

# The Southeast Florida Marine Debris Reporting and Removal Program



Southeast Florida Coral Reef Initiative  
Fishing, Diving and Other Uses  
Local Action Strategy Projects 29, 30 and 32



Southeast  
Florida  
Coral Reef  
Initiative

*Acting above to protect what's below.*

# The Southeast Florida Marine Debris Reporting and Removal Program

4<sup>th</sup>, 5<sup>th</sup>, and 6<sup>th</sup> Annual Southeast Florida Reef Cleanup Summary

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## INTRODUCTION

Marine debris is a widespread problem on southeast Florida’s coral reefs and is generated from two primary sources: (1) from actions and activities that take place on land (land-based sources), and (2) from actions and activities that take place in waterways and the marine environment (water-based sources) (Mata 2017). Land-based sources of marine debris come from inland areas where the debris is transported by waterways. City streets, public parks, waterfront areas, ports, marinas, fishing piers, landfills and other land sources all pose as opportunities for litter materials to be blown by the wind, washed by rain into storm drains to enter streams, lakes or other watersheds and eventually transported into the ocean. Marine debris is also generated by recreational and commercial activities at sea and in waterways. These activities include fishing, scuba diving, snorkeling, boating (both large and small vessels). Another water-based source of marine debris is abandoned and derelict vessels. These are issues of particular concern for southeast Florida due to the high volume of boaters and fishers. Regardless of the source and fate of marine debris, it can cause numerous problems to both human healthy and marine life. Abandoned or discarded fishing and boating materials, lost dive equipment, plastics, household items, and hurricane related debris are becoming increasingly more common on southeast Florida reefs.

After entering the waterways, debris can drift in the water column or sink to the seabed at various depths and can cause indirect, unintended impacts on coral reefs and other benthic organisms. Such debris can cause tissue abrasion to sponges, hard corals, soft corals, and other sessile organisms. To more mobile organisms such as fish, crustaceans, and echinoderms, marine debris can cause entanglement and ingestion resulting in injury or death to these animals. Not only are there environmental impacts associated with marine debris, but also social and economic impacts as well. The social and public impacts affect people’s health and safety by causing potential hazards to swimmers, divers and boaters, reducing recreational opportunities, and an overall loss of aesthetics (Cho, 2006; Cheshire et al., 2009). Economically, marine debris is costly to the tourism industry (Ofiara and Brown, 1999), vessel operators (McIntosh et al., 2000), fisheries and aquaculture operations due to damage or entanglement (Scheld et al. 2016) which results in more cleanups, recoveries and disposals. With population growth and human use of southeast Florida reefs on the rise, minimizing the impacts of marine debris is a priority.

To effectively address the issue of marine debris in Florida, the Marine Debris Reporting and Removal Program was originally created in 2008 as a partnership between the Florida



**Figure 1. The Southeast Florida Action Network (SEAFAN) is a reporting and response network that encourages divers and other reef users to report marine debris and other marine incidents.**

Department of Environmental Protection (DEP), the Florida Fish and Wildlife Conservation Commission (FWC) and Palm Beach County Reef Rescue (PBCRR). In 2009, the Southeast Florida Coral Reef Initiative (SEFCRI) identified this program under Local Action Strategy (LAS) Issue 3 – indirect impacts on habitat. The program was identified within Fishing, Diving, and Other Uses (FDOU) Projects 29, 30, & 32. The goals of this program were to (1) minimize indirect impacts on the reef ecosystem and associated organisms from recreational and commercial use; and (2) increase awareness and understanding among reef user groups of the causes and consequences of marine debris (Bohnsack & Monty, 2012). These goals were accomplished by organizing annual reef cleanups across Miami-Dade, Broward, Palm Beach, and Martin counties. Additionally, this program encourages local divers and dive shops to remove small debris, when appropriate, and to report marine debris to the Southeast Florida Action Network (SEAFAN) by calling the hotline at (866) 770-7335 or filling out an online form at [www.SEAFAN.net](http://www.SEAFAN.net) (Figure 1).



**Figure 2. Post-cleanup photo from Sea Experience in Broward County during the 5<sup>th</sup> Annual Southeast Florida Reef Cleanup.**

Throughout the summers of 2014, 2015, and 2016, the Florida Department of Environmental Protection’s Coral Reef Conservation Program (DEP CRCP) and the Southeast Florida Coral Reef Initiative (SEFCRI) hosted their Annual Southeast Florida Reef Cleanup in partnership with local diver operators. The 4<sup>th</sup>, 5<sup>th</sup>, and 6<sup>th</sup> Annual Southeast Florida Reef Cleanups were coordinated through SEFCRI’s Marine Debris Reporting and Removal Program, which seeks to combat marine debris issues in the southeast Florida region. Underwater cleanups were held in Miami-Dade, Broward, and Palm Beach counties to

remove marine debris from the local coral reefs (Figure 2). In Martin County, DEP CRCP and SEFCRI supported the annual Peck’s Lake Reef Dive Cleanup. This event was coordinated by the Marine Industries Association of the Treasure Coast and the Port Salerno Commercial Fishing Dock Authority in conjunction with their Annual Treasure Coast Waterway Cleanup. A separate cleanup was organized for each county over a single weekend during the summer for multiple dive operators of that county to participate.

## METHODOLOGY

### *Cleanup Participants*

The 4<sup>th</sup>, 5<sup>th</sup>, and 6<sup>th</sup> Annual Southeast Florida Reef Cleanups took place exclusively aboard local dive charter boats and, to the extent possible, all dive operators within Miami-Dade, Broward, and Palm Beach counties were invited to participate. The total number of participating dive operators increased each year with seven in 2014, nine in 2015, and twelve in 2016 (Table 1). In 2015 and 2016, Diver's Paradise of Key Biscayne partnered with Debris Free Oceans in Miami-Dade County and South Florida Diving Headquarters partnered with Force-E in Broward County to gain more dive participants and engage more of the dive community. In 2016, two additional dive operators from Broward County and Palm Beach County volunteered to participate, however, last minute changes in the dive plan resulted in unforeseen cancellations.

**Table 1. Participating dive operators by county in 2014, 2015, and 2016.**

<b>County\Year</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>
<b>Miami-Dade</b>	1. RJ Diving Ventures	1. Divers Paradise of Key Biscayne	1. Divers Paradise of Key Biscayne 2. DECO Divers
<b>Broward</b>	1. American Dream 2. South Florida Diving Headquarters & Force-E	1. American Dream 2. South Florida Diving Headquarters & Force-E 3. Sea Experience	1. American Dream 2. South Florida Diving Headquarters & Force-E 3. Sea Experience
<b>Palm Beach</b>	1. Narcosis Dive Charters 2. Jupiter Dive Center 3. Dolphin Sun Dive Charters 4. Pura Vida Divers	1. Narcosis Dive Charters 2. Jupiter Dive Center 3. Dolphin Sun Dive Charters 4. Pura Vida Divers 5. Paradise Below Diving	1. Narcosis Dive Charters 2. Jupiter Dive Center 3. Dolphin Sun Dive Charters 4. Pura Vida Divers 5. Paradise Below Diving 6. Loggerhead Divers 7. Calypso Dive Charters
<b>TOTAL</b>	<b>7 Dive Operators</b>	<b>9 Dive Operators</b>	<b>12 Dive Operators</b>

### *Site Selection*

Dive sites for the 4<sup>th</sup>, 5<sup>th</sup>, and 6<sup>th</sup> Annual Southeast Florida Reef Cleanups were selected by each of the local dive operators. Dive operators used their knowledge of local reefs and previously successful reef cleanup locations to identify sites. Sites were also determined based on the wind and water conditions that day. In 2014, a total of 14 sites were visited throughout Miami-Dade, Broward, and Palm Beach counties (Figure 3). A total of 14 sites were visited in 2015 (Figure 3) and 18 sites in 2016 (Figure 3). Some sites, particularly those known to accumulate debris, were

targeted over the course of several dives, including repetitive dives from the same boat and by different boats within the region.

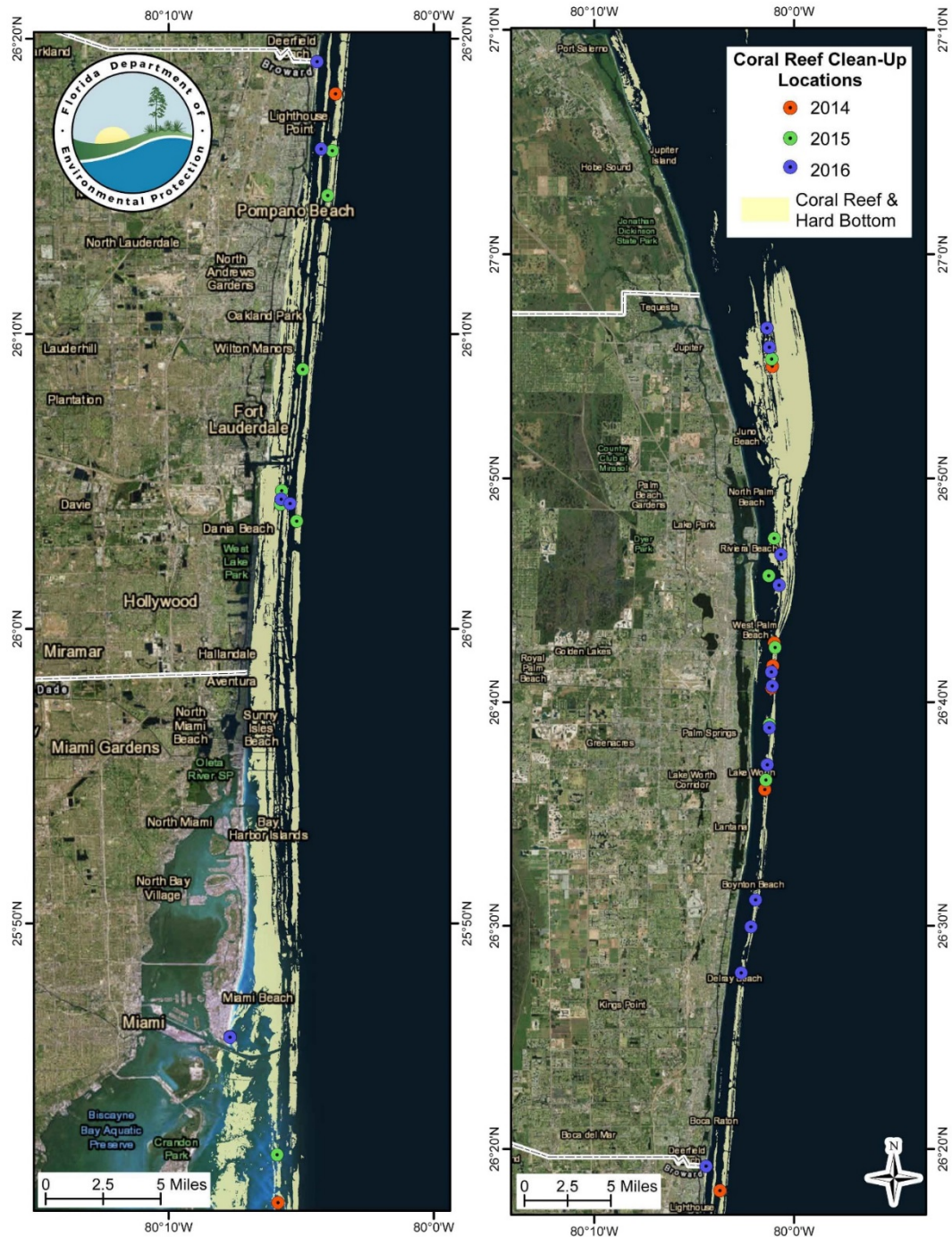


Figure 3. Dive sites in Miami-Dade, Broward, and Palm Beach counties visited during the 4<sup>th</sup>, 5<sup>th</sup> and 6<sup>th</sup> Annual Southeast Florida Reef Cleanups.



## Cleanup Logistics

Registration and execution of the reef cleanup dives occurred per the standard practice maintained by each dive company; divers signed-up, rented scuba gear (if needed) and paid for a 2-tank dive trip directly through the individual dive charters. Divers also adhered to the established diving procedures and safety standards maintained by each dive boat. To conduct the reef cleanup, DEP CRCP prepared and loaned all supplies necessary, which included a marine debris dive cleanup briefing, guidelines for administering the cleanup, gloves, catch bags (one per buddy pair), cutting shears (one per buddy pair), clipboards, data sheets, trash bags, a waterproof scale (as available), small promotional giveaways, and informational packets for all participants. For each boat, depending on the vessel size and number of divers, one to two site coordinators were designated to liaise with DEP CRCP staff and to oversee the actual cleanup event, which included providing a marine debris dive cleanup briefing to all participants, loaning ‘cleanup kits’ consisting of gloves, cutting shears, and catch bags to remove debris (Figure 4 – left) overseeing the proper documentation and disposal of debris, and distributed promotional items to participants at the conclusion of the event (Figure 4 – right).



**Figure 4. (Left) Cleanup kits loaned to divers participating in the 4<sup>th</sup>, 5<sup>th</sup>, and 6<sup>th</sup> Annual Southeast Florida Reef Cleanup. (Right) Promotional giveaways for all participants. Photo Credit: DEP CRCP.**

Site coordinators during the 4<sup>th</sup>, 5<sup>th</sup>, and 6<sup>th</sup> Annual Southeast Florida Reef Cleanups consisted of DEP CRCP staff, members of the SEFCRI Marine Debris Program Project Team (including staff from FWC, Palm Beach County Reef Rescue, Miami-Dade County Department of Environmental Resources Management, and Friends of Our Florida Reefs), and in some cases staff or partners of the participating dive boats.

The reef cleanup consisted of one dive trip (two dives per trip) aboard each of the dive boats. In 2014, Pura Vida Divers participated in the reef cleanup during both the morning and afternoon trips for a total of 4 dives. For some dive operators in 2015 and 2016, only one dive on the trip was dedicated to cleaning up the reef, while the other was selected for recreational purposes (often a wreck). Thus, all debris removed during the 4<sup>th</sup>, 5<sup>th</sup>, and 6<sup>th</sup> Annual Southeast Florida Reef Cleanup occurred over the course of 15, 17, and 18 dive opportunities, respectively.

## Data Collection

During each dive, participants collected debris underwater and then returned to the boat to sort and record their findings onto the Marine Debris Program's Reef Dive Cleanup Data Card (Figure 5). These data cards were designed based on the Dive Against Debris data sheets produced by the PADI Project Aware Foundation specifically for underwater cleanup activities (Project AWARE Foundation, 2013). Using these data sheets, divers recorded the debris they collected based on its material of construction: plastic, glass & ceramic, wood, metal, cloth, rubber, paper/cardboard, or other/mixed materials. Contrary to the Dive Against Debris data sheets, the SEAFAN Reef Dive Cleanup Data Cards provides blank spaces within each debris category for divers to record the specific type of debris they found. This method was developed by the SEFCRI Marine Debris Project Team to streamline the debris recording process for participating divers, while still maintaining compatibility with Project AWARE so that these cleanup results can easily be reported on the Dive Against Debris website.

Other fields collected on the datasheets were determined as follows:

- *'Number of Participants'* - divers who entered the water with the intent of participating in the reef cleanup, whether any debris was recovered or not.
- *'Dive Time'* - the total amount of time that cleanup participants spent underwater participating in the cleanup, calculated based on the bottom time recorded by each dive team multiplied by the number of members participating in that dive team.
- *'Distance Covered'* - determined based on diver estimates and, where available, calculated based on GPS coordinates recorded at the beginning and end of drift dives, with distance proportional to the dive time.
- *'Pieces of Debris Removed'* - the tally of items recorded on data sheets by cleanup participants. Some items, such as fishing line are inherently difficult to quantify. In these instances, divers determined a numerical tally based on the number of bundles or discrete pieces collected. Therefore, a piece of line that is 0.5 feet is tallied as 1 item, as is a single piece of fishing line that is 100 feet in length. On a few data sheets, however, an estimated total length of line collected was provided instead of a total count. Although little literature is available on quantifying marine debris items such as fishing line, a study on the spatial distribution of lost fishing gear in the Florida Keys by Chiappone et al. (2002) provides both a quantity of 'hook-and-line' debris items removed (e.g., monofilament and fishing wire, both with and without hooks, sinkers, and leaders), and a measurement of their total linear length (Chiappone, Swanson, Miller, & Dienes, 2004). Although the actual lengths of debris recorded during this study varied from <0.5 m to >5 m, the average length was approximately 1.4 m, or 4.5 ft. (Chiappone, Swanson, Miller, & Dienes, 2004). In an effort to most accurately reflect the amount of fishing line recovered during the cleanup dives, when only a total length of line was provided, these numbers were converted to quantity by dividing the estimated linear length by five (4.5 ft. average length, rounded to the nearest whole number). Thus, when only an estimated length was provided on the data sheets, each

five feet of length was considered to be one discrete item. In a few instances where neither a quantity nor a length estimation was provided for an item, the minimum number was assumed. For example, a singular item recorded on the data sheet, such as ‘fishing line,’ was counted as one item, and plural items such as ‘hooks’ were considered two items.

- *‘Weight of Debris’* - combination of estimated and measured amounts, as scales were not always available for boats. Weight was measured or estimated immediately following each dive when debris was still wet. As such, the total weight collected is higher than it would be for dry debris, as some items (e.g., towels) retained water that was then included in the aggregate weight. While this makes it difficult to compare these data with the weight of dry debris collected from beach cleanups, it still represents the amount of effort contributed by volunteers, who lifted the heavier, wet debris items from the water during the event.



**Figure 5. Divers sort and record marine debris on the SEAFAN data sheet. Photo Credit: Nikole Ordway and Debris Free Oceans**

### *Post-Dives and Debris Disposal*

After the cleanup dives, volunteers turned in their completed data sheets including loaned cleanup kits and were given small giveaway items and informational handouts from DEP CRCP and SEFCRI. The collected debris was recycled or disposed of in trash cans or dumpsters at each location. To the extent possible, clean monofilament was separated out for recycling through the Florida Fish and Wildlife Conservation Commission’s Monofilament Recovery and Recycling

Program, while heavily encrusted line was cut up before disposal to reduce the likelihood of additional entanglement in the landfill (Florida Fish and Wildlife Conservation Commission, 2011).

## RESULTS

Following the reef cleanup, data sheets submitted from each boat in each county were compiled and analyzed. In 2014, across the three counties, divers collectively spent 152.2 hours underwater cleaning up approximately 95.3 linear miles of southeast Florida’s reefs. They succeeded in removing an estimated 2,274 pieces of debris, which weighed approximately 391 pounds. In 2015, divers spent 108.3 hours underwater cleaning up approximately 29.3 linear miles of reef. They collected 587 pieces of debris, which weighed approximately 469 pounds. In 2016, divers spent over 183 hours underwater and collected 404 pieces of debris, which weighed approximately 373 pounds, across approximately 50 linear miles of reef (Table 2).

When comparing between counties, Palm Beach consistently had more participants and therefore, longer dive times and distance covered due to the number of charter boats available in this county. Conversely, Miami-Dade County consistently had the least number of participants and dive time. However, this trend was not necessarily observed in the amount of debris removed. In 2016, Miami-Dade contributed to 80% of the weight and 39% of the number of pieces of debris removed. This is likely due to the amount of fishing, boating, and recreational pressure on these waters and along the beaches (Figure 6).

**Table 2. Summary comparison of diver participation and debris removed from Miami-Dade, Broward, and Palm Beach counties during the 4<sup>th</sup>, 5<sup>th</sup>, and 6<sup>th</sup> Annual Southeast Florida Reef Cleanup.**

Year	Number of Participants			Dive Time (hours)			Distance Covered (linear miles)			Pieces of Debris Removed			Weight of Debris (pounds)		
	'14	'15	'16	'14	'15	'16	'14	'15	'16	'14	'15	'16	'14	'15	'16
Miami-Dade	9	13	34	18.0	10.6	35.0	4.0	2.4	4.0	92	7	276	102	134	301
Broward	18	35	33	27.2	42.7	43.3	4.9	8.3	9.9	468	616	92	161	114	17
Palm Beach	92	60	68	107.0	54.9	105.4	86.4	18.6	40.0	1714	500	344	128	221	55.5
<b>Total</b>	<b>119</b>	<b>108</b>	<b>135</b>	<b>152.2</b>	<b>108.3</b>	<b>183.6</b>	<b>95.3</b>	<b>29.3</b>	<b>53.8</b>	<b>2274</b>	<b>1123</b>	<b>712</b>	<b>391</b>	<b>469</b>	<b>373</b>

Although it is expected that more dive participants translate into more debris collected, it is important to recognize that a single item may vary between <1lb (e.g. wrapper or piece of monofilament) to >80lbs (e.g. tire or anchor) which largely affects the totals. The decrease in debris removed over three consecutive cleanup events may be attributed to six consecutive

summers of debris removal efforts. Each year, more and more divers are participating and learning about the issues associated with marine debris, doing their part and spreading the word to others.

The data collected during these cleanup events is inherently uncertain as tallies and calculations were recorded at the discretion of the individual divers and site coordinators. In some cases, measurements such as distance covered, volume, and weight were estimated. Guidance was provided to the site coordinators and divers to standardize data collection as much as possible, however, individual judgement likely varied between participants and the accuracy of all data cannot be confirmed. A level of uncertainty is common when collecting community data, but these data still provide a means of assessing and quantifying the amount of marine debris present along southeast Florida's reefs as well as location and types of debris collected on the reefs.



**Figure 6. (Left) Debris removed by RJ Diving Ventures in Miami-Dade County as part of the 4<sup>th</sup> Annual Southeast Florida Reef Cleanup. Photo: Scott Sheckman. (Right) Debris removed by DECO Divers in Miami-Dade County as part of the 6<sup>th</sup> Annual Southeast Florida Reef Cleanup. Photo: DEP CRCP.**

### *Type of Debris - By Material*

Of the total debris collected across all three counties from 2014, 2015, and 2016, 72.4% or 2,930 pieces of debris were made of plastic (Figure 8). Items within this material category include beverage bottles, monofilament fishing line, food wrappers, grocery store bags, PVC pipes, dive equipment, among others. Metal debris, the second most commonly collected material (14.8% or 599 pieces), consisted of items such as aluminum beverage cans, fishing hooks, sinkers, and leader line, boat anchors, chains, and dive weights. The remaining debris items recovered were composed of cloth (4.6% - rope and cloth bags), glass and ceramic (4.4% - glass beverage bottles), other or mixed materials (2.0% - fiberglass boat pieces, fishing poles, shoes, golf balls), wood (1.1% - wood slats, processed wood fragments), rubber (0.3% - tires, rubber gloves, rubber bands), and paper/cardboard (0.3% - paper fragments).

Plastic debris pieces were the most noted for causing direct impacts on marine life during cleanup dives. In particular, monofilament fishing line was frequently observed to be wrapped around sponges, coral, and other benthic organisms. Over the last 50 years, plastic debris has become one

of the most ubiquitous issues and has gained widespread recognition. Globally, plastics are estimated to comprise 60-80% of marine debris due to their popular use in consumer products and slow rate of decomposition (Derraik, 2002). Monofilament fishing line, for example, may last in the marine environment for up to 600 years (Florida Fish and Wildlife Conservation Commission, 2011).

Other impacts from debris noted on the reefs included entanglement by plastic bags, rope, and metal fishing wire, all of which are harmful for reef-associated species and other marine life. The large increase in cloth material in 2016 was primarily due to the 500ft of rope collected from a cleanup in Miami-Dade County (Figure 7). This rope was found draped around, over, and through reef structure and habitat and was noted to have caused impacts to coral, sponges, and gorgonians. Other notable debris items include tires and cinder blocks. In most cases, these items were too large to be removed, but are known to cause harm to marine life, particularly during storm events as these objects tend to roll around on the sea floor.



**Figure 7. Large rope (~500ft) removed during the Debris Free Oceans and Divers Paradise Cleanup in Miami-Dade in 2016. Photo: DEP CRCP**

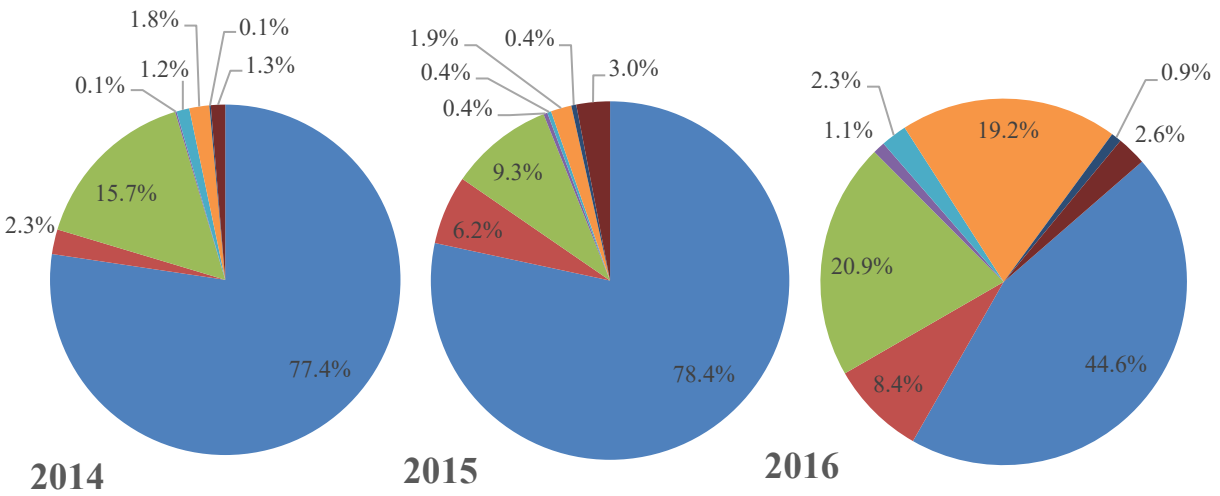
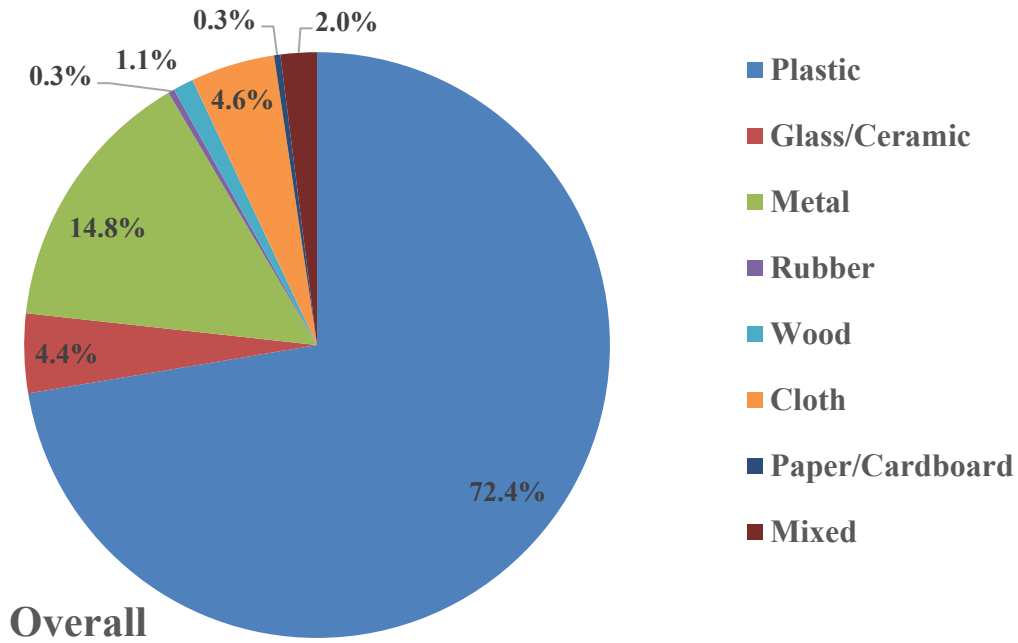


Figure 8. Distribution of total debris items by material collected overall (top) and during the 4<sup>th</sup>, 5<sup>th</sup>, and 6<sup>th</sup> Annual Southeast Florida Reef Cleanup (bottom left to right, respectively).

*Type of Debris – By Source*

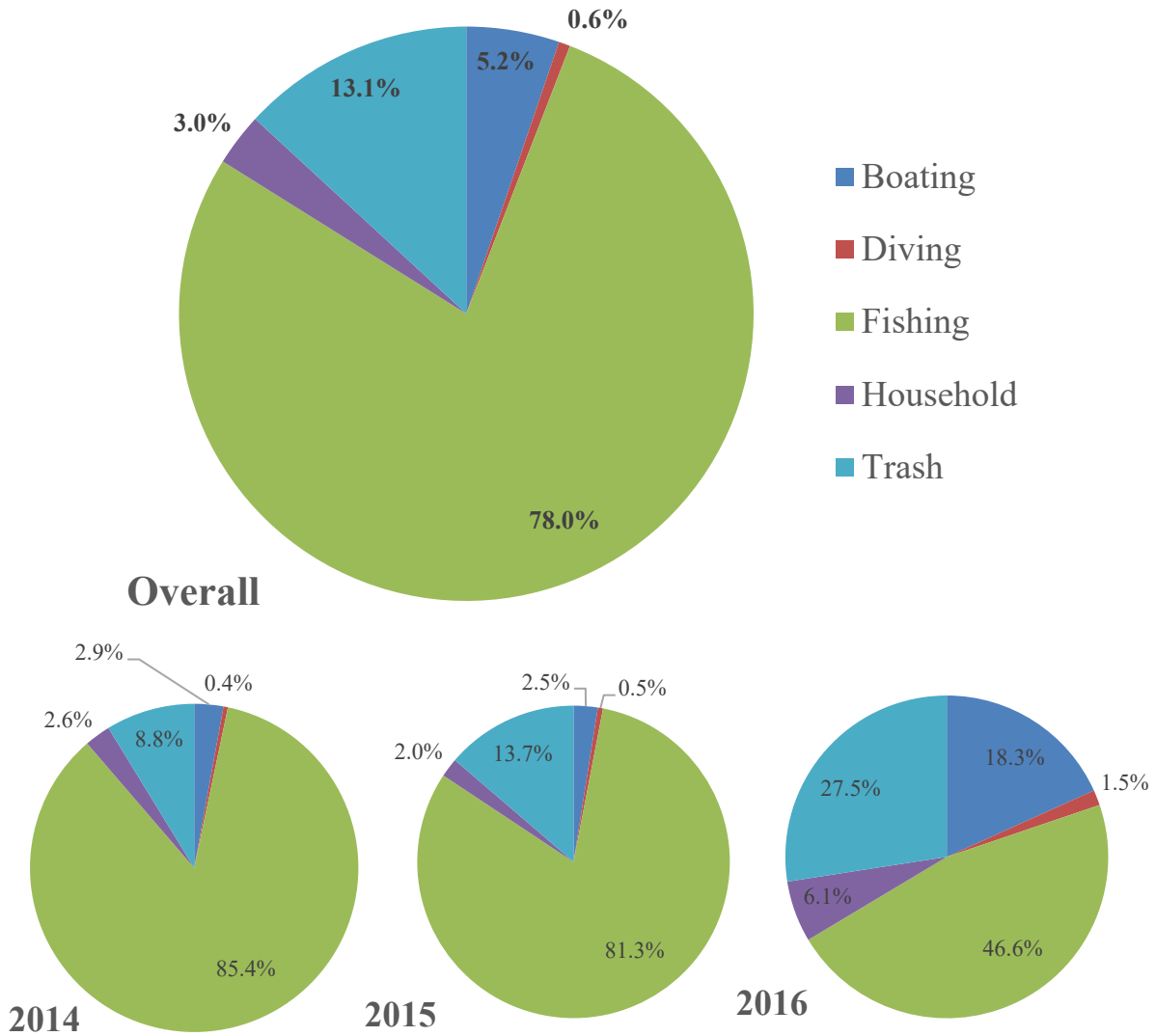
Following the cleanup dives, the collected debris was further analyzed and categorized into five main groups, based on their most likely source:

- Fishing debris – Monofilament, leader line, hooks, sinkers, lures, fishing rods, etc.
- Boating debris – Lines, anchor chain, boat parts (trim tab, intake cover, hull pieces), etc.
- Diving debris – Dive masks, snorkels, dive weights, weight belts, etc.
- Trash – Bottles, cans, food wrappers, plastic bags, miscellaneous plastic, tires, etc.
- Household debris – Sunglasses, golf balls, clothing, mattress pads, furniture, etc.

Among the debris categories, fishing was the by far the most common, comprising 78.0% of the total debris collected in southeast Florida in 2014, 2015, and 2016 (Figure 9). Trash debris was the second commonly collected item, comprising 13.1% of the total with boating, household, and diving debris contributing to 5.2%, 3.0%, and 0.6%, respectively. Of the fishing debris, the majority was composed of monofilament fishing line which was collected at just about every site. From the trash category, cans and beverage bottles (aluminum, plastic, and glass) were among the most commonly collected items. These fishing and trash debris results followed similar historical trends in 2012 and 2013 as being the top two most commonly removed categories. Typically, marine debris is derived from two sources: (1) actions that take place on land (land-based sources), and (2) actions that take place in waterways and in the marine environment (water-based sources) (Mata 2017). Of these five categories, fishing, boating, and diving debris are considered to be water-based sources, while trash and household debris are characterized as land-based. Therefore, 83.8% of the debris collected appears to have come from water-based activities, whereas 16.2% originated on land. The proportion of water-based debris is much higher from these three years than was observed in 2012 and 2013 (Bohnsack 2013).

It is important to note the uncertainty in classifying marine debris on the reefs by source due to the overlap between the types of products used on land versus on the water. This makes it difficult when determining the origin of debris. For example, although we are considering trash as land-based debris, it may have accidentally been lost while boating or even intentionally disposed of at sea (e.g. tires). Similarly, household debris can encounter similar misidentification such as sunglasses, fold-up field chairs, or children's toys (Figure 10). Despite these shortcomings, this classification system provides a simple representation of the types and quantities of debris on southeast Florida's reefs.





**Figure 9. Distribution of total items collected by source overall (top) and during the 4<sup>th</sup>, 5<sup>th</sup>, and 6<sup>th</sup> Annual Southeast Florida Reef Cleanup (bottom left to right, respectively).**

The percent contribution to marine debris by material and by source is calculated based on the number of items found, rather than the contribution to the total weight of debris (see sections below). Further analysis of the debris collected is required to determine the percent contribution by weight, which would likely yield different results. For example, boating debris comprises only 5.2% of the overall debris removed when calculated based on the quantity of items. However, boating debris includes anchors, chain, and rope, all of which tend to be larger and heavier than other debris from other sources. Thus, boating debris could be considered a larger contributor to marine debris if calculated by weight. The same is true when analyzing the percent contribution based on the material of construction. While only 0.3% of the overall debris items collected are

made of rubber, many of these items were tires, which contributed more to the total weight of debris removed. As the extent of damage to coral reef habitat is likely influenced by both the size and prevalence of marine debris items, both of these factors should be accounted for in determining the true amount and impacts associated with marine debris in southeast Florida, however, this level of analysis is not considered in this report summary.



**Figure 10. Examples of marine debris removed from southeast Florida’s reefs. (Photo credit from top left to bottom right: Debris Free Oceans (2015), Laura Kloetz (2016), DEP CRCP (2015), and DEP CRCP (2016).**

### *Spatial Distribution of Debris*

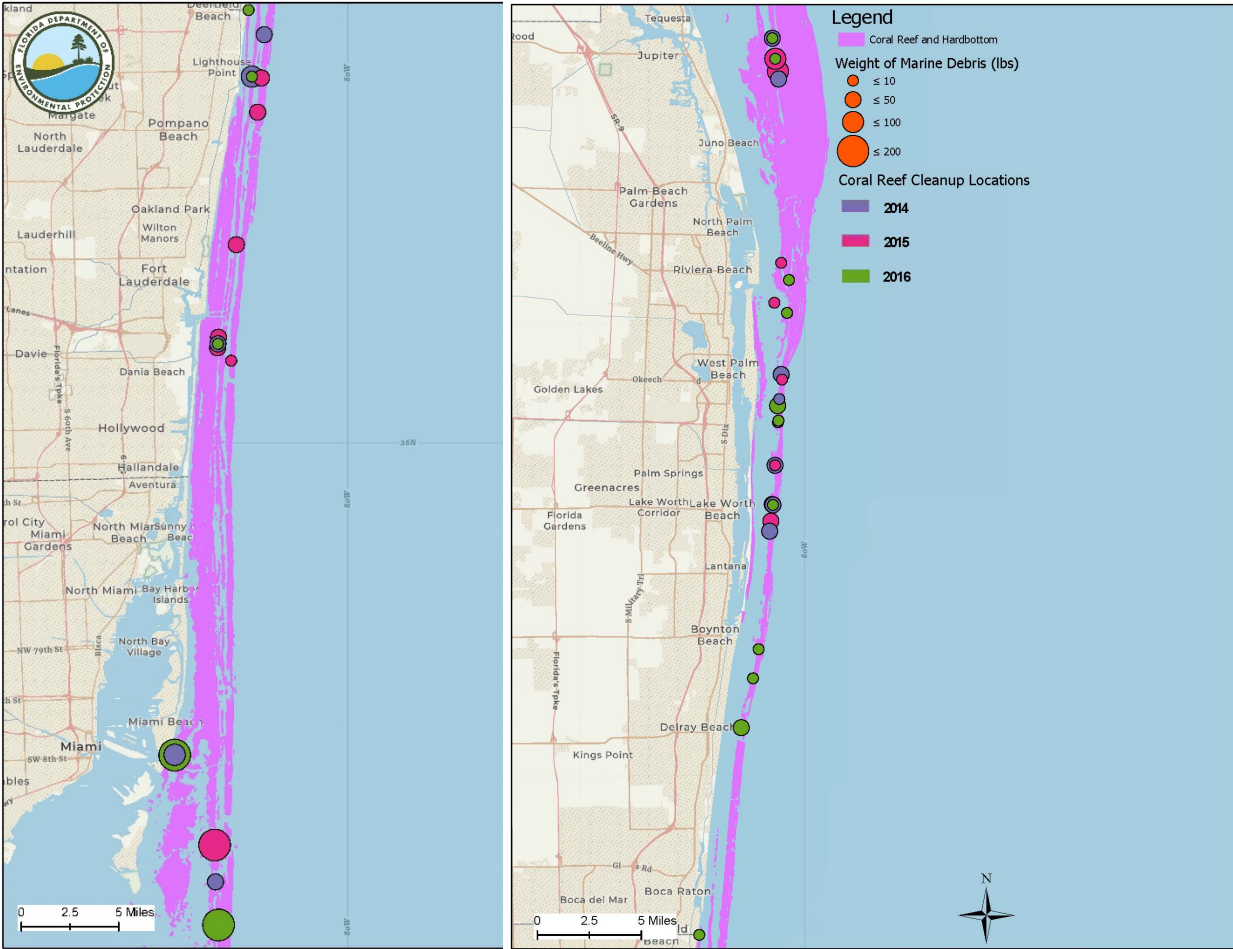
The debris removed during the 4<sup>th</sup>, 5<sup>th</sup>, and 6<sup>th</sup> Annual Southeast Florida Reef Cleanups varied greatly by location. Of all three years combined, Miami-Dade County removed the most debris by weight (537 lbs. out of a total 1,233 lbs.), despite only representing one or two dive operators each summer (Figure 11). This was due to the larger, heavier items removed from the reefs like tires and anchors. In general, Miami-Dade County has a disproportionately larger amount of boaters, fishermen and beach goers and produces a more concentrated amount of debris off Miami Beach as a result. In 2016, DECO Divers purposefully dedicated their reef cleanup to removing debris after Miami Beach’s Jose Cuervo Floatopia event where thousands of beach goers and boaters party on floating rafts. This event has historically been known to produce tons of debris both underwater and on the beaches including cans, bottles, chairs and rafts. As part of this cleanup event, DECO Divers removed 28% of the total weight with majority of the items as either

household debris or trash during the 6<sup>th</sup> Annual Reef Cleanup. An even larger amount of debris was removed by Diver's Paradise and Debris Free Oceans at Bowling Pin Reef in Miami that same summer. On a single tank dive, they removed 52% of the total weight, however, majority of these items were fishing debris including hooks, line and rope.

Palm Beach County as a whole has also been a large contributor of debris removal, likely due to the number of dive operators that participate when compared to other counties, making it a truly county-wide effort. At Bonnie's Ledge in Jupiter in 2015, a total of 410 pieces of debris (37%) and 121 pounds (26%) were removed by Jupiter Dive Center, making it the largest removal effort overall that summer (Figure 11). By contrast, there were several reefs with very little to no trash found during the cleanup including Breakers Reef (in both 2014 and 2015) and Loggerhead in Palm Beach County. Debris removed at these sites amounted to less than 1% each of the total by year.

There are many factors that may influence the spatial distribution and abundance of marine debris throughout southeast Florida. These factors may include proximity to popular beaches, fisheries abundance, proximity to mooring buoys, boater, fisher and diver traffic, and the movement of marine debris by tides, currents, and storms (Sheridan et al. 2005). It's been shown that areas prone to concentrated fishing activity and mooring buoys were often associated with greater amounts of fishing gear (Bauer, Kendall, & Jeffrey, 2008). An example of this is at Horseshoe reef in Broward County and Bowling Pin Reef in Miami where there is high boating and fishing traffic. In 2014, 20% of the debris by weight was collected at Horseshoe Reef and majority of that was fishing related debris.

At some reef sites, debris abundance may also be influenced by proximity to inlets where land-based debris may be a source. Coupled with tides, currents and/or storms, this land-based debris may drift and end up on nearby reefs. It has also been shown that reefs with high rugosity or relief like ledges are more prone to accumulate debris (Kendal, Bauer, and Jeffery, 2007). Bonnies Ledge, Horseshoe Reef and Bowling Pin are all sites with high relief, which may contribute to the greater abundance of debris removed at these sites. Bonnies Ledge reef is also in close proximity to Jupiter Inlet making this site even more susceptible to debris accumulation.



**Figure 11: Spatial distribution by weight of debris removed in 2014, 2015, and 2016. The size of the circle indicates the weight (in pounds) of debris removed at that site. The map on the left shows Miami-Dade and Broward County. The map on the right shows Palm Beach and Martin County.**

## DISCUSSION

### *Reef Cleanup Recommendations*

The 4<sup>th</sup>, 5<sup>th</sup>, and 6<sup>th</sup> Annual Southeast Florida Reef Cleanup were all successful cleanup events hosted by SEFCRI and DEP CRCP. In each consecutive year, more and more charter boats participated which made the 2016 cleanup the largest event to date, despite the limited capacity of CRCP staff and SEFCRI Marine Debris Project Team members. Coordination among dive charters included flyer distribution, supply delivery, data collection, and debris removal. Fortunately, most dive operators could provide their own site coordinators responsible for the success of each event. After six years of the Southeast Florida Reef Cleanup, most of the site coordinators had gained enough experience that they are able to run these events without any further training. However, a goal for future years is to ensure all cleanup leaders, both new and seasoned, understand the safety

guidelines, instructions, and how to fill out the datasheets. This will help to prevent any discrepancies during data collection, recording, and reporting.

Due to the extreme variation in the amount and distribution of marine debris along southeast Florida's coral reefs, site selection is another important consideration in planning future cleanup events. To maximize the productivity of the cleanup and the subsequent benefit to the marine environment, sites which have a greater accumulation of debris should be prioritized over sites that have historically had very little debris. Data from the last six Annual Southeast Florida Reef Cleanups will help to inform site selection for future cleanup events. Reef users are also encouraged to report their individual marine debris sightings and removal efforts throughout the year and on a regular basis to SEAFAN. This will provide additional insight about marine debris in the region and facilitate a more targeted approach. An improved understanding about the types, amounts, and distribution of debris in southeast Florida will enhance future cleanup efforts.

Every year, the Marine Debris Reporting and Removal Program hopes to continue to generate even more interest within the local community of divers and to increase participation among dive operators. Ultimately, this program hopes to coordinate cleanup events throughout the year rather than just once during the summer months. However, this type of expansion is limited by the availability of supplies, staff, and local interest. Therefore, partnering with other local and global organizations and leveraging the Southeast Florida Coral Reef Initiative will help to build capacity in the region, raise awareness and foster community engagement.

### *Other Marine Debris Management Strategies*

While reef cleanups are more of a reactive strategy to reduce the amount of debris in southeast Florida, more efforts should be focused on being proactive. Proactive strategies target marine debris issues at the source. Therefore, management strategies should be focused on preventing these items from entering the marine environment. Holding region-wide debris removal events will allow boaters, divers, and recreational and commercial fishermen to dispose of damaged or unwanted gear. Additionally, there are several programs in southeast Florida that focus on recycling and/or repurposing certain types of gear, parts, and supplies. These are great opportunities for those members of the community to discard items in a safe and responsible manner.

Based on results from this summary, fishing debris and trash have the greatest impact, as these types of debris accounted for 91% of the total debris collected from the 2014, 2015, and 2016 reef cleanups combined. The fishing debris collected for these cleanup events were predominately hook-and-line gear from recreational fishermen. This is common when the hook snags the hardbottom habitat and breaks (National Research Council, 2008). As a result, damaged line either accidentally gets lost or intentionally discarded, commonly referred to as derelict fishing gear. Derelict fishing gear is known to cause significant and persistent threats to coral reef ecosystems as it causes entanglement, ingestion, abrasion, and fragmentation (Chiappone et al., 2004). According to Macfadyen et al. (2009), lost or discarded fishing gear represented 10% of all marine debris around the world. Targeted outreach and proper education will increase awareness among

boaters and fishermen on the impacts of derelict fishing gear and encourage participation in monofilament recycling programs.

In addition to derelict fishing gear, plastic pollution has become an imminent issue and has started to gain large media attention around the world. It has been estimated that 8 million tons of plastic waste reaches the ocean each year (Jambeck et al., 2015) and according to Nicolau et al. (2016), plastic represents between 45-95% of marine litter. Southeast Florida is particularly susceptible to plastic waste accumulation due to the high resident population density and high tourism. This region is also exposed to significant amounts of land-based debris released upstream. Plastics materials are known for their stability, durability, and persistence in the environment. Once plastics enter the marine environment, they begin to degrade into smaller and smaller particles which are easily mistaken as food by marine organisms. Ingestion of plastics introduces these chemicals into marine food webs and have also been shown to interfere with an organism's ability to feed leading to starvation (Plastic and Ocean Platform, 2017). Public awareness campaigns against littering plastic and other trash and encouraging the use of recycling efforts will help to reduce the amount of trash and plastic waste that ends up in the marine environment.

### *Final Remarks*

Much remains to be learned about the prevalence, distribution and sources of marine debris, both in southeast Florida and worldwide. Even the cumulative impacts to population dynamics and ecosystem goods and services are poorly understood. Studying hotspots of debris in southeast Florida will help to better understand the sources and can inform cleanup efforts. However, to contribute to the larger global effort against marine debris, the results from each cleanup during the 4<sup>th</sup>, 5<sup>th</sup>, and 6<sup>th</sup> Annual Southeast Florida Reef Cleanups were reported to PADI Project Aware. This data, along with information from marine debris reports submitted to [www.SEAFFAN.net](http://www.SEAFFAN.net), and other marine debris research throughout the region will be an important first step for creating possible strategies for reducing, preventing, and abating marine debris in southeast Florida.

Special thanks to all of the divers and dive boats who participated in the 4<sup>th</sup>, 5<sup>th</sup>, and 6<sup>th</sup> Annual Southeast Florida Reef Cleanup, including: RJ Diving Ventures, Divers Paradise, Debris Free Oceans, DECO Divers, American Dream Dive Charters, South Florida Diving Headquarters, Force-E, Sea Experience, Jupiter Dive Center, Narcosis Dive Charters, Pura Vida Divers, Dolphin Sun Dive Charters, Paradise Below Diving, and Loggerhead Dive Charters. Special thanks to the many Marine Debris Project Team members and site coordinators who helped plan and facilitate this event, including those from: the Florida Department of Environmental Protection, the Florida Fish and Wildlife Conservation Commission, Palm Beach County Reef Rescue, Miami-Dade County Department of Environmental Resources Management, Palm Beach County Department of Environmental Resources Management, Friends of Our Florida Reefs, Broward County Environmental Protection and Growth Management Department, SeaGrant, and the National Oceanic and Atmospheric Administration (NOAA).

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