base to prevent it from breaking on impact, and a larger (40 feet) power pole made from pre-stressed concrete. Each module measures 45 feet tall, weighs 8 to 10 tons, and costs ~$3,500 to create. The improved reef darts were deployed in the same location as the first deployment but were placed closer together in order to create more complex habitat. The strong current made the deployment challenging and some of the reef darts were damaged when they landed on top of one another during deployment. The majority of the reef darts were undamaged and provide the relief and complexity that the fishing club was hoping for.

The most recent deployment of reef darts occurred in 2019 offshore Palm Beach at a depth of 500 feet. The deeper reef darts were deployed to create habitat that was attractive to deep water grouper species. Researchers from the Florida Fish and Wildlife Research Institute are planning on placing acoustic receivers at both the shallow and deep reef dart site to track fish movements around each site. In addition, the West Palm Beach Fishing Club is planning to deploy deep water video gear to monitor changes in the fish community at the deep reef dart site.

Figure 44. Reef darts that were deployed offshore Palm Beach, where some of the structures were damaged during deployment. Each structure is around 30 feet tall and was designed by a local fishing club.
Photo credit: FL FWC.

The reef dart initiative is a great example of the collaboration between local fishermen, county managers, and state agency representatives to create ARs to achieve a specific goal defined by the local stakeholders. Additionally, the partners involved have plans to monitor the sites to evaluate project performance, user satisfaction, and to determine if their goal is being met.

USS Vandenberg

The U.S. Navy and the U.S. DOT Maritime Administration (MARAD) will occasionally have large decommissioned military vessels available as a donation to the states for shallow water ARs (less than 500 foot depth) as an authorized disposal option. Availability of large military ships for donation is typically greatest when the value of scrap steel and other metals is low, resulting in high costs to otherwise scrap the decommissioned vessels. A 540 foot long former missile tracking ship, the USS Vandenberg, became available from MARAD for reefing in 2001 but the estimated cost of cleaning and deploying the vessel was $5.69 million. The high cost was due to the size of the vessel, the deteriorating hull and cleaning of PCBs. MARAD committed to covering a portion of the cleanup costs, but funds had to be raised by Monroe County, the City of Key West, the state of Florida (FWC and the Florida Office of Tourism and Economic Development), and private donors before the title would be transferred.

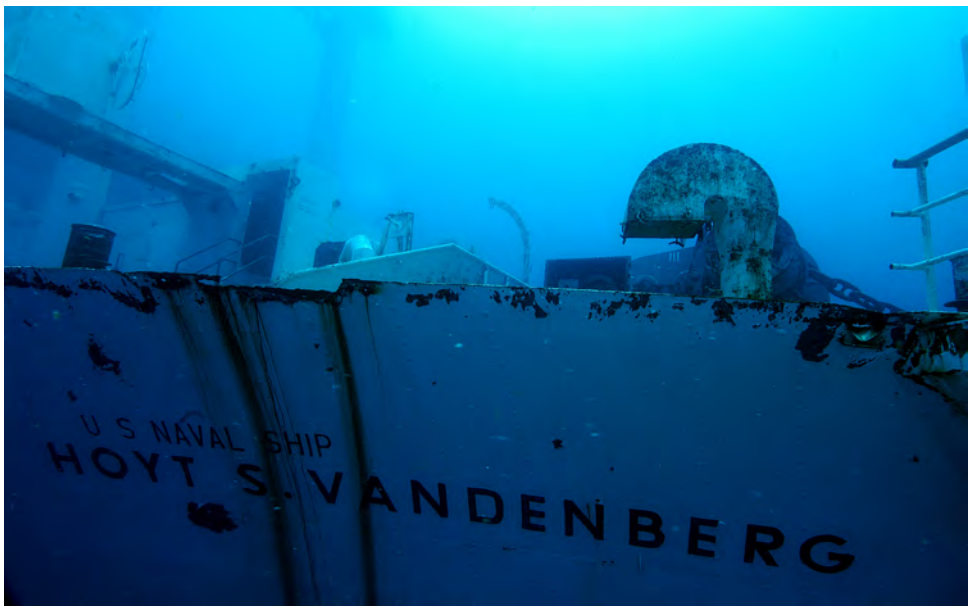


Figure 45. Bow of the USS Vandenberg offshore Key West after it was deployed in 2009.
Photo credit: FL FWC.

By the time the Vandenberg entered dry dock in April 2007, PCB remediation costs were

significantly higher than expected and the vessel was eventually seized by the U.S. Marshal due to back bills owed to the shipyard. FWC and Florida's Governor's Office approved another $2.6 million to salvage the project and cover outstanding debts. The Vandenberg was towed to Key West in 2009 where a series of walkthrough inspections were conducted by FWC and the EPA to ensure cleanup was completed in accordance with all state and federal regulating requirements. In May 2009 the Vandenberg was successfully sunk within a designated permitted area six miles off Key West at a depth of 142 feet within the boundaries of the Florida Keys National Marine Sanctuary.

In September 2017, a major Category 4 storm (Hurricane Irma) impacted the Florida Keys. Post-hurricane dives on the USS Vandenberg indicated that the vessel was still upright but it had shifted towards deeper water and one of the radar dishes was ripped off. However, this vessel still remains an iconic dive spot for visitors and residents of the Florida Keys. Divers visiting the vessel can observe a wide range of reef fish species from smaller tropical fish (damselfish, *Chromis*, butterflyfish, etc.), resident Goliath grouper, and large pelagic species (amberjack, sharks, horseeye jacks, etc.). A socio-economic study also found that the Vandenberg contributed to significant increases in business for dive operators resulting in an increase in sales, income, and employment in the Florida Keys economy.

Boca Step Reef

Palm Beach County has been constructing nearshore limestone boulder reefs since 2009 to create "stepping stone" reefs to promote offshore movement of recreationally and commercially important fish species from inshore nursery habitat. Southeast Florida has experienced a decline in nearshore hard bottom habitat due to beach nourishment, so the step reef concept is trying to regain some of this critical habitat. Four of the nearshore boulder reefs were monitored by a non-profit organization in 2018, and the limestone boulder sites had the highest average abundance of fish compared to other reef types and over 40 unique fish species between the reef sites. The fish species observed at these sites included schooling baitfish as well as juvenile/sub-adult grunts, wrasses, jacks, and snapper. However, it has yet to be determined as to whether these nearshore reefs have increased the density of fish species at adjacent offshore reefs.

The FWC ARP funded Palm Beach County to deploy another nearshore limestone boulder reef in 2018. The limestone boulders were deployed in a depth of 35 feet to create a patch reef consisting of 15 foot tall limestone boulder piles that are approximately 100 feet apart. Each pile is comprised of approximately 250 tons of 3-4 foot diameter boulders at the cost of about $60,000 per patch reef ($240 per ton). They were placed in an area devoid of hard bottom so there would be no unintentional impacts to the existing natural reefs in the region. Monitoring of over two dozen ARs offshore Palm Beach County conducted by a non-profit organization in 2015 found that the three AR sites with the highest abundance of fish were all step reefs.

Figure 46. Florida Fish and Wildlife biologist inspecting the recently deployed Boca Step Reef boulders in Palm Beach. Photo credit: FL FWC.

Conclusion

ARPs on the Atlantic coast have seen many changes over the past three decades. These range from changes in material selection, usage of new technology, and increasing complexity in permitting reef projects. Despite some differences in program structures, funding, and objectives, many similarities exist across state lines.

Since 1988, program use of most reef materials have shifted towards those with superior performance value such as heavy concrete structures, aggregate rock, and steel vessels rather than tires, vehicles, and other assorted scrap metal which lack stability and durability. This transition was just beginning at the time the state profiles were originally published in 1988. With recently updated material guidance *(Guidelines for Marine Artificial Reef Materials Third Edition)* there is reef building consistency among state programs on the Atlantic and Gulf coasts. Interestingly, in the 1988 report, several states described plans to build prefabricated concrete structures. These structures are ubiquitous among reef programs today.

Nearly every state has embraced new technologies like ROVs, underwater video cameras, sidescan sonar, multi-beam surveys, and GPS to designate new sites, map existing materials, and evaluate established reef habitats. These technologies provide considerably more information about reef sites than was previously known and provide more accurate methods (GPS) for placement and users to locate deployed materials. Many state reef programs have developed reef guides and other related online and printed reef resources so anglers and divers can identify reef site locations and compositions.

Over the past three decades it's become commonplace to conduct bathymetric surveys and benthic characterizations before reef construction permits are authorized. Survey requirements are not the only changes to the permitting process. In many states, USACE now requires consultation with NOAA Fisheries Protected Resources Division to assess impacts of ARs to protected species and EFH. Additional consultations are also required with many state and federal agencies including but not limited to the USCG, EPA, U.S. Fish and Wildlife Service, and National Ocean Service. Mapping technology advancements have improved each reef program's ability to identify key areas for AR enhancement, avoid impacts to essential fish habitat, and adhere to changing state and federal requirements. However, this process has slowed reef construction in several states and is a topic of increased concern for ARPs. With the limited resources and budgets for many ARPs, meeting these requirements has significant costs and ultimately decreases the programs' ability to effectively enhance fish habitat through AR projects.

Though there are many differences in individual state reef program characteristics (e.g. size and funding), some overarching themes are consistent. Large reef projects are often made possible through donation of acceptable materials and services from local entities such as the state's DOT or private companies. Reefing of project material (i.e. concrete and steel bridge material) is most attractive to companies looking for a low-cost disposal method. Many projects are located on or near the water which facilitates the transport of the material to a reef site. State programs typically do not have funding to conduct projects of this scale on their own, as waterfront property is at a premium, causing state programs to have less opportunity to accept and stockpile donated material.

Research needs are broadly similar among states. Some reef programs are affiliated with local universities interested in evolving reef research issues. Emphasis is given to existing habitat enhancement, fisheries production, population dynamics, and reef usage by fishermen and divers.

ARPs continue to provide beneficial use of aquatically recycled materials of opportunity that create new research, fishing, and diving opportunities in the coastal U.S., as well as contribute to responsible fisheries management.

Appendix

Abbreviations and Acronyms

in order of appearance

AR	artificial reef
MA DMF	Massachusetts Division of Marine Fisheries
USCG	United States Coast Guard
UVC	Underwater Visual Census
BRUVS	Baited Remote Underwater Video Stations
NEU	Northeastern University
EPA	Environmental Protection Agency
DOT	Department of Transportation
RI DMF	Rhode Island Division of Marine Fisheries
EFH	Essential Fish Habitat
SHU	Sacred Heart University
USACE	United States Army Corps of Engineers
CIRCA	Connecticut Institute for Resilience and Climate Adaptation
NYSDEC	New York State Department of Environmental Conservation
GEIS	Generic Environmental Impact Statement
SGEIS	Supplemental Generic Environmental Impact Statement
ROV	Remote Operated Vehicle
NOAA Fisheries	National Oceanic and Atmospheric Administration National Marine Fisheries Service
MORF	Moriches Offshore Reef Fund
Reef Initiative	Governor Andrew Cuomo's Artificial Reef Initiative
NYPA	New York Power Authority
NYTA	New York Transit Authority
NYDOT	New York Department of Transportation
NYCC	New York Canals Corporation
NYC	New York City
NAGD	National Grid
NJDFW	New Jersey Division of Fish and Wildlife
DE DFW	Delaware Division of Fish and Wildlife
RFP	request for proposals
PCB	polychlorinated biphenyl
VMRC	Virginia Marine Resources Commission
ODU	Old Dominion University
NCDMF	North Carolina Division of Marine Fisheries
NCDOT	North Carolina Department of Transportation
AIS	Automatic Identification System
SCDNR	South Carolina Department of Natural Resources
SCMARP	South Carolina Marine Artificial Reef Program
CCA	Coastal Conservation Association
SAFMC	South Atlantic Fishery Management Council
SMZ	Special Management Zone
MPA	Marine Protected Area
GADNR	Georgia Department of Natural Resources
OAR	Offshore Artificial Reef
CRD	Coastal Resources Division
FWC	Florida Fish and Wildlife Conservation Commission
DEP	Department of Environmental Protection
MARAD	Maritime Administration

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