Restoration of Osborne Tire Reef
Status Report
Fiscal Year 2023-24

Office of Resilience and Coastal Protection
Florida Department of Environmental Protection
December 2023

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Executive Summary

The Osborne Tire Reef, a site located off the coast of Broward County, consists of over 1 million used tires bound for disposal that were placed between two coral reefs tracts in the 1970s for fishery enhancement purposes. Since the early 2000s, the state and its partners have embarked on a restoration effort to remove tires and more recently, relocate coral from the tires in order to protect and restore the reef tract. In response to the large number of tires remaining and their continued impacts to the natural reef habitat, the 2023 Legislature enacted the Restoration of Osborne Reef Act, (Chapter No. 2023-126 [HB641 / SB546]). This Act requires the Florida Department of Environmental Protection (DEP) to submit a Status Report on the tire removal efforts (due Dec. 1, 2023) and develop a Restoration Plan for the impacted reef (due July 1, 2024).

This Status Report is provided to address the following bill requirements:

> *"By December 1, 2023, the Department of Environmental Protection shall submit a report to the President of the Senate and the Speaker of the House of Representatives on the status of the Osborne Reef cleanup and tire removal project. At a minimum, the report must include a description of the condition of the remaining Osborne Reef structure, any restoration efforts undertaken to restore the reef structure, the number of tires retrieved since the project began and the number of tires that still need to be retrieved, and an estimated timeline for the completion of the cleanup and tire removal project."*

This report documents the status of the Osborne Tire Reef, various tire removal projects to date, and other restoration efforts that have occurred. The majority of the Osborne Tire Reef structure is composed of individual tires or compressed tire bundles in the sand flat between the Middle and Outer Reefs (unburied, partially buried, and fully buried). Additionally, individual tires can be found on the western edge of the Middle Reef, on the eastern edge of the Outer Reef, and, in smaller quantities, on the Middle and Outer Reefs. While hundreds of thousands of tires remain, an estimated 543,000 tires have been retrieved since the cleanup and tire removal projects began in 2001. The numbers of tires removed during each tire removal project are depicted in Figure ES-1. Additionally, a total of 747 corals have been relocated from the tires thereby facilitating tire removal.

Based on current funding levels and using only methods permitted in the Tire Abatement Project, complete tire removal is estimated to take at least ten more years. This estimated timeline for tire removal will likely need to be adjusted based on a new survey to assess the distribution of tires found outside of the 2019 Tire Survey area. The Restoration Plan, due to be completed by July 1, 2024, will include these findings as well as a preliminary plan for the restoration of the existing reef, the restoration of any nearby natural reefs that were destroyed by the tire installation, the shifting of resources from tire retrieval to reef restoration, and coordination with other coral reef restoration projects and resources, per language in the Act.

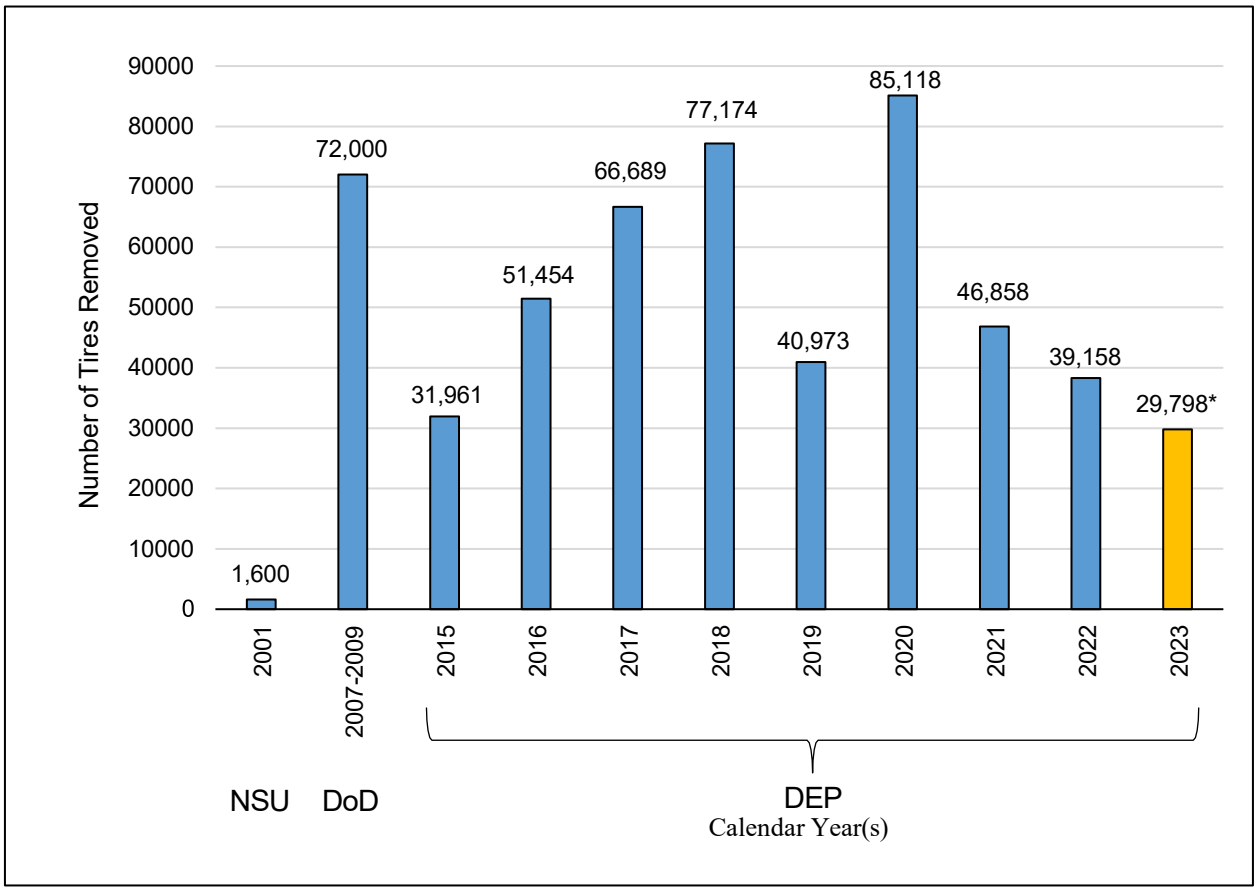

*Figure ES-1. Number of tires removed per calendar year for each tire removal program from 2001 to the present. This graph does not include tire removal efforts from 4Ocean (414 tires). *Number of tires removed as of the most recent tire removal report in September 2023. NSU = Nova Southeastern University; DoD = Department of Defense; DEP = Florida Department of Environmental Protection.*

Habitat Overview

The reef system offshore of Broward County is composed of multiple linear reef complexes (e.g., reef tracts) running parallel to shore (Moyer et al. 2003; Banks et al. 2007; Walker et al. 2008) (*Figure* 1). The Inner Reef crests in 3 to 7 meter (m) depths. The Middle Reef crests in 12 to 14 m depths. The Outer Reef crests in 15 to 21 m depths. Other studies may have referred to the Inner, Middle, and Outer Reef complexes as First, Second, and Third Reef, respectively. The Inner and Middle Reefs have more structural complexity, but the Outer Reef has stronger vertical relief. While benthic species compositions vary among the three reef complexes, they are generally characterized by the presence of sponges, octocorals, and stony corals, including multiple stony corals currently listed as threatened under the Endangered Species Act.

Sand habitat (sand flat) is the main habitat found between the Middle and Outer Reef and to the east of the Outer Reef. The sand flat between the Middle and Outer Reef, where the majority of tires are located, is approximately 20 and 23 m in depth and contains numerous artificial reef structures (e.g., barges, memorial reefs, and "Ero-jack" structures[1]). Among these is an artificial reef composed of "ero-jack" structures in a circular arrangement named "Osborne Reef.", which should not be confused with the Osborne Tire Reef discussed in this report.

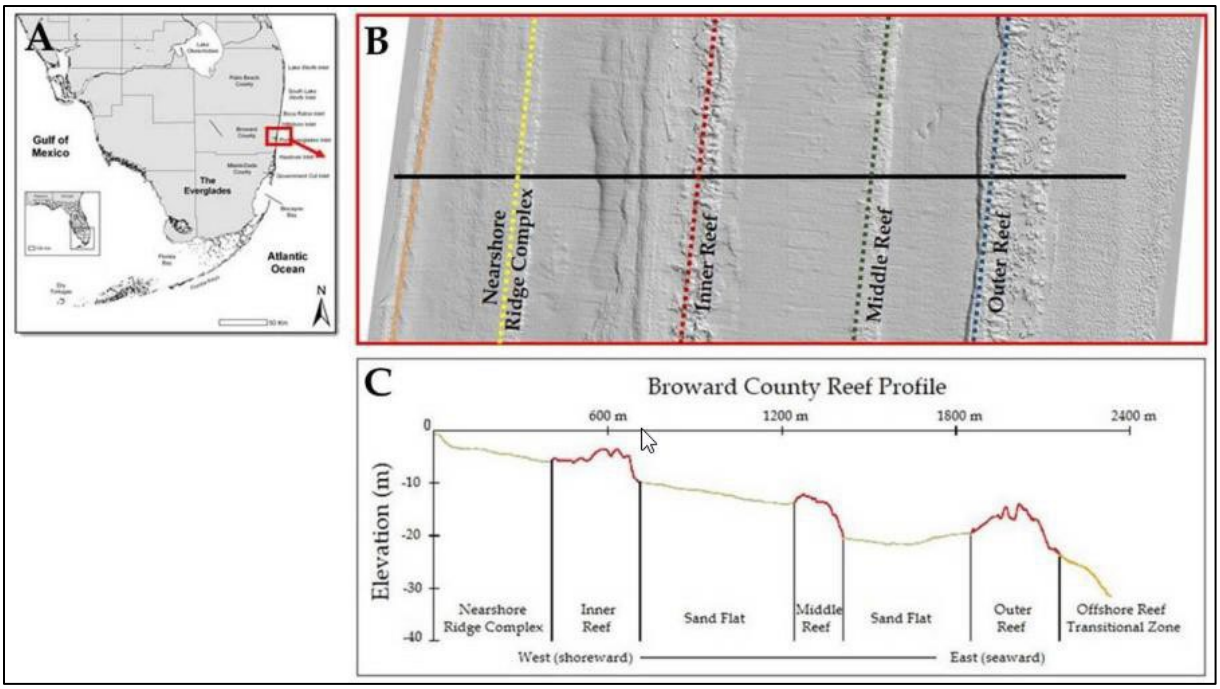

Figure 1. View of the Southeast Florida coastline (Source: Walker et al. 2008). (A) Area of Broward County that corresponds to (B), the sea floor bathymetry. The black line in (B) shows the location of a bathymetric profile illustrated in (C) showing Inner, Middle, and Outer Reefs.

[1] Among these is an artificial reef composed of "ero-jack" structures in a circular arrangement named "Osborne Reef." The artificial reef composed of tires was not officially associated with "Osborne Reef", but over time became known colloquially as the Osborne Tire Reef. This Status Report discusses the history of the Osborne Tire Reef and not the "ero-jack" reef.

History of Osborne Tire Reef

Background

Throughout Florida's history, increasing fishing pressure on commercially important species (e.g., grouper and snapper) has created a demand for additional habitat where these fish could reproduce and grow. Reports and studies in the 1960s and early 1970s recommended the use of tires for construction of artificial reefs, as the tires were abundant, inexpensive and easy to handle (Stone and Buchanon, 1970). There was also a great demand for a useful method of tire disposal (Stone et al., 1974). In the early 1970s, a large number of tires (estimated between 1 and 2 million [Raymond, 1979; Sherman and Spieler, 2006]) were deployed offshore between the Middle and Outer Reefs in Broward County, Florida, as an artificial reef for fishery enhancement purposes. The activities were completed under permits issued by the state of Florida and the U.S. Army Corps of Engineers.

Deployment

While records are unavailable for many of the tire deployment events, there are reports of tires being placed in groups as large as 50,000 (April 1972) and 190,000 (November 1973) (D.E. Britt Associates, 1974). Actual deployment methods ranged from bundled tires being transported on a barge (Image 1) and dropped using a clamshell crane to single tires being deployed by citizens from private vessels (Image 2). Poor record-keeping, lack of monitoring and issues associated with deployment are the primary reasons why a more precise estimate of the total number of deployed tires is unavailable.

Image 1. Most of the tires deployed in the 1970s were placed as bundles.

Image 2. Tires were also deployed individually from private vessels.

Several problems were encountered during and after deployment of the tires (D.E. Britt Associates, 1974). Tire bundles were held together with plastic strapping and a metal binding clip. Many of the strappings broke during the clamshell deployment, and the remaining straps became loose due to the corrosion of the metal binding clips. Lack of navigational controls and strong currents resulted in haphazard deployment of tires over a broad area. Single tires unable to be hole-punched were easily transported away from the intended deployment site or onto the surrounding natural reef by surface currents. In later years, high-energy wave action during storm events and natural currents transported tires further way from the intended deployment site (Morely, 2008). The highly unstable nature of the tires indicated that they were not suitable as an artificial reef.

Tire Survey and Mapping

In 2019, DEP contracted a consultant to map the density and distribution of tires associated with the Osborne Tire Reef on reef and sand habitats (CSA Ocean Sciences Inc. [CSA], 2019) ("2019 Tire Survey"). The 2019 Tire Survey was targeted to a limited area and did not encompass the full potential extent of tire spread; however, it determined that tires were primarily concentrated offshore from Sunrise Boulevard and Hugh Taylor Birch State Park, Fort Lauderdale, approximately 3-4 miles north of Port Everglades Inlet (Figure 2). Relative tire abundance was separated into two categories: dense and sparse. Where tires were touching or overlapping, tire accumulation was categorized as "dense" (i.e., more than 50% cover of tires). Where tires were not touching or overlapping, tire accumulation was categorized as "sparse" (i.e., less than approximately 50% cover). Relative abundance is depicted in Figures 2 and 3. The area termed "Tire Abatement Permit Area" in Figure 3 was determined to be a priority area for tire removal due to high density and multiple layers of tires (see Section: **Initial Tire Removal Efforts** for more details).

Results from the 2019 Tire Survey indicated that tires were located mainly in a few habitats: on the Middle and Outer Reefs; on the sand flat between the Middle and Outer Reefs (tires are partially and fully buried in sand or exposed); on the western edge of the Middle Reef; and on the eastern edge of the Outer Reef (Figure 3). Additionally, tires have been observed outside of the 2019 Tire Survey area in varying concentrations around Broward County.

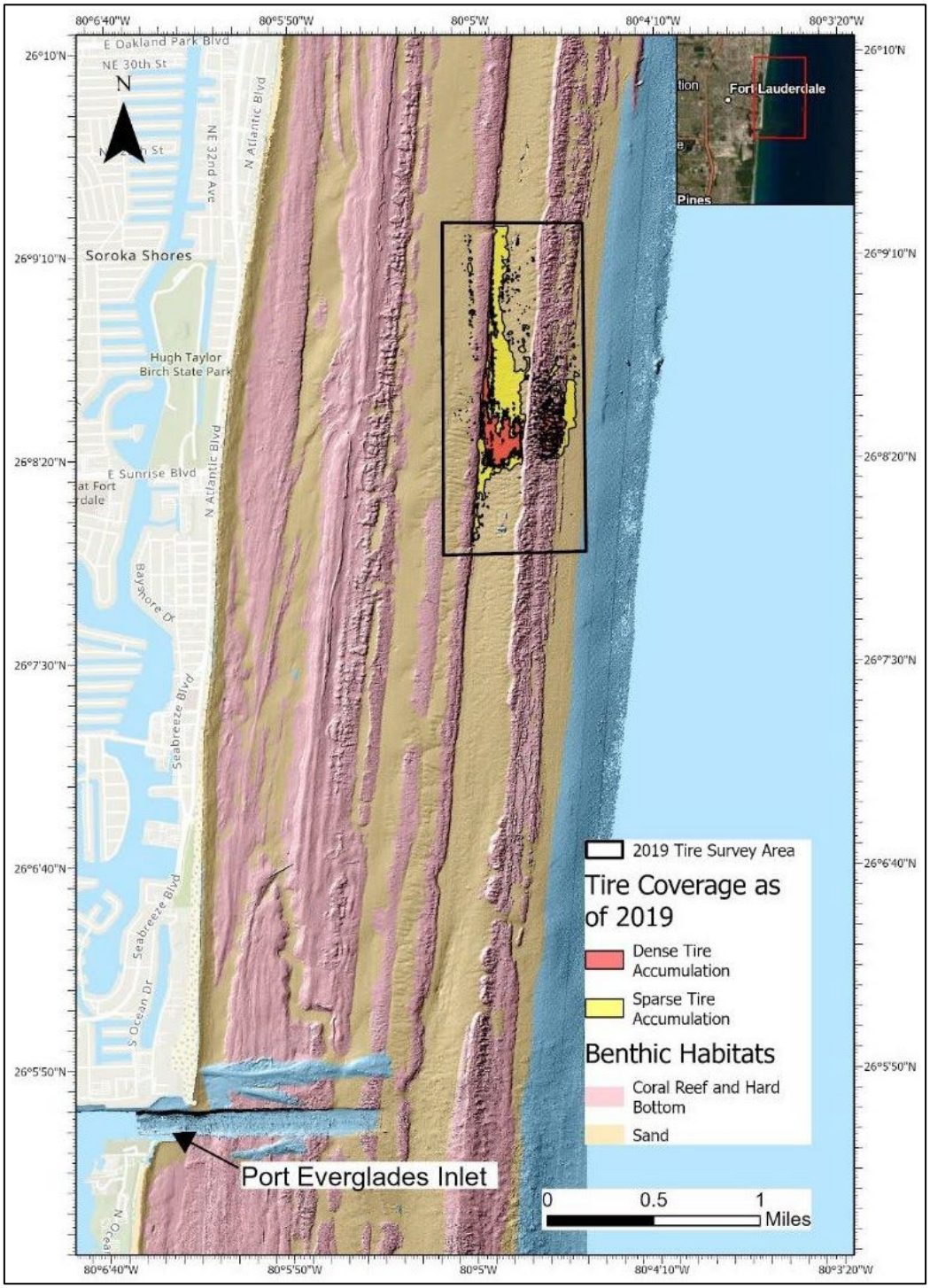

Figure 2. Overview and location of tires from the 2019 Tire Survey relative to Port Everglades Inlet, individual reef tracts, and the Broward County shoreline. Relative tire abundance was classified as dense (red: tires were touching or overlapping; over 50% coverage of tires) or sparse (yellow: tires were not touching or overlapping; less than 50% coverage of tires).

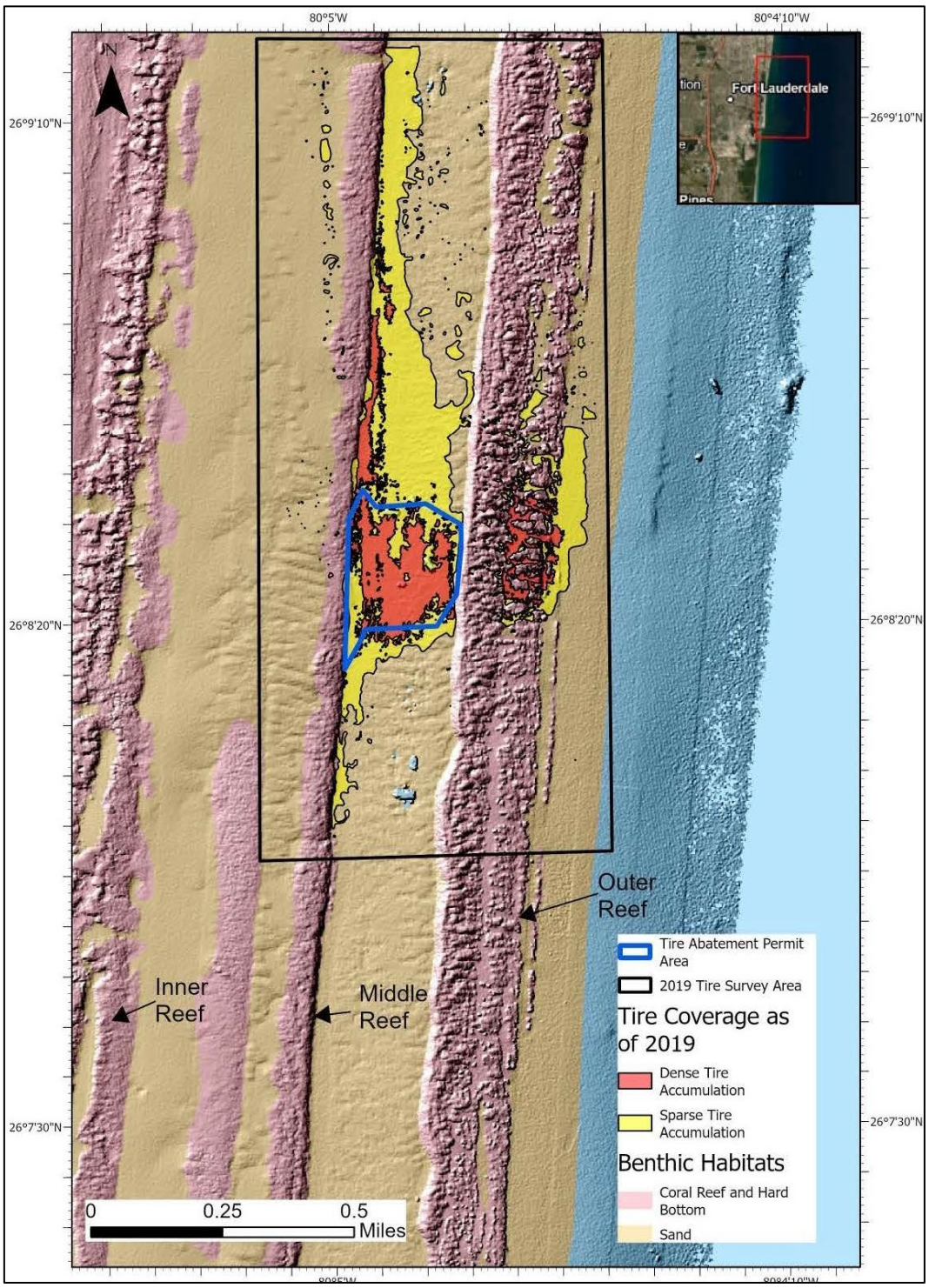

Figure 3. Location of tires from the 2019 Tire Survey on and adjacent to the Middle and Outer Reefs. Relative tire abundance was classified as dense (red: tires were touching or overlapping; over 50% coverage of tires) or sparse (yellow: tires were not touching or overlapping; less than 50% coverage of tires).

Descriptions of the deployed tires at the Osborne Tire Reef (i.e., grouping patterns and orientation of individual tires and tire bundles) were obtained from the 2019 Tire Survey and supplemented by scuba dives conducted by DEP and Broward County. The orientation and characteristics of the tires vary with their location. The majority of observed tires were found in the sand flat between the Middle and Outer Reefs and covering sand/rubble between reef structures (Figure 3). Most commonly, tires in sand flats were found as individual tires in small groups (Image 3A), large aggregations of over 3 tires per square meter (Image 3B), or in bundles (Image 4). Some of the tire aggregations have been stable enough for stony coral growth (Image 4B). Tires were also found fully buried or partially buried in sand (Image 5). In some areas, there are multiple layers of tires buried in the sand; however, the degree to which tires are buried was not an objective of the 2019 Tire Survey (See Section: **Estimated Tire Abundance**). Large aggregations of tires were found on sand and rubble between reef structures on the Outer Reef (Image 6). Relatively fewer tires were observed on elevated reef areas and, where present, were generally in sand-filled depressions (Image 7).

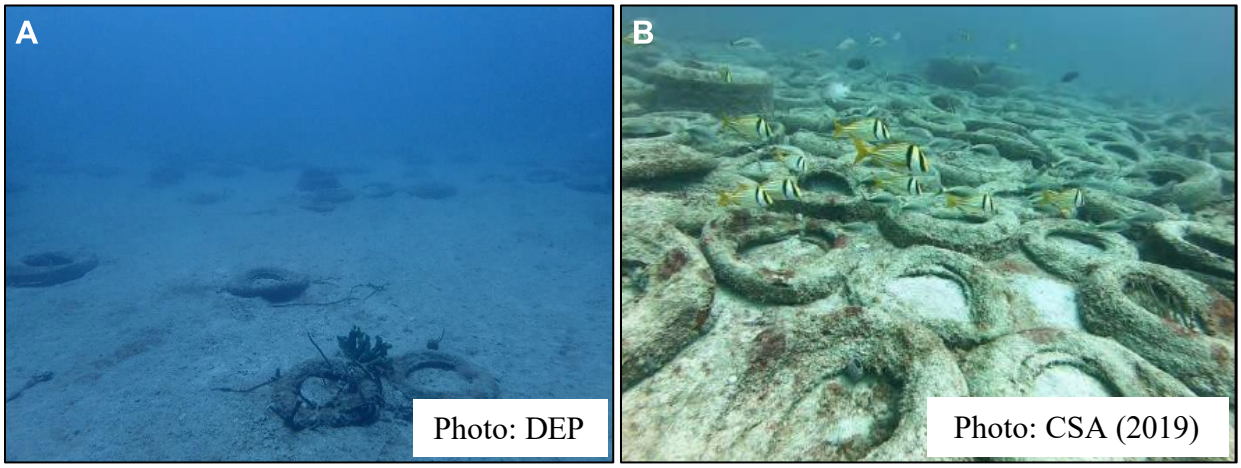

Image 3. Tires in the sand flat between the Middle and Outer Reefs. (A) Single tires and small groups of tires in the sand flat. (B) Large aggregation of tires in the sand flat.

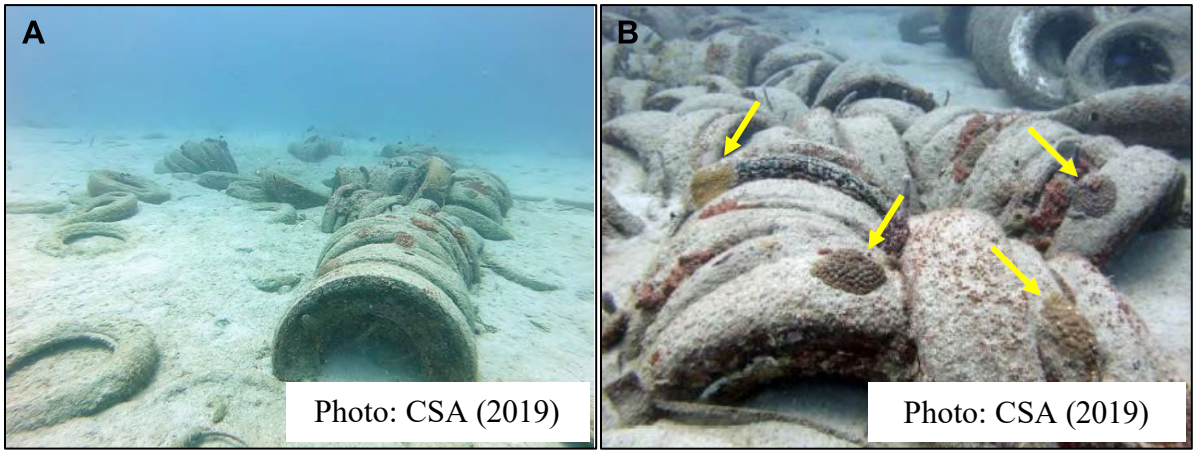

Image 4. Tires in the sand flat between the Middle and Outer Reef. (A) Partially buried, intact bundles of tires; and (B) yellow arrows pointing to stony coral growth on intact bundles of tires.

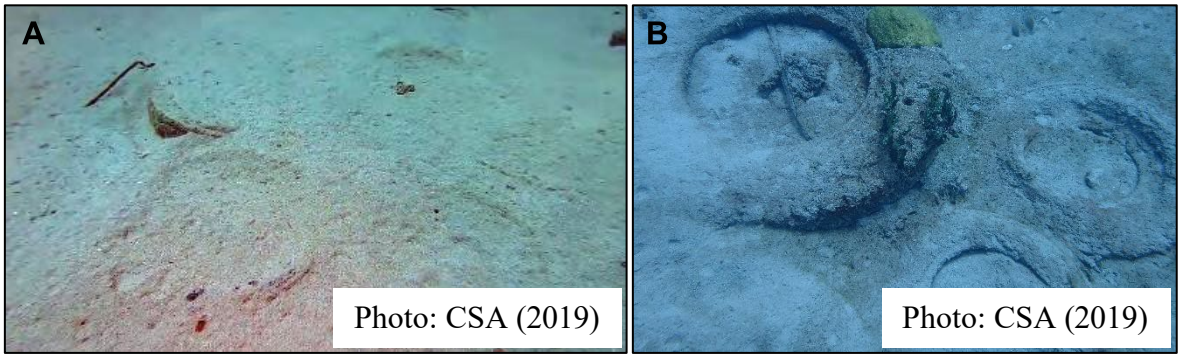

Image 5. Examples of (A) fully buried tires and (B) partially buried tires in the sand.

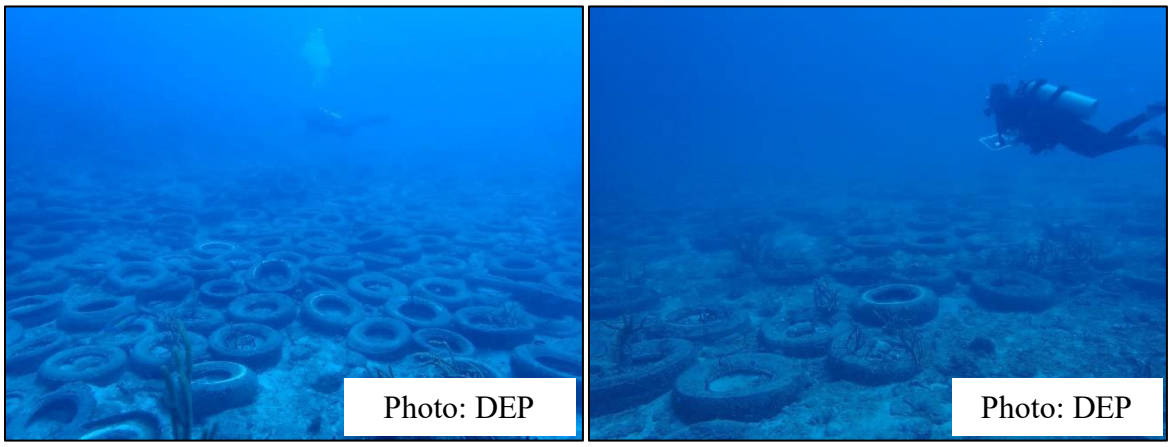

Image 6. Abundant tires observed on the Outer Reef covering sand and rubble.

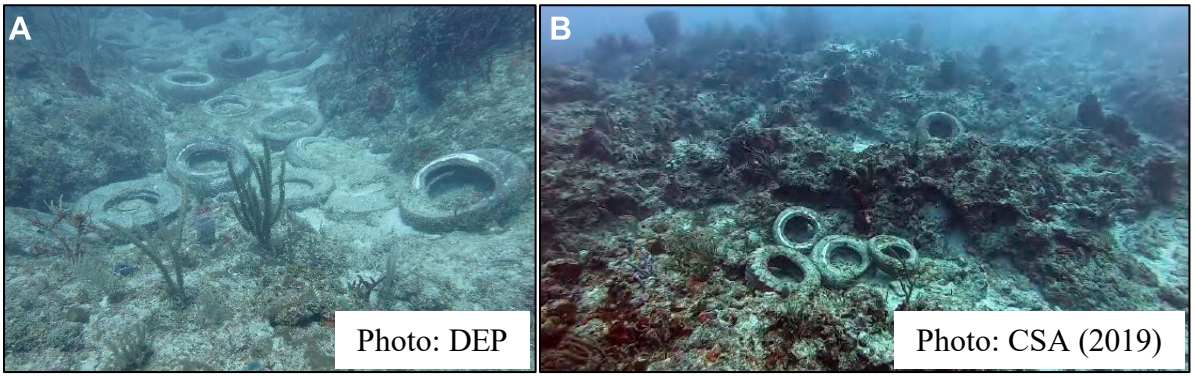

Image 7. Tires found in sand filled depressions or small sand channels on reef.

Tire Removal Projects

Initial Tire Removal Efforts

In 2001, the first tire removal effort was organized by Nova Southeastern University (NSU) with assistance from Broward County, the National Coral Reef Institute, and various volunteer groups (Sherman and Spieler, 2006). This effort was funded by the National Oceanographic and Atmospheric Administration (NOAA). A total of 1,600

tires were removed from the natural reef using lift bags. This effort was conducted to understand the feasibility of removing tires and it demonstrated the need for a larger scale operation to successfully remove all the tires.

From 2007 to 2009, DEP, Broward County, and NOAA partnered with the U.S. Department of Defense (DoD) through the DoD's Innovative Readiness Training Program (DoD Program) to use military assets for the removal of tires as a training opportunity for military personnel (Army, Navy and Coast Guard). During the three missions combined, the DoD Program removed over 72,000 tires from an area between the Middle and Outer Reefs that was determined to be a priority area for tire removal due to high density and multiple layers of tires. For the purposes of this Status Report, this priority area is called the Tire Abatement Permit Area (Figure 3).

Removal is a laborious and time-consuming task due to depth limitations, currents, and potential for environmental impacts. SCUBA teams bundled tires onto wire ropes and used lift bags to send the bundles to the surface, where the bags were taken on board the support ship by crane before being unloaded into one of two open-top trailers (Image 8). Once the trailers were full, the ship would dock in Port Everglades and trailers full of tires would be offloaded and empty trailers reloaded. Tires were then trucked to recycling plants in either Georgia or central Florida.

Image 8. (A) Tire bundle being hoisted aboard the support ship after being brought to the surface by a lift bag. (B) Bundled tires being loaded into an open-top trailer during the military's tire salvage mission.

More recently, two organizations, 4Ocean, a Certified B corporation, and Reef Discovery Center, a nonprofit organization, have obtained Environmental Resource Permits to conduct smaller-scale tire removal efforts areas outside of the Tire Abatement Permit Area. These tire removal efforts have been limited to date (414 and 0 tires, respectively).

Tire Abatement Project

In 2015, DEP began tire removal operations in the Tire Abatement Permit Area using a contractor. To expedite the removal process, priority was given to those tires without biological growth (i.e., corals and sponges). The removal method typically requires a single diver on the bottom bundling tires (Image 9). The bundle is hoisted onto the surface support vessel using a surface crane or winch (Image 10). Once the vessel is fully loaded (approximately 300 tires), the vessel travels to Port Everglades and unloads the tires into an open-top trailer staged on the port property. From Port Everglades, the tires are transported to a waste tire processing facility for proper disposal. This was determined to be the least environmentally destructive method available considering proximity of tires to natural and artificial reef and permit-required buffer zones around those habitats (as described in **Habitat Overview**). In some subsections of the seafloor, tires have been completely cleared over the course of several years (Images 11 and 12). The number of tires removed during this project as of September 2023 is 469,183. Further details on tire abundance and timelines for tire removal are discussed later in this document (see **Estimated Tire Abundance**).

Image 9. Surface air supplied diver hand bundling tires for transport to the surface by crane (Photo: Industrial Divers Corporation [IDC]).

Image 10. Current commercial tire removal operation using a similar method to that used during the DoD Program. Once the support vessel is loaded with approximately 300 tires, the vessel will return to Port Everglades to offload the tires into an open-top container (Photo: IDC).

Image 11. View of individual tires and tire bundles in the sand next to "Matt's Barge", a previously placed artificial reef. This image was taken in 2017 prior to tire removal (Photo: IDC).

Image 12. A view of the sand next to the same barge in Image 10 following tire removal in 2023 (Photo: IDC).

Coral Relocation

Under the current permit for tire removal in the Tire Abatement Permit Area, tires with any coral growth were not allowed to be displaced or removed. The corals growing on tires represent an important resource that can be used for restoration and research. As tires without corals became sparse in the Tire Abatement Permit Area, DEP developed methods to relocate corals from the tires in advance of tire removal. Groups of semi-stable tires with high stony coral growth were identified and described during the Tire Abatement Project. Six areas were characterized as localized aggregations of individual tires and/or compressed tire bundles with high coral growth (Figure 4). A seventh area was characterized by lower tire density covering a larger area (scattered tires lying flat in a single layer) and high stony coral growth (hashed area in Figure 4). Using funds allocated to the Division of Waste Management and administered through the Office of Resilience and Coastal Protection, DEP contracted a local university (NSU) to transplant corals from all seven tire areas (2022–2023 Fiscal Year; Figure 4). NSU has sufficiently removed corals from two of the seven areas. DEP coordinates the efforts among the tire removal and coral removal groups.

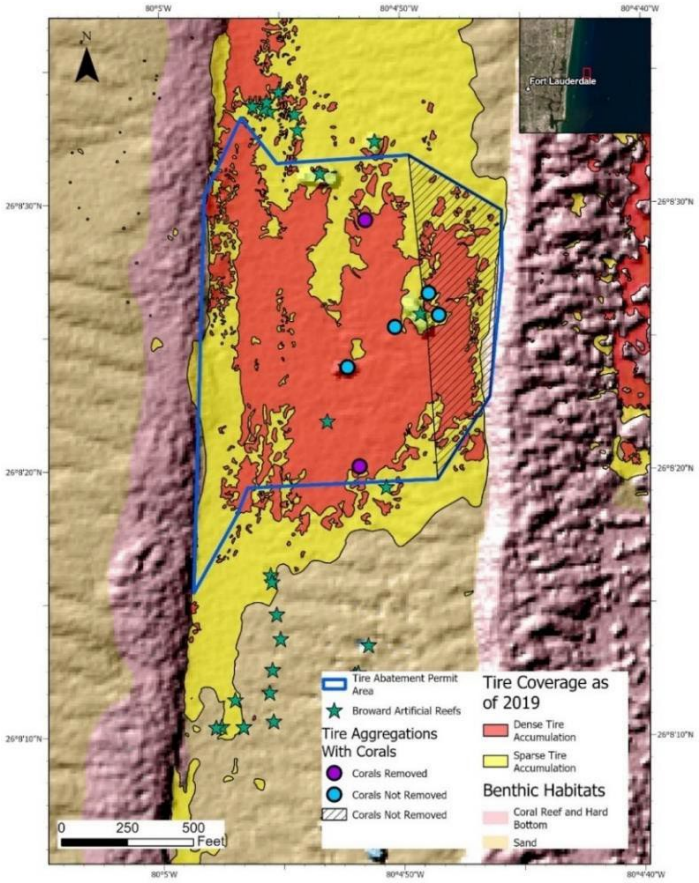

Figure 4. Commercial divers identified tire aggregations composed of semi-stable tires and high stony coral growth. Coral removal was completed from two tire aggregation areas (purple circle icons) during the 2022 to 2023 Fiscal Year. Coral removal is planned from the remaining four aggregations (blue circle icons) and one diffuse tire aggregation area (hatched) in the 2023-2024 Fiscal Year. Nearby existing artificial reefs are marked with green star icons.

A total of 747 coral colonies have been removed from the tire aggregations (Image 13 and 14) as of September 2023. This includes 700 coral colonies relocated in Fiscal Year 2022–23. Of those colonies, 472 were relocated to four outplanting sites (Image 15; Figure 5). NSU is contracted to remove an additional 700 corals from the remaining tire aggregations in Figure 4 during Fiscal Year 2023–24, of which they have relocated 47 to date. After all corals have been sufficiently removed from a tire aggregation area, the commercial divers will remove those tires as part of the Tire Abatement Project. Due to this additional environmental consideration, tire removal efforts may be slower in areas where corals need to be removed prior to moving tires, but the ecosystem benefit of transplanting the corals outweighs the drawbacks of any additional time needed to complete the project.

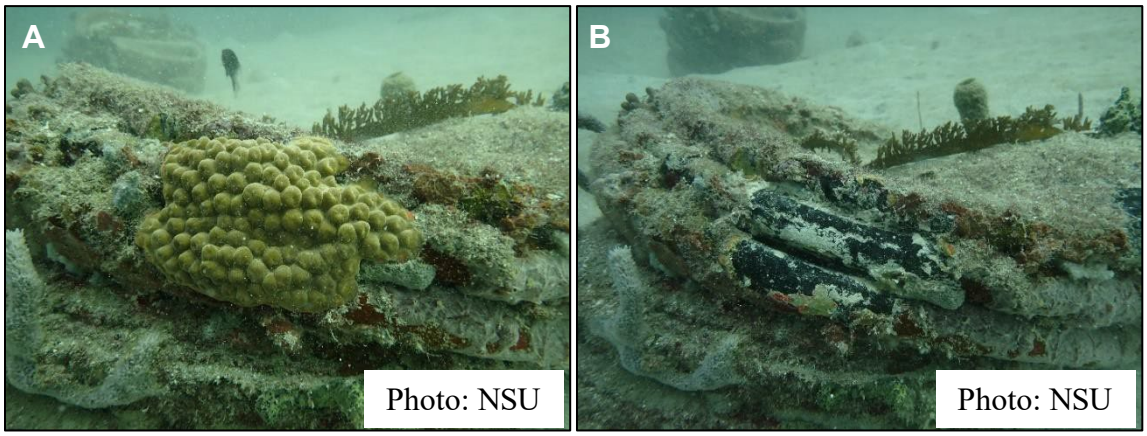

Image 13. Photograph of a tire bundle with a Montastrea cavernosa colony (A) before removal and (B) after removal.

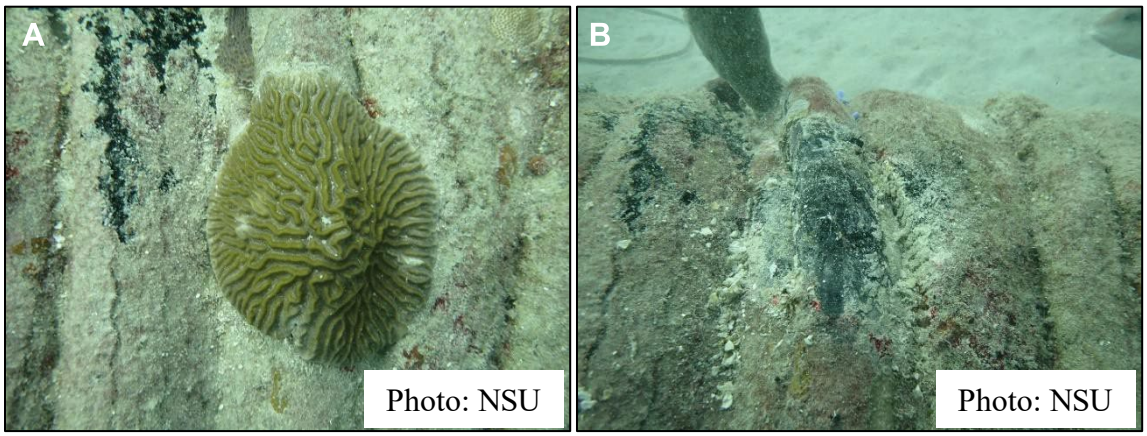

Image 14. Photograph of a tire bundle with a Psuedodiploria strigosa colony (A) before removal and (B) after removal.

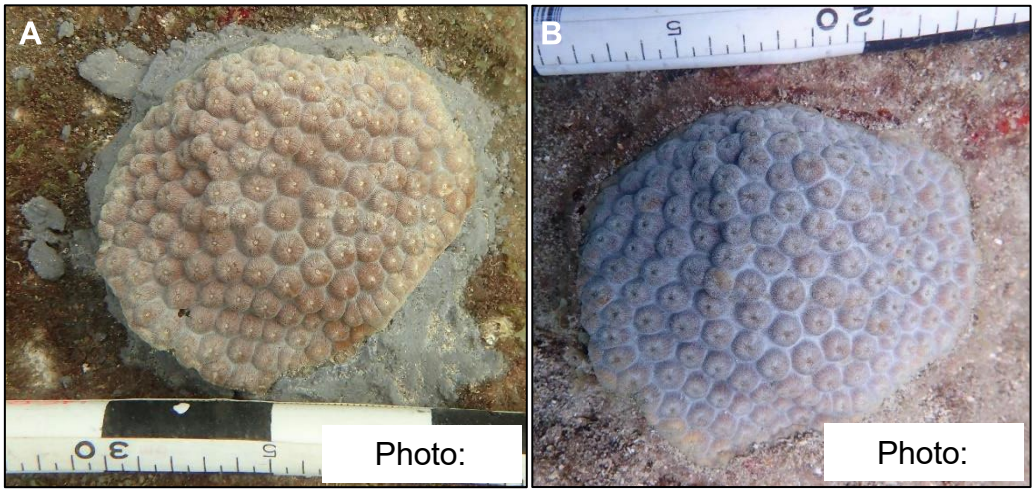

Image 15. Photograph of a Montastrea cavernosa colony (A) shortly after being relocated to a nearby reef and (B) during a 6-month monitoring period.

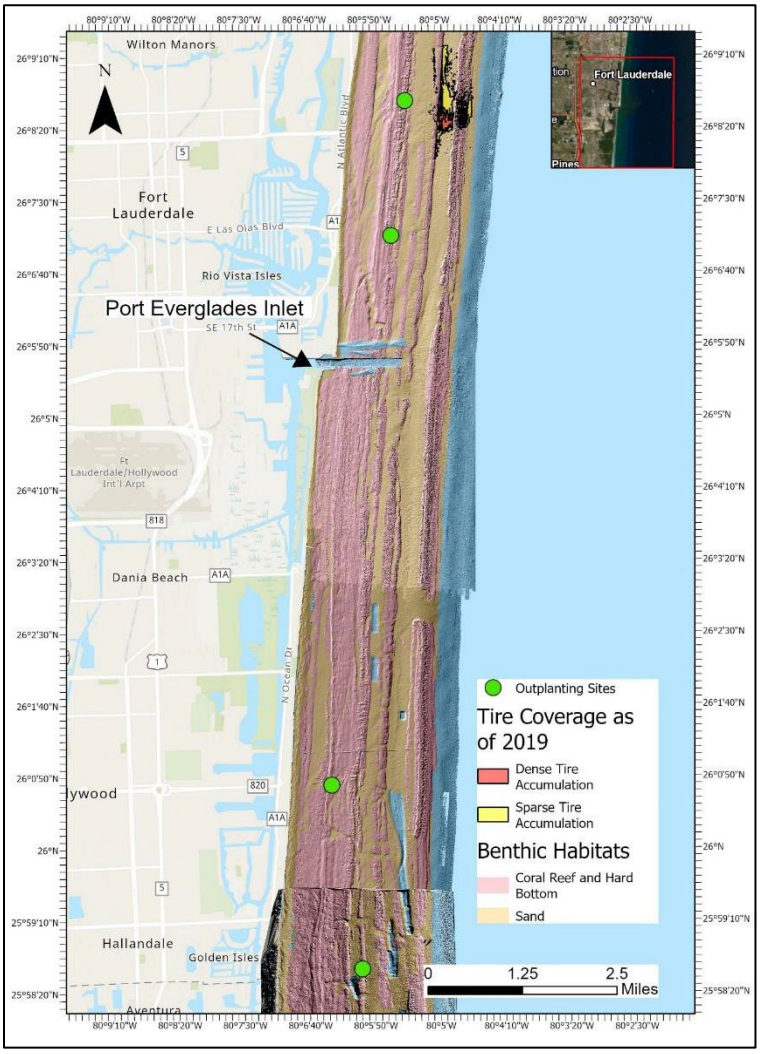

Figure 5. Location of coral outplanting sites for coral removed from tires.

Estimated Tire Abundance

Since tire removal activities began, a total of 543,197 tires have been removed, 469,183 of which were removed in the Tire Abatement Permit Area since the start of the Tire Abatement Project in 2015. The number of tires removed each calendar year since the start of the Tire Abatement Project varies, with a low of 31,961 to a high of 85,118 (Table 1; Figure 6). This variability is due to the necessary relocation of corals, decreasing tire density, whether the tires are unburied, partially buried or fully buried, a work stoppage during the 2019 Tire Survey, and other factors.

The number of exposed (unburied) tires on the seafloor within the 2019 Tire Survey area (Figure 3) was conservatively estimated using areal coverage and density data. The estimated number of exposed (unburied) tires was approximately 684,000. A total of 199,507 tires have been removed since the survey, under the Tire Abatement Project. Thus, as of September 2023, there are approximately 484,000 unburied tires remaining on the seafloor within the boundaries of the 2019 Tire Survey area.

For future tire removal efforts, the projected number of tires to be removed each calendar year, using only the current methods from the Tire Abatement Project, ranges between 41,000 to 57,000, except in 2033 when the remaining several thousand tires will be removed (Table 1; Figure 6). Projections are based on currently permitted methods (which includes removing buried tires) within the Tire Abatement Permit Area and past performance by the commercial divers, but with fewer tires removed over time as less dense areas are targeted. As tires are removed and density decreases, the effort to locate, bundle, and send to the water surface the same number of tires for a full vessel load (approximately 300 tires) takes more effort and time, which can also result in increased costs per tire. DEP is exploring whether a contract amendment and permit modification may be needed to expand the Tire Abatement Permit Area to locations with higher tire densities.

It is important to note that the projections in Figure 6 will likely need to be adjusted for differences in methods and costs required to remove tires located on reef habitat and in deeper waters. Tire removal from the reef will require more restrictive methods to reduce impacts to reef organisms and habitat. Tires in deeper waters are likely to require increased restrictions in bottom time and different equipment. The accessibility of tires in contact with reef/hardbottom, their potential impacts, and necessary restoration techniques will be assessed in the Restoration Plan due July 1, 2024.

Furthermore, while significant progress has been made removing unburied tires in the Tire Abatement Permit Area, the full extent and volume of tires remaining buried in the 2019 Survey Area or located outside the survey area needs to be quantified. Buried tires require considerably more time and effort to remove. Another tire survey is being developed to accompany the Restoration Plan required by the Restoration of Osborne Reef Act. This survey will more fully characterize the distribution of tires outside of the 2019 Survey area, but supplemental in-water surveys may be needed to assess the abundance of buried tires. Data from new surveys will update the projections for tire removal from the seafloor and offer a more complete quantification of tires outside the 2019 Tire Survey area.

Table 1: Number of tires removed and corals relocated from tires in the Tire Abatement Permit Area for each calendar year.

Calendar Year	Tires Removed	Corals Relocated
2015	31,961	No Corals Relocated
2016	51,454	
2017	66,689	
2018	77,174	
2019	40,973	
2020	85,118	
2021	46,858	
2022	39,158	551
2023	29,798	196
Total	**469,183**	**747**

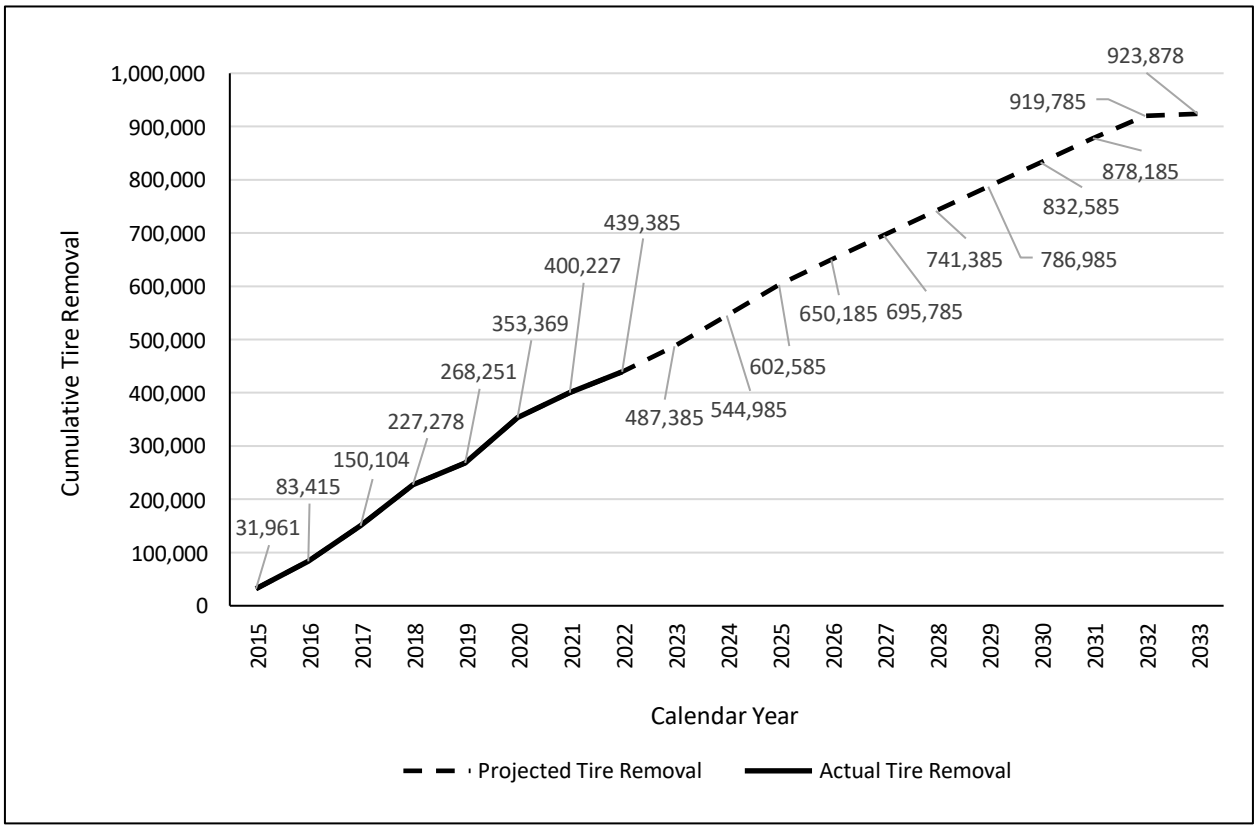

Figure 6. Actual and projected cumulative tire removal from the Tire Abatement Permit Area during each calendar year between 2015 and 2033. This graph does not include the 1,600 tires removed by NSU, the 72,000 tires removed by the DoD Program, nor the 414 tires removed by 4Ocean.

Next Steps

The Fiscal Year 2023-24 budget includes the state investment of $2.5 million for the continuation of the Tire Abatement Project to continue the tire removal efforts and coral relocations that are underway. A portion of the appropriation will be used for the development of the Restoration Plan including the three phases described below. The report is due to the Legislature by July 1, 2024.

The continuing Osborne Tire Reef restoration will further the existing tire removal efforts to remove tires from sensitive benthic habitat locations, minimize impacts due to tire removal, relocate coral reef resources as necessary, and restore the underlying reef habitat and monitor success of the restoration. Tire removal and disposal progress will continue as funding and timing allows.

In order to determine the best way to restore the reef habitat and monitor for success once the tires have been removed, a Restoration Plan is being developed that includes three phases of work. Phase 1 involves an expanded benthic survey to better estimate the spread of tires beyond the 2019 Tire Survey and assess the full extent of impacts. Phase 2 will use the resulting data to analyze the imagery, detect tire locations and create GIS maps. These results will provide a more accurate approximation of the total number of tires remaining on the seafloor and the habitat being impacted to inform a restoration strategy. Phase 3 of the plan will be the creation of a Restoration Plan. The Restoration Plan, as requested by Legislature, will include a preliminary plan for the restoration of the existing reef, the restoration of any nearby natural reefs that were destroyed by the tire installation, the shifting of resources from tire retrieval to reef restoration, and coordination with other coral reef restoration projects and resources, per language in the Act.

REFERENCES

Banks, K., Riegl, B., Piller, W., Dodge, R.E., and Shinn, E.A. 2007. Geomorphology of the Southeast Florida continental reef tract (Dade, Broward and Palm Beach Counties, USA). Coral Reefs 26: 617-640.

CSA Ocean Sciences Inc. 2019. Osborne Tire Reef Benthic Survey Diver Verification Surveys Report. Prepared for the Florida Department of Environmental Protection. Miami, FL. 32 pp.

D.E. Britt Associates, Inc. 1974. Report of Investigation of Broward Artificial Reef (Tire Reef). 8 pp.

Morley, D. M., Sherman, R. L., Jordan, L. K., Banks, K. W., Quinn, T. P., and Spieler, R. E. 2008. Environmental enhancement gone awry: characterization of an artificial reef constructed from waste vehicle tires. Environmental Problems in Coastal Regions 7: 73-87.

Moyer, R.P., Riegl, B., Banks, K., and R.E. Dodge. 2003. Spatial patterns and ecology of benthic communities on a high-latitude South Florida (Broward County, USA) reef system. Coral Reefs 22: 447-464.

Raymond, B. 1979. Underwater photogrammetric survey of a tire reef, Proceedings of the Conference on Artificial Reefs, Florida Sea Grant. Daytona Beach, FL, 13 September. pp. 211-218.

Sherman, R.L. and Spieler R.E. 2006. Tires: unstable materials for artificial reef construction, Proceedings of Environmental Problems in Coastal Regions Including Oil Spill Studies. pp. 215-223.

Stone, R.B. and C.C. Buchanan. 1970. Old tires make new fishing reefs. In: Underwater Naturalist. Bulletin of the American Littoral Society. 6: 24-28.

Stone, R. B., Buchanan, C. C., and Steimle, F.W. 1974. Scrap tires as artificial reefs. US Environmental Protection Agency.

Walker, B.K., Riegl, B., and Dodge, R.E. 2008. Mapping coral reefs in suboptimal water clarity: Southeast Florida, USA. Journal of Coastal Research 24: 1138-1150.